A systematic review of the prevalence of comorbid cancer and dementia and its implications for cancer-related care

DOI:
10.1080/13607863.2017.1348476

Document Version
Accepted author manuscript

A systematic review of the prevalence of comorbid cancer and dementia and its implications for cancer-related care

Journal:	*Aging and Mental Health*
Manuscript ID	CAMH-2017-0033.R1
Manuscript Type:	Review
Keywords:	Dementia and Cognitive Disorders, Physical Health Status, Health Service Use, Cancer, Systematic Review

Abstract

Objectives: A co-morbid diagnosis of cancer and dementia (cancer-dementia) may have unique implications for patient cancer-related experience. The objectives were to estimate prevalence of cancer-dementia and related experiences of people with dementia, their carers and cancer clinicians including cancer screening, diagnosis, treatment and palliative care. **Method:** Databases were searched (CINAHL, Psychinfo, Medline, Embase, BNI) using key terms such as dementia, cancer and experience. Inclusion criteria were: a) English language, b) published any time until early 2016, c) diagnosis of cancer-dementia and d) original articles that assessed prevalence and/or cancer-related experiences including screening, cancer treatment and survival. Due to variations in study design and outcomes, study data were synthesized narratively. **Results:** Forty-seven studies were included in the review with a mix of quantitative (n = 44) and qualitative (n = 3) methodologies. Thirty-four studies reported varied cancer-dementia prevalence rates (range 0.2-45.6%); the others reported reduced likelihood of receiving: cancer screening, cancer staging information, cancer treatment with curative intent and pain management, compared to those with cancer only. The findings indicate poorer cancer-related clinical outcomes including late diagnosis and higher mortality rates in those with cancer-dementia despite greater health service use. **Conclusions:** There is a dearth of good quality evidence investigating the cancer-dementia prevalence and its implications for successful cancer treatment. Findings suggest that dementia is associated with poorer cancer outcomes although the reasons for this are not yet clear. Further research is needed to better understand the impact of cancer-dementia and enable patients, carers and clinicians to make informed cancer-related decisions.

Keywords: Dementia and Cognitive Disorders, Cancer, Physical Health Status, Health Service Use, Systematic Review

Word count: 3848

Introduction

An increase in the ageing population coupled with improved life expectancy, raises unique challenges for health and social care. It is estimated that by 2050, at least 30% of the global population will be aged 65 years or older resulting in the increased likelihood and management of chronic and multiple illnesses, otherwise known as multi-morbidity (Barnett et al., 2012; World Health Organization, 2015). By 2040, it is predicted that nearly one quarter of people aged over 65 years in England and Wales will have a cancer diagnosis and older age is linked with poorer cancer outcomes including lower likelihood of successful completion of cancer treatment (Cancer Research UK, 2015; Maddams, Utley, & Møller, 2012). An aging population is also linked to a projected increase in the world-wide prevalence of dementia as approximately 5-9% (Prince et al., 2015). Taken together, this means that the number of older people with co-morbid cancer and dementia is also likely to rise; although it is currently unclear what the co-morbid cancer-dementia prevalence is.

A diagnosis of dementia has additional implications in accessing healthcare for cancer diagnosis and treatment, due to cognitive functioning and communication difficulties associated with the disease (Dooley, Bailey, & McCabe, 2015). Behaviour and psychological symptoms of dementia are also likely to also impact on undiagnosed acute illness and healthcare use (Hodgson, Gitlin, Winter & Czekanski, 2011; Silwanowicz et al, 2016). In the context of dementia, little is known about the experience of being diagnosed with cancer or the process of receiving cancer treatment, cancer-related decision-making and the impact of those decisions. The complexities of managing cancer in a person with dementia is likely to place a significant burden on patients, their family carers, and health care professionals

including cancer clinicians (HCP), particularly with greater involvement in cancer-related decisions placed to support the person with dementia (Alzheimer's Society, 2009; All-Party Parliamentary Group on Dementia, 2016; Guthrie Bruce, 2012).

The aim of this review was to systematically identify and critically review studies that investigated the prevalence of co-morbid cancer and dementia and its effect on cancer-related pathways including prevention, detection and diagnosis, cancer treatments and clinical outcomes including palliative care. Cancer patients', informal caregivers', and HCPs' experiences and views were included. Specific objectives were to:

I. Estimate the prevalence of cancer-dementia

II. Describe cancer related experiences of people with cancer-dementia , their informal caregivers and HCPs at any stage of the cancer pathway

III. Describe cancer-related outcomes for people with cancer-dementia

Methods

Search strategy and selection criteria

Given the likely range of mixed methods used to investigate cancer-dementia, this review was conducted using a structured narrative approach [13] and follows the PRISMA checklist for reporting systematic reviews (Moher, Liberati, Tetzlaff, & Altman, 2009; Pope, Mays, & Popay, 2007). This approach enables qualitative and quantitative studies to be reviewed

simultaneously in order to synthesise the existing evidence and identify gaps when it is not practical to apply meta-analytic review methods.

A systematic search of electronic databases (CINAHL, BNI, Embase, PsycINFO and MEDLINE) was conducted in December 2015 and updated June 2016. All study designs were considered for inclusion with no publication date limitations. Two authors (LM and JY) reviewed papers for inclusion criteria and discussed any disagreements. The search strategy was tailored to the review objectives using combinations of the following MesH search terms, which were adapted for terms used by each database:

Comorbidity AND dementia OR alzheimer OR lewy AND tumour OR cancer OR neoplasms AND prevalence AND economic OR Cost OR expenditure. Dementia OR alzheimer adjacent by 5 words to cancer OR tumour OR neoplasm OR Oncol*, AND treatment outcome OR mortality OR experience OR burden OR distress OR attitude OR preference* adjacent by five words to patient OR carer OR clinician OR nurse OR doctor OR family OR relative AND/OR information adjacent by five words to needs AND/OR decision-making.

The reference lists of included studies and relevant review papers were scanned for additional studies not already found in the searches. An additional search of the main authors of included studies was conducted.

The following inclusion criteria were used:

- Participants aged 18 years and older

- Investigated cancer-dementia using medical classification in methodology e.g. International Classification of Diseases (ICD), medical notes or Diagnostic and Statistical Manual for Mental Disorders (DSM-V) psychiatric interview

- Full empirical research article written in the English language

The following exclusion criteria were used

- Comparisons between samples of patients with cancer and samples of patients with dementia (or other illness), but not those with cancer-dementia

- Self-reported diagnoses (of cancer or dementia) not confirmed by a clinician

- Reviews, opinions, editorials, conference abstracts, case studies

Given the mixed methods of studies identified in the review, the Mixed Methods Appraisal Tool (MMAT; Pluye et al 2009, 2011) tool was used to appraise each study that met inclusion criteria. This has been specifically developed for mixed-method reviews to appraise qualitative and quantitative designs concurrently. Each study receives an overall quality percentage score based on four items that reflect study design, appropriateness of outcome measures including validity, randomisation (if appropriate) and completeness of data. The score ranges from 0 to 100%; – (0% of quality criteria met); * (25% of quality criteria met); ** (50% of quality criteria met); *** (75% of quality criteria met) or **** (100% of quality criteria met).

Results

In total, 47 studies met inclusion criteria and one or more of the review objectives (see Figure 1), 14 of which specifically investigated cancer-dementia as an aim of the paper. Most studies were conducted in the USA (n=31), Denmark (n=7), two studies each from the Netherlands, Sweden, and Japan, and one study from England, Taiwan and Switzerland (Table 1). Three studies received a quality appraisal rating of – (0%), 13 studies received a rating of *, 14 received a rating of **, 17 studies met criteria for 3 of 4 items *** and one study met full criteria **** (100%). Studies are presented in the results using sub-headings related to each of the review objectives.

[Table 1 insert here]

[Figure 1 insert here]

Objective 1

1.1 Prevalence of cancer-dementia

Thirty-four studies reported prevalence estimates using a range of settings predominantly nationwide, nursing homes and individual hospitals (see Table 2). All but three studies investigated the prevalence of dementia in samples of patients with cancer whilst one study reported cancer-related data in a nationwide sample of hospital in-patients with Alzheimer's disease (Beydoun et al., 2015). The remaining two studies used a sample of end-of-life nursing home hospice residents including those with cancer-dementia (Miller, Gozalo, & Mor, 2001; Miller, Mor, Wu, Gozalo, & Lapane, 2002).

The lowest prevalence rates for dementia were reported in five Danish studies of ovarian (0.2%), breast (both 0.5%) and prostate (both 0.6%) cancer (Nguyen-Nielsen et al., 2013; Ording, Cronin-Fenton, et al., 2013; Ording, Garne, et al., 2013; Ording et al., 2016; Tetsche, Nørgaard, Jacobsen, Wogelius, & Sørensen, 2008). The highest cancer-dementia prevalence rates of 32% and 45.6% were reported in the two US studies with samples of nursing home hospice resident studies (Miller et al., 2001; Miller et al., 2002). Seven studies compared dementia prevalence rates between cancer patients and a non-cancer control group; four studies reported similar rates between the two groups (range: 0.5-1% in cancer-dementia and 0.4-1.2% in non-cancer) (Erichsen, Horvath-Puho, Iversen, Lash, & Sorensen, 2013; Jorgensen, Hallas, Friis, & Herrstedt, 2012; Ording, Cronin-Fenton, et al., 2013; Ording, Garne, et al., 2013); two studies found higher rates of cancer-dementia patients in hospice nursing home residents (range 32-43.2% in cancer-dementia and 16-28.5% in non-cancer) (Miller et al., 2001; Miller et al., 2002): and one study found slightly lower rates of dementia in patients with cancer (1.3% in cancer-dementia and 1.9% in non-cancer).

[Table 2 insert here]

Objective 2

Included studies for objective two are presented as cancer screening, cancer diagnosis, cancer treatment decisions and HCP views.

2.1 Cancer screening

Only three studies explored dementia and cancer screening (Smyth, 2009; Torke, Schwartz, Holtz, Montz, & Sachs, 2013; Walter et al., 2009). In a sample of male veterans with and without dementia, study findings show that only 19% of those with a diagnosis of dementia (2% of the sample) received colorectal cancer screening over 2 years compared to 47% with no morbidity or other morbidities such as diabetes (48%) or congestive heart failure (41%) (Walter et al., 2009). Exploring possible reasons for reduced likelihood of receiving breast cancer screening, two studies (Smyth, 2009; Torke et al., 2013) explored the impact a diagnosis of dementia had on decision-making. Findings indicated that the involvement of the person with dementia in the decision-making process, potential distress from screening test procedures and the influence of the clinician are important decision-making factors.

2.2 Cancer diagnosis

Ten studies reported the impact of having a dementia diagnosis on the diagnostic processes of cancer (see Table 3). Five studies reported that some patients with dementia were diagnosed with cancer at autopsy three of which included control groups for comparison (Burke et al., 1994; Fu et al., 2004; Gupta & Lamont, 2004; Magaki, Yong, Khanlou, Tung, & Vinters, 2014). Six studies reported that in the presence of dementia, it is less likely that a cancer diagnosis includes information on tumour size (cancer staging) (Baillargeon et al., 2011; Gupta & Lamont, 2004) and that cancer is diagnosed at a later stage of disease, compared to individuals without dementia (Odds Ratios; OR ranged from 0.97-2.31) (Bradley, Clement, & Lin, 2008; Gorin, Heck, Albert, & Hershman, 2005; Gupta & Lamont, 2004; Raji, Kuo, Freeman, & Goodwin, 2008; Tammemagi, Neslund-Dudas, Simoff, & Kvale, 2003).

[Table 3 insert here]

2.3 Cancer treatment decisions

Seven studies reported differences in cancer treatment decisions in samples of patients with cancer-dementia (see Table 3). Patients with a diagnosis of colon cancer and dementia were less likely to receive any treatment (OR 2.47), surgical (OR 0.43) or chemotherapy (OR range 0.21-3.23) treatment than those with cancer only (Baillargeon et al., 2011; Gupta & Lamont, 2004). Another study with a colorectal sample found patients with dementia were less likely to receive chemotherapy (12.5%) compared to other comorbidities such as congestive heart failure (44.8%) (Fleming et al., 2014). Similar findings were reported for breast cancer patients (Gorin et al., 2005; Kimmick et al., 2014). However, a dementia diagnosis had no impact on whether patients received cancer-directed surgery in a sample of nursing home residents with breast, prostate, colorectal or lung cancer (Bradley et al., 2008).

When considering the hypothetical scenario of a relative with dementia receiving a breast cancer diagnosis, carers with a relative with more severe dementia symptoms expressed 'comfort care' treatment as an option rather than treatment with curative intent (Smyth, 2009).

2.4 Health care professional's views on cancer treatment in cancer-dementia

Two studies investigated the influence of dementia on cancer treatment with health care professionals. A Dutch study found that in the previous 12 months 60% of clinicians recalled

one or more nursing home residents with suspected breast cancer and a third (33%) chose not to refer for diagnostic testing or treatment (Hamaker et al., 2012). Of the 121 responses relating to reasons why patients were not referred, a diagnosis of end-stage dementia was the primary reason in over half of the cases (57%) and only 41% of decisions for non-referral were discussed with the patient.

A small (n=5) qualitative study identified: the need for experienced staff and specialist care for dementia patients dying with cancer; the provision of support to families; involving families in patient care decision-making; HCPs experience frustration due to the communication difficulties often associated with dementia and recommend that a holistic approach should be taken (Bartlett & Clarke, 2012).

Objective 3

Studies relating to objective three are presented under the themes of management of cancer symptoms and cancer outcomes

3.1 Management of cancer symptoms

Seven studies explored the management of cancer symptoms in patients with cancer-dementia (see final column, Table 3). Cross-sectional data indicated in two studies that as dementia severity increases, reported pain and administration of cancer pain medication decreases (Iritani, Tohgi, Miyata, & Ohi, 2011; Monroe, Carter, Feldt, Tolley, & Cowan, 2012). Patients with cancer-dementia and higher scores on a cognitive ability scale used as a

proxy for dementia severity (higher scores indicated greater impairment) were less likely to be enrolled in hospice care for cancer than patients with lower cognitive impairment (OR 0.3) and hospice enrolment was associated with greater likelihood of receiving pain medication (OR 3.9) (Monroe, Carter, Feldt, Dietrich, & Cowan, 2013). In patients who died from a primary diagnosis of cancer and received hospice care in the six months prior to death, patients with cancer-dementia were more likely to use emergency health services, be admitted to hospital as an in-patient and no longer receive hospice services compared to patients with cancer alone (OR range 0.92-1.26) (Legler, Bradley, & Carlson, 2011). Additionally, data from geriatric drug prescription databases in the USA showed that hospice enrolled nursing home residents with cancer-dementia were more likely to receive daily pain medication (OR 1.25) but were still more likely to be hospitalised than those with cancer only (OR 1.09) (Miller et al., 2001; Miller et al., 2002). Lastly, co-morbid metastatic cancer and dementia was associated with a longer stay in hospital and greater health care costs compared to in-patients with dementia only; the same findings were not reported in patients with non-metastatic cancer or lymphoma (Beydoun et al., 2015).

3.2 Cancer outcomes

Thirteen studies estimated the impact of a co-morbid diagnosis of dementia on survival and/or mortality risk in cancer patients (Baillargeon et al., 2011; Beydoun et al., 2015; Bradley et al., 2008; Chen et al., 2015; Daskivich et al., 2011; Erichsen et al., 2013; Louwman et al., 2005; Mohammadi et al., 2015; O'Rourke et al., 2008; Ording, Garne, et al., 2013; Patnaik, Byers, DiGuiseppi, Denberg, & Dabelea, 2011; Raji et al., 2008; Tammemagi et al., 2003). Periods of follow-up ranged from up to five years to 17 years from year of

cancer diagnosis. All 13 studies reported an increased risk of death in patients with cancer-dementia compared to cancer only (all-cause hazard ratios range from 1.45 – 3.74; see Table 4). Five of these studies reported that those with cancer-dementia had a poorer survival rate than those with cancer and no comorbidity (Louwman et al., 2005; Mohammadi et al., 2015; Ording, Garne, et al., 2013; Patnaik et al., 2011; Tammemagi et al., 2003).

[Table 4 insert here]

Discussion

This is a timely review given that the developed world comprises an ageing population with increased risk of developing both cancer and dementia. The primary aim of this review was to estimate cancer-dementia prevalence and describe the cancer-related journey of patients with cancer-dementia, their families and HCPs. In order to conduct a comprehensive review of the cancer-dementia literature, we used broad inclusion criteria and extracted data from a range of research methods that investigated a number of key themes including; cancer prevalence, cancer screening, diagnostic and treatment processes, cancer symptom management, and HCP views across these themes. We found no research that directly explored the views and experiences of patients. Furthermore, the review was limited by the sparse amount of studies evaluating the impact of cancer-dementia on cancer outcomes and ~~poor~~ low quality appraisal scores of included papers, with the majority of studies being retrospective and cross-sectional. Only one of the three qualitative studies met any criteria for appraisal using the MMAT tool, although only received one star of a possible four (Torke et al., 2013).

In this review, prevalence rates for cancer-dementia varied widely. This is likely due to heterogeneity in data collection methods and sample inclusion criteria. The SEER register used in seven studies only covered about a quarter of the US population so is unlikely to reflect true prevalence (Taylor, Ostbye, Langa, Weir, & Plassman, 2009). Half of the included studies also used small regional databases or individual hospitals and 24 studies reported prevalence of specific cancer types. The highest prevalence rates were reported by Miller and colleagues and are difficult to generalise given that the two samples were nursing home residents at end of life using hospice care (Miller et al., 2001; Miller et al., 2002). Additionally, the differences of reported dementia prevalence found between cancer and non-cancer control group studies are likely also to be indicative of varied data collection methods. However, in the studies that collected multiple comorbidity data, the prevalence of cancer-dementia was noticeably lower compared to other conditions such as diabetes, congestive heart failure and chronic obstructive pulmonary disease (Gross et al., 2006; Jorgensen et al., 2012). No study provided sufficient data to comment on the presence of different types of dementia, the potential differences in cancer-related experiences and outcomes.

Little published evidence relates to the impact of dementia on cancer screening beliefs and behaviours. This, in part, is due to the exclusion of older adults aged 74 and older from screening trials, at least for breast cancer (Schonberg et al., 2014; Walter & Schonberg, 2014). The only study to investigate the impact of a dementia diagnosis on attending cancer screening found that patients were far less likely to attend colorectal screening if they had dementia, despite being a very small percentage of the total sample than for participants with no or any other comorbidity (Walter et al., 2009). The sample was aged 70 years or older so it

may reflect the general decrease in guideline recommended screening behaviour, which typically ends at age 75 years old in the USA, regardless of comorbidity.

The review findings suggest that compared with other co-morbid disease groups, patients with dementia tend to be diagnosed with cancer at an unknown or later stage compared to patients with cancer only. This has likely implications for successful cancer treatment outcomes, potential to receive curative treatment and quality of life; as was found for comorbidities in general (Sarfati, Koczwara, & Jackson, 2016). Other findings have demonstrated that older age can significantly impact cancer treatment decisions over and above comorbidity levels (Lavelle et al., 2012). It may be that the patients with dementia included in this review had an advanced stage of disease or are older with associated health conditions such as frailty, which would impact on cancer treatment decisions. A recently developed framework for cancer-related end-of-life decision-making in the context of frailty could be adapted for use in patients with dementia (Amblàs-Novellas et al 2015). Schonberg and colleagues did attempt to describe the factors influencing clinician treatment decisions in females aged 80 or older with breast cancer, however it was not possible to extract data on treatment decisions in relation to co-morbid dementia (Schonberg, Silliman, McCarthy, & Marcantonio, 2012). Although eligible studies should have been identified with the search terms used for this review, no included study explored palliative or end-of-life decision-making in patients with cancer-dementia and highlights an important and unmet research need in order to answer questions around treatment goals in this population. It could be that treatment goals are quality of life-based rather than for curative intent. This would suggest an even greater emphasis on the need for evidence-based guidelines to support cancer clinicians as well as patients with cancer-dementia and their caregivers.

Whilst studies in the review reported varied prevalence rates for cancer-dementia, 11 out of 12 studies reported increased risk of death and poorer survival rates for this population compared to cancer only. Additionally, a co-morbid diagnosis of dementia inferred a greater risk of death than other comorbidities such as congestive heart failure including cancer discovery after death. It is well known that multi-morbidity in older people negatively impacts on quality of life, but it is not yet clear why there appears to be a specific higher mortality risk in those with cancer-dementia (Marengoni et al., 2011). One explanation could be the greater risk of death associated with frailty in older people; however none of the included studies assessed the specific impact of this on cancer outcomes (Handforth et al, 2015).

The number and quality of papers reporting management of cancer symptoms in patients with cancer-dementia was low as demonstrated by the quality appraisal tool used to score each study. Our review demonstrates that dementia-related impairments are likely to be related to suboptimal cancer-related pain assessment and management practices although further research is need to confirm these results (Monroe et al., 2012; Monroe et al., 2013). It is well documented that people with dementia, without a cancer diagnosis, find it difficult to verbally communicate their experiences of pain and that tools used to assess pain need to be appropriate and sensitive to the needs of people with dementia (Dowding et al. 2016; Lichtner et al., 2016). A single study reported increased use of emergency services and inpatient hospitalisation in patients with cancer-dementia; another reported greater healthcare costs for metastatic cancer although both were American studies with limited generalizability (Beydoun et al., 2015; Legler et al., 2011). As yet, the economic impact of cancer-dementia,

although likely to be substantial in the absence of adequate clinical and support services, remains unknown.

This review included limited research that explored health care professionals' views and experiences in relation to cancer-dementia care at any stage of the cancer screening, diagnosis and treatment pathways. It is important to establish cancer treatment goals despite age or comorbidity as set out in recommendations for palliative support of patients with dementia (Naik, Martin, Moye, & Karel, 2016; van der Steen et al., 2013). Given that we were unable to locate any high quality evidence of HCPs cancer treatment decision-making experiences for patients with cancer-dementia, future research should focus on exploring this given that we have reported lower likelihood of receiving cancer treatment and higher mortality risk in patients with co-morbid dementia.

Clinical and policy implications

It is clear that the findings from this review indicate that a co-morbid diagnosis of cancer and dementia has particular implications for healthcare service use, care management and delivery, which should be reflected in government policy and health guideline updates. At present, although quality standards published by the National Institute for Clinical Excellence (NICE, 2010, QS1) reflect that clinicians supporting patients with dementia should be adequately trained to provide dementia care, there is no mention of education regarding complex treatment decision-making discussions. However, there is a growing acknowledgement that there are specific priorities for the older population nationally and internationally that need to be addressed. For example, in the UK, implementation guidance

on the second Prime Minister's challenge on dementia (Department of Health, 2016) advocates dementia-related research including comorbidity in older adults. Considerations also need to be made for the development of appropriate decision-making frameworks for this vulnerable population given the complexity clinicians, patients and their families' face, which has been alluded to in the findings from this review. Future work may involve conducting a systematic search of the grey literature to clarify this.

Conclusion

There is substantial variation in the reported cancer-dementia prevalence rate yet cancer-dementia appears to present as a unique challenge for the patient, carer and clinicians. Additional work is required to investigate the impact of different levels of dementia severity on the cancer pathway from prevention, diagnosis to end of life. Further investigations are warranted to understand and optimise the cancer care pathways for these at-risk individuals.

References

All-Party Parliamentary Group on Dementia. (2016). Dementia rarely travels alone: Living with dementia and other conditions. 1-16.

Alzheimer's Society. (2009). *Counting the cost: Caring for people with dementia on hospital wards*. London.

Amblàs-Novellas, J., Espaulella, J., Rexach, L., Fontecha, B., Inzitari, M., Blay, C., & Go´mez-Batiste, X. (2015). Frailty, severity, progression and shared decision-making: A pragmatic framework for the challenge of clinical complexity at the end of life. *European Geriatric Medicine, 6*(2), *189-194.*

Attner, B., Lithman, T., Noreen, D., & Olsson, H. (2010). Low Cancer Rates among Patients with Dementia in a Population-Based Register Study in Sweden. *Dementia and Geriatric Cognitive Disorders, 30*(1), 39-42

Baillargeon, J., Kuo, Y.-F., Lin, Y.-L., Raji, M. A., Singh, A., & Goodwin, J. S. (2011). Effect of Mental Disorders on Diagnosis, Treatment, and Survival of Older Adults with Colon Cancer. *Journal of the American Geriatrics Society, 59*(7), 1268-1273. doi: 10.1111/j.1532-5415.2011.03481.x

Barnett, K., Mercer, S. W., Norbury, M., Watt, G., Wyke, S., & Guthrie, B. (2012). Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *The Lancet, 380*(9836), 37-43. doi: 10.1016/S0140-6736(12)60240-2

Bartlett, A., & Clarke, B. (2012). An exploration of healthcare professionals' beliefs about caring for older people dying from cancer with a coincidental dementia. *Dementia, 11*(4), 559-565. doi: 10.1177/1471301212437824

Beydoun, M. A., Beydoun, H. A., Gamaldo, A. A., Rostant, O. S., Dore, G. A., Zonderman, A. B., & Eid, S. M. (2015). Nationwide Inpatient Prevalence, Predictors, and Outcomes of Alzheimer's Disease among Older Adults in the United States, 2002-2012. *J Alzheimers Dis, 48*(2), 361-375. doi: 10.3233/jad-150228

Bouchardy, C., Rapiti, E., Fioretta, G., Laissue, P., Neyroud-Caspar, I., Schafer, P., . . . Vlastos, G. (2003). Undertreatment strongly decreases prognosis of breast cancer in elderly women. *J Clin Oncol, 21*(19), 3580-3587. doi: 10.1200/jco.2003.02.046

Bradley, C. J., Clement, J. P., & Lin, C. (2008). Absence of Cancer Diagnosis and Treatment in Elderly Medicaid-Insured Nursing Home Residents. *Journal of the National Cancer Institute, 100*(1), 21-31. doi: 10.1093/jnci/djm271

Burke, W. J., McLaughlin, J. R., Chung, H. D., Gillespie, K. N., Grossberg, G. T., Luque, F. A., & Zimmerman, J. (1994). Occurrence of cancer in Alzheimer and elderly control patients: an epidemiologic necropsy study. *Alzheimer Dis Assoc Disord, 8*(1), 22-28

Cancer Research UK. (2015). *Cancer incidence by age*. Retrieved from http://www.cancerresearchuk.org/health-professional/cancer-statistics/incidence/age#heading-Zero#VUVKIf7RwvZVzEZR.97

Chen, C.-I., Kuan, C.-F., Miser, J., Fang, Y.-A., Lam, C., Chiu, W.-T., & Li, Y.-C. (2015). Comorbidity as an Independent Risk Factor in Patients With Cancer: An 8-Year Population-Based Study. *Asia-Pacific Journal of Public Health, 27*(2), NP590-NP599. doi: 10.1177/1010539513481491

D'Amico, A. V., Braccioforte, M. H., Moran, B. J., & Chen, M. H. (2010). Luteinizing-hormone releasing hormone therapy and the risk of death from Alzheimer disease. *Alzheimer Dis Assoc Disord, 24*(1), 85-89

Daskivich, T. J., Chamie, K., Kwan, L., Labo, J., Dash, A., Greenfield, S., & Litwin, M. S. (2011). Improved Prediction of Long-Term, Other Cause Mortality in Men With Prostate Cancer. *The Journal of Urology, 186*(5), 1868-1873. doi: 10.1016/j.juro.2011.07.033

Department of Health (2016). Prime Minister's challenge on dementia 2020: Implementation plan. Retrieved on [30th May 2017] from https://www.gov.uk/government/publications/challenge-on-dementia-2020-implementation-plan

Derogatis, L. R., Morrow, G. R., Fetting, J., & et al. (1983). The prevalence of psychiatric disorders among cancer patients. *JAMA, 249*(6), 751-757. doi: 10.1001/jama.1983.03330300035030

Dooley, J., Bailey, C., & McCabe, R. (2015). Communication in healthcare interactions in dementia: a systematic review of observational studies. *International Psychogeriatrics, 27*(8), 1277-1300. doi: 10.1017/S1041610214002890

Dowding, D., Lichtner, V., Allcock, N., Briggs, M., James, K., Keady, J., . . . José Closs, S. Using sense-making theory to aid understanding of the recognition, assessment and management of pain in patients with dementia in acute hospital settings. *International Journal of Nursing Studies, 53*, 152-162. doi: 10.1016/j.ijnurstu.2015.08.009

Erichsen, R., Horvath-Puho, E., Iversen, L. H., Lash, T. L., & Sorensen, H. T. (2013). Does comorbidity interact with colorectal cancer to increase mortality? A nationwide population-based cohort study. *Br J Cancer, 109*(7), 2005-2013. doi: 10.1038/bjc.2013.541

Fleming, S. T., Mackley, H. B., Camacho, F., Seiber, E. E., Gusani, N. J., Matthews, S. A., . . . Yao, N. (2014). Clinical, sociodemographic, and service provider determinants of guideline concordant colorectal cancer care for Appalachian residents. *J Rural Health, 30*(1), 27-39. doi: 10.1111/jrh.12033

Fu, C., Chute, D. J., Farag, E. S., Garakian, J., Cummings, J. L., & Vinters, H. V. (2004). Comorbidity in dementia: an autopsy study. *Arch Pathol Lab Med, 128*(1), 32-38. doi: 10.1043/1543-2165(2004)128<32:cid>2.0.co;2

Gorin, S. S., Heck, J. E., Albert, S., & Hershman, D. (2005). Treatment for Breast Cancer in Patients with Alzheimer's Disease. *Journal of the American Geriatrics Society, 53*(11), 1897-1904. doi: 10.1111/j.1532-5415.2005.00467.x

Gozalo, P. L., Miller, S. C., Intrator, O., Barber, J. P., & Mor, V. (2008). Hospice Effect on Government Expenditures among Nursing Home Residents. *Health Services Research, 43*(1 Pt 1), 134-153. doi: 10.1111/j.1475-6773.2007.00746.x

Gross, C. P., McAvay, G. J., Krumholz, H. M., Paltiel, A. D., Bhasin, D., & Tinetti, M. E. (2006). The effect of age and chronic illness on life expectancy after a diagnosis of colorectal cancer: implications for screening. *Ann Intern Med, 145*(9), 646-653

Gupta, S. K., & Lamont, E. B. (2004). Patterns of Presentation, Diagnosis, and Treatment in Older Patients with Colon Cancer and Comorbid Dementia. *Journal of the American Geriatrics Society, 52*(10), 1681-1687. doi: 10.1111/j.1532-5415.2004.52461.x

Guthrie Bruce, P. K., Alderson Phil, McMurdo Marion E T, Mercer Stewart W. (2012). Adapting clinical guidelines to take account of multimorbidity. *BMJ, 345*(e6341)

Hamaker, M. E., Hamelinck, V. C., van Munster, B. C., Bastiaannet, E., Smorenburg, C. H., Achterberg, W. P., . . . de Rooij, S. E. (2012). Nonreferral of Nursing Home Patients With Suspected Breast Cancer. *Journal of the American Medical Directors Association, 13*(5), 464-469. doi: 10.1016/j.jamda.2012.01.002

Handforth, C., Young, C., Simpkins, S., Seymour, M. T., Selby, P. J. (2015). The prevalence and outcomes of frailty in older cancer patients: a systematic review. *Ann Oncol, 26* (6): 1091-1101. https://doi.org/10.1093/annonc/mdu540

Hodgson NA, Gitlin LN, Winter L, Czekanski K. (2011). Undiagnosed illness and neuropsychiatric behaviors in community residing older adults with dementia. *Alzheimer Dis Assoc Disord, 25*(2):109-115.

Iritani, S., Tohgi, M., Miyata, H., & Ohi, G. (2011). Impact of dementia on cancer discovery and pain. *Psychogeriatrics, 11*(1), 6-13. doi: 10.1111/j.1479-8301.2010.00344.x

Jorgensen, T. L., Hallas, J., Friis, S., & Herrstedt, J. (2012). Comorbidity in elderly cancer patients in relation to overall and cancer-specific mortality. *Br J Cancer, 106*(7), 1353-1360

Kimmick, G., Fleming, S. T., Sabatino, S. A., Wu, X.-C., Hwang, W., Wilson, J. F., . . . Prevention National Program of Cancer Registry Patterns of Care Study, G. (2014). Comorbidity Burden and Guideline-Concordant Care for Breast Cancer. *Journal of the American Geriatrics Society, 62*(3), 482-488. doi: 10.1111/jgs.12687

Koroukian, S. M., Murray, P., & Madigan, E. (2006). Comorbidity, Disability, and Geriatric Syndromes in Elderly Cancer Patients Receiving Home Health Care. *Journal of Clinical Oncology, 24*(15), 2304-2310. doi: 10.1200/jco.2005.03.1567

Lavelle, K., Downing, A., Thomas, J., Lawrence, G., Forman, D., & Oliver, S. E. (2012). Are lower rates of surgery amongst older women with breast cancer in the UK explained by co-morbidity[quest]. *Br J Cancer, 107*(7), 1175-1180. doi: http://www.nature.com/bjc/journal/v107/n7/suppinfo/bjc2012192s1.html

Legler, A., Bradley, E. H., & Carlson, M. D. A. (2011). The Effect of Comorbidity Burden on Health Care Utilization for Patients with Cancer Using Hospice. *Journal of Palliative Medicine, 14*(6), 751-756. doi: 10.1089/jpm.2010.0504

Lichtner, V., Dowding, D., Allcock, N., Keady, J., Sampson, E. L., Briggs, M., . . . Closs, S. J. (2016). The assessment and management of pain in patients with dementia in hospital settings: a

multi-case exploratory study from a decision making perspective. *BMC Health Serv Res, 16*(1), 427. doi: 10.1186/s12913-016-1690-1

Louwman, W. J., Janssen-Heijnen, M. L., Houterman, S., Voogd, A. C., van der Sangen, M. J., Nieuwenhuijzen, G. A., & Coebergh, J. W. (2005). Less extensive treatment and inferior prognosis for breast cancer patient with comorbidity: a population-based study. *European journal of cancer (Oxford, England : 1990), 41*(5), 779-785. doi: 10.1016/j.ejca.2004.12.025

Maddams, J., Utley, M., & Møller, H. (2012). Projections of cancer prevalence in the United Kingdom, 2010–2040. *British Journal of Cancer, 107*(7), 1195-1202. doi: 10.1038/bjc.2012.366

Magaki, S., Yong, W. H., Khanlou, N., Tung, S., & Vinters, H. V. (2014). Comorbidity in Dementia: Update of an Ongoing Autopsy Study. *Journal of the American Geriatrics Society, 62*(9), 1722-1728. doi: 10.1111/jgs.12977

Marengoni, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Garmen, A., . . . Fratiglioni, L. (2011). Aging with multimorbidity: A systematic review of the literature. *Ageing Research Reviews, 10*(4), 430-439. doi: http://dx.doi.org/10.1016/j.arr.2011.03.003

Miller, S. C., Gozalo, P., & Mor, V. (2001). Hospice enrollment and hospitalization of dying nursing home patients. *The American Journal of Medicine, 111*(1), 38-44. doi: http://dx.doi.org/10.1016/S0002-9343(01)00747-1

Miller, S. C., Mor, V., Wu, N., Gozalo, P., & Lapane, K. (2002). Does Receipt of Hospice Care in Nursing Homes Improve the Management of Pain at the End of Life? *Journal of the American Geriatrics Society, 50*(3), 507-515. doi: 10.1046/j.1532-5415.2002.50118.x

Minagawa, H., Uchitomi, Y., Yamawaki, S., & Ishitani, K. (1996). Psychiatric morbidity in terminally III cancer patients: A prospective study. *Cancer, 78*(5), 1131-1137. doi: 10.1002/(SICI)1097-0142(19960901)78:5<1131::AID-CNCR26>3.0.CO;2-2

Mohammadi, M., Cao, Y., Glimelius, I., Bottai, M., Eloranta, S., & Smedby, K. E. (2015). The impact of comorbid disease history on all-cause and cancer-specific mortality in myeloid leukemia and myeloma – a Swedish population-based study. *BMC Cancer, 15*, 850. doi: 10.1186/s12885-015-1857-x

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA StatementThe PRISMA Statement. *Annals of Internal Medicine, 151*(4), 264-269. doi: 10.7326/0003-4819-151-4-200908180-00135

Monroe, T., Carter, M., Feldt, K., Tolley, B., & Cowan, R. L. (2012). Assessing advanced cancer pain in older adults with dementia at the end-of-life. *Journal of Advanced Nursing, 68*(9), 2070-2078. doi: 10.1111/j.1365-2648.2011.05929.x

Monroe, T., Carter, M. A., Feldt, K. S., Dietrich, M. S., & Cowan, R. L. (2013). Pain and hospice care in nursing home residents with dementia and terminal cancer. *Geriatrics & gerontology international, 13*(4), 1018-1025. doi: 10.1111/ggi.12049

Naik, A. D., Martin, L. A., Moye, J., & Karel, M. J. (2016). Health Values and Treatment Goals of Older, Multimorbid Adults Facing Life-Threatening Illness. *Journal of the American Geriatrics Society, 64*(3), 625-631. doi: 10.1111/jgs.14027

Nguyen-Nielsen, M., Nørgaard, M., Jacobsen, J. B., Borre, M., Thomsen, R. W., & Søgaard, M. (2013). Comorbidity and survival of Danish prostate cancer patients from 2000–2011: a population-based cohort study. *Clinical Epidemiology, 5*(Suppl 1), 47-55. doi: 10.2147/CLEP.S47153

National Insitute of Clinical Excellence (2010) Dementia: Support in health and social care. Quality Standard (QS1). Retrieved on [30th May 2017] from https://www.nice.org.uk/guidance/qs1

O'Rourke, R. W., Diggs, B. S., Spight, D. H., Robinson, J., Elder, K. A., Andrus, J., . . . Jobe, B. A. (2008). Psychiatric illness delays diagnosis of esophageal cancer. *Diseases of the esophagus : official journal of the International Society for Diseases of the Esophagus / I.S.D.E, 21*(5), 416-421. doi: 10.1111/j.1442-2050.2007.00790.x

Ording, A. G., Cronin-Fenton, D. P., Jacobsen, J. B., Nørgaard, M., Thomsen, R. W., Christiansen, P., & Søgaard, M. (2013). Comorbidity and survival of Danish breast cancer patients from 2000–2011: a population-based cohort study. *Clinical Epidemiology, 5*(Suppl 1), 39-46. doi: 10.2147/CLEP.S47152

Ording, A. G., Garne, J. P., Nyström, P. M. W., Frøslev, T., Sørensen, H. T., & Lash, T. L. (2013). Comorbid Diseases Interact with Breast Cancer to Affect Mortality in the First Year after Diagnosis?A Danish Nationwide Matched Cohort Study. *PLoS ONE, 8*(10), e76013. doi: 10.1371/journal.pone.0076013

Ording, A. G., Horváth-Puhó, E., Lash, T. L., Ehrenstein, V., Borre, M., Vyberg, M., & Sørensen, H. T. (2016). Does comorbidity interact with prostate cancer to increase mortality? A Danish cohort study of 45 326 prostate cancer patients diagnosed during 1995–2011. *Acta Oncologica, 55*(5), 611-618. doi: 10.3109/0284186X.2015.1105382

Patnaik, J. L., Byers, T., DiGuiseppi, C., Denberg, T. D., & Dabelea, D. (2011). The Influence of Comorbidities on Overall Survival Among Older Women Diagnosed With Breast Cancer. *Journal of the National Cancer Institute*. doi: 10.1093/jnci/djr188

Pluye, P., Gagnon, M. P., Griffiths, F. & Johnson-Lafleur, J. (2009). A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in Mixed Studies Reviews. *International Journal of Nursing Studies, 46*(4), 529-546.

Pluye, P., Robert, E., Cargo, M., Bartlett, G., O'Cathain, A., Griffiths, F., Boardman, F., Gagnon, M.P., & Rousseau, M.C. (2011). *Proposal: A mixed methods appraisal tool for systematic mixed studies reviews.* Retrieved on [11th May 2017] from http://mixedmethodsappraisaltoolpublic.pbworks.com.

Pope, C., Mays, N., & Popay, J. (2007). *Synthesizing qualitative and quantitative health evidence*. Berkshire, England: Open University Press.

Prince, M., Wimo, A., Guerchet, M., Ali, G.-C., Wu, Y.-T., & Prina, M. (2015). *World Alzheimer Report 2015 The global impact of dementia: An analysis of prevalence, incidence, cost and trends*. London: A. s. D. International.

Raji, M. A., Kuo, Y.-F., Freeman, J. L., & Goodwin, J. S. (2008). Effect of a Dementia Diagnosis on Survival of Older Patients After a Diagnosis of Breast, Colon, or Prostate Cancer: Implications for Cancer Care. *Archives of internal medicine, 168*(18), 2033-2040. doi: 10.1001/archinte.168.18.2033

Sarfati, D., Koczwara, B., & Jackson, C. (2016). The impact of comorbidity on cancer and its treatment. *CA: A Cancer Journal for Clinicians, 66*(4), 337-350. doi: 10.3322/caac.21342

Schonberg, M. A., Beth Hamel, M., Davis, R. B., Griggs, C. M., Wee, C. C., Fagerlin, A., & Marcantonio, E. R. (2014). Development and Evaluation of a Decision Aid on Mammography Screening for Women Aged 75 and Older. *JAMA internal medicine, 174*(3), 417-424. doi: 10.1001/jamainternmed.2013.13639

Schonberg, M. A., Silliman, R. A., McCarthy, E. P., & Marcantonio, E. R. (2012). Factors Noted to Affect Breast Cancer Treatment Decisions of Women Aged 80 and Older. *Journal of the American Geriatrics Society, 60*(3), 538-544. doi: 10.1111/j.1532-5415.2011.03820.x

Siegelmann-Danieli, N., Khandelwal, V., Wood, G. C., Mainali, R., Prichard, J., Murphy, T. J., . . . Bernath, A. M. (2006). Breast Cancer in Elderly Women: Outcome as Affected by Age, Tumor Features, Comorbidities, and Treatment Approach. *Clinical Breast Cancer, 7*(1), 59-66. doi: http://dx.doi.org/10.3816/CBC.2006.n.014

Silwanowicz, R. M., Maust, D. T., Seyfried, L. S., Chiang, C., Stano, C., and Kales, H. C. (2016) Management of older adults with dementia who present to emergency services with neuropsychiatric symptoms. Int J Geriatr Psychiatry. doi: 10.1002/gps.4599.

Smyth, K. A. (2009). Current Practices and Perspectives on Breast Cancer Screening and Treatment in Older Women with Dementia. *Journal of the American Geriatrics Society, 57*, s272-s274. doi: 10.1111/j.1532-5415.2009.02510.x

Tammemagi, C. M., Neslund-Dudas, C., Simoff, M., & Kvale, P. (2003). Impact of comorbidity on lung cancer survival. *International Journal of Cancer, 103*(6), 792-802. doi: 10.1002/ijc.10882

Taylor, D. H., Jr., Ostbye, T., Langa, K. M., Weir, D., & Plassman, B. L. (2009). The accuracy of Medicare claims as an epidemiological tool: the case of dementia revisited. *J Alzheimers Dis, 17*(4), 807-815. doi: 10.3233/jad-2009-1099

Tetsche, M. S., Nørgaard, M., Jacobsen, J., Wogelius, P., & Sørensen, H. T. (2008). Comorbidity and ovarian cancer survival in Denmark, 1995–2005: a population-based cohort study. *International Journal of Gynecological Cancer, 18*(3), 421-427. doi: 10.1111/j.1525-1438.2007.01036.x

Torke, A. M., Schwartz, P. H., Holtz, L. R., Montz, K., & Sachs, G. A. (2013). Caregiver Perspectives on Cancer Screening for Persons with Dementia: "Why Put Them Through It?". *Journal of the American Geriatrics Society, 61*(8), 1309-1314. doi: 10.1111/jgs.12359

van der Steen, J. T., Radbruch, L., Hertogh, C. M., de Boer, M. E., Hughes, J. C., Larkin, P., . . . Care, o. b. o. t. E. A. f. P. (2013). White paper defining optimal palliative care in older people with dementia: A Delphi study and recommendations from the European Association for Palliative Care. *Palliative Medicine*. doi: 10.1177/0269216313493685

Walter, L. C., Lindquist, K., Nugent, S., Schult, T., Lee, S. J., Casadei, M. A., & Partin, M. R. (2009). Impact of Age and Comorbidity on Colorectal Cancer Screening Among Older Veterans. *Annals of internal medicine, 150*(7), 465-473

Walter, L. C., & Schonberg, M. A. (2014). Screening Mammography in Older Women: A Review. *JAMA, 311*(13), 1336-1347. doi: 10.1001/jama.2014.2834

World Health Organization (Ed.). (2015). *World Report on Ageing and Health*. Geneva, Switzerland.

Zeber, J. E., Copeland, L. A., Hosek, B. J., Karnad, A. B., Lawrence, V. A., & Sanchez-Reilly, S. E. (2008). Cancer rates, medical comorbidities, and treatment modalities in the oldest patients. *Critical Reviews in Oncology/Hematology, 67*(3), 237-242. doi: http://dx.doi.org/10.1016/j.critrevonc.2008.02.002

Table 1 Studies included in the review, organised by objective(s) (n = 47)

Authors & country of study	Study design	Study aim/objective(s)	Sample size (N)	Participants & setting	Relevancy to review objective(s)	Study Appraisal score study type; * (%quality criteria met)
(Attner et al., 2010) Sweden	Retrospective cohort	Investigated the role of dementia for 18 cancer diagnoses	19,756 Multiple (main: prostate 18%)	Cancer Registry of southern Sweden (2005-2007) patients affected by dementia 90 days prior to diagnosis of cancer (invasive tumours excluded)	Prevalence	***
(Bouchardy et al., 2003) Switzerland	Retrospective chart review	To evaluate the determinants and the effect of treatment on prognosis among women aged over 80 years who are diagnosed with breast cancer.	407 Breast	Geneva Cancer Registry (1989-1999) female patients aged 80 or older	Prevalence	**
(D'Amico, Braccioforte, Moran, & Chen, 2010)	Cohort study	To evaluate the risk of death from AD in men undergoing therapy for prostate cancer with or without a LHRH agonist.	6647 Prostate	Chicago Prostate Cancer Centre – patients undergoing brachytherapy treatment only (1997-2007)	Prevalence	***
(Derogatis et al., 1983) USA	Cross-sectional	To estimate the prevalence of psychiatric disorder among cancer patients	215 Multiple (main: lung 20%)	Patients over 19 years at 3 medical centres newly admitted for active cancer treatment	Prevalence	**
(Gross et al., 2006) USA	Retrospective cohort	To determine the degree to which life expectancy after diagnosis of early stage cancer varies according to age or co-existing chronic illness	35,755	SEER Register 1993-1999 patients over 67 years with colorectal cancer diagnosis	Prevalence	**
(Gozalo et al., 2008) USA	Retrospective cohort	To estimate treatment effect of Medicare hospice benefit on end of life government expenditures among nursing home residents	5774	All nursing home residents in Florida who died Jul-Dec 1999 aged => 65 years (using Medicare/Medicaid expenditure data)	Prevalence	**

(Jorgensen et al., 2012) Denmark	Retrospective cohort	To describe the prevalence of comorbidity in newly diagnosed elderly cancer cases compared with background population and its influence on overall and cancer-specific mortality	6,325 Multiple	Danish Cancer Registry from a Danish province (1996-2006)	Prevalence	****
(Koroukian et al., 2006) USA	Cross-sectional	To assess prevalence of comorbidity, disability and geriatric syndromes or a combination thereof in elders with cancer receiving home health care	952 Breast 324 Prostate 1,276 Colorectal	Ohio Cancer Incidence Surveillance system (Aug 1999-Nov 2001) patients 65 years or older diagnosed with cancer	Prevalence	*
(Miller et al., 2002) USA	Retrospective cohort	To compare analgesic management of daily pain for dying nursing home residents enrolled and not enrolled in Medicare hospice	2,644 enrolled 7,929 not enrolled	Systematic assessment of geriatric drug use via epidemiology database (1992-1996)	Prevalence	*
(Minagawa et al., 1996) Japan	Cross-sectional	To clarify the nature and prevalence of psychiatric disorders in terminally ill cancer patients	93	Cancer patients newly admitted to a hospital palliative care unit (1994-1995)	Prevalence	**
(Nugyen-Nielson et al., 2013) Denmark	Prospective cohort	To examine the impact of comorbidity on overall prostate cancer survival in the 12-year study period	7654	Central Denmark Region: Danish National Registry of Patients with first time diagnosis of cancer in 2000-2011 median age 72 years	Prevalence 46/7654 = 0.6% can-dem prevalence (reducing over time in the study period) Further analyses conducted with CCI only	***

(Ording, Garne, et al., 2013) Denmark	Retrospective cohort	To study temporal changes in mortality in a cohort of breast cancer patients diagnosed in 2000-2011 by extent of co-morbid diseases	9,239	Central Denmark region, Danish National Registry of Patients (2000-2011, females, first time diagnosis of breast cancer)	Prevalence	***
(Ording et al. 2016) Denmark	Retrospective cohort	To compare mortality rates for prostate cancer patients with that of men from the general population and examined whether prostate cancer and specific comorbid conditions interact to increase mortality more than expected by each factor acting alone	45,326	Danish Cancer Registry patients diagnosed with prostate cancer 1995-2011	Prevalence	***
(O'Rourke et al., 2008) USA	Retrospective cohort	To determine the impact of co-existing psychiatric illness on time to diagnosis, disease stage and survival in patients with cancer	160	Veteran hospital patients diagnosed with esophegeal cancer (1989-2003)	Prevalence	**
(Schonberg et al., 2012) USA	Retrospective chart review	To identify factors that influence the breast cancer treatment decisions of women aged 80 and older	65	Female, aged 80 or older at 3 health centres (1994-2004 and followed up to 2010)	Prevalence	*
(Tetsche et al., 2008) Denmark	Retrospective cohort	To examine (i) the prevalence of comorbidity from 1995 to 2004 and (ii) the impact of comorbidity on ovarian cancer survival and mortality during the study period.	1,995	University hospital database (1995-2004)	Prevalence	**
(Zeber et al., 2008) USA	Cross-sectional	To examine the prevalence, medical comorbidities and treatment modalities of four commonly diagnosed cancers (Lung, colorectal, prostate,	197,797	Veterans Health Administration national database (2004-2005) patients aged 70 or older	Prevalence	**

		head and neck) among veterans affairs patients aged 70 and older				
Smyth (2009) USA	Qualitative (semi-structured phone interviews)	To explore the nature of breast cancer screening and treatment decisions in older women with dementia	23	Caregivers of women with dementia (15 spouse, 2 sons, 4 daughters, 1 niece, 1 friend)	Cancer screening	-
				of 6 severe, 9 mild, 8 moderate dementia	Cancer treatment decisions	
(Torke et al., 2013) USA	Qualitative (focus groups)	To describe perspectives of family caregivers toward cancer screening tests for their relatives with dementia	32	Caregivers attending dementia support group meetings (mostly daughter or spouse; 5 other)	Cancer screening	*
(Walter et al., 2009) USA	Retrospective cohort	To determine whether colorectal cancer screening is targeted to healthy older patients and is avoided in older patients with severe comorbidity who have a life expectancy of less than 5 years	27,068	National veteran systems (2001-2007) patients 70 years or older with at least 1 outpatient visit during 2000 (96% males age 77 median)	Cancer screening	**
(Burke et al., 1994) USA	Autopsy chart review	To compare autopsy incidence of cancer between Alzheimer's disease cases and a non-Alzheimer's control group	646	University hospital histopathology reports (1983-1988)	Cancer diagnosis	**
(Fu et al., 2004) USA	Autopsy chart review	To examine general autopsy findings in patients with a dementia syndrome and to establish patterns of central nervous system comorbidity in these patients	52	Patients who had general autopsy and clinical diagnosis of dementia (1995-2000) at a large academic medical centre	Cancer diagnosis	*

(Magaki et al., 2014) USA	Autopsy chart review	To examine systemic and central nervous system comorbidities of individuals with dementia evaluated during general autopsy	86 with dementia 124 without dementia	Completed autopsy reports and clinical information of deceased patients from a tertiary medical centre	Cancer diagnosis	**
(Fleming et al., 2014) USA	Retrospective chart review	Examined the clinical, socio-demographic and provider determinants of variation in concordance with widely accepted treatment guidelines for colorectal cancer patients	2,932 stage 1-3 colon cancer diagnosis	New colorectal diagnoses as per Medicare claims assessed (2005-2009 in 4 States	Cancer treatment	*
			184 rectal cancer diagnosis	Patients we less than 80 years and scheduled for chemotherapy or radiotherapy		
(Kimmick et al., 2014) USA	Cross-sectional	To explore the relationship between level and type of comorbidity and guideline concordant care for early-stage breast cancer	6,439	National Program of Cancer Registry females with breast cancer from (2004)	Cancer treatment decisions	***
Bartlett & Clarke (2012) England	Qualitative (semi-structured interviews)	How do HCPs assess the needs of an older person dying from cancer with a coincidental dementia?	5	HCP within a single acute hospital	HCP views on cancer treatment in cancer-dementia	-
(Hamaker et al., 2012) Netherlands	Cross-sectional (online survey)	To determine the extent of non-referral of patients suspected of breast cancer by elderly care physicians and the motivations behind this choice	419	Elderly care physicians across the Netherlands	HCP views on cancer treatment in cancer-dementia	**
(Monroe et al., 2012) USA	Retrospective chart review	To use medical records to assess advanced cancer pain in older adults with dementia at the end of life	48	Nursing home residents in final 3m of life	Management of cancer symptoms	*
(Monroe et al., 2013) USA	Retrospective chart review	To examine the association between hospice enrolment,	55	Deceased nursing home residents with dementia who had	Management of cancer symptoms	*

		dementia severity and pain among nursing home		advanced cancer [top 10 cancers in 2004 in USA, CDC]		
(Siegelmann-Danieli et al., 2006) USA	Retrospective chart review	To study the effect of age, comorbidity, tumor features and treatment appropriate to overall survival and breast	992	Institutional Tumor Registry (1971-2001) females aged 70 or older	Prevalence Cancer diagnosis	**
(Gorin et al., 2005) USA	Retrospective cohort	To report use of breast cancer treatment by patients with Alzheimer's Disease	50,460	SEER Register (1992-1999) females over 64 years stage I-III breast cancer	Prevalence Cancer diagnosis Cancer treatment decisions	***
(Legler et al., 2011) USA	Cross-sectional	To estimate the comorbidity burden of hospice users with a primary diagnosis of cancer and burden on admissions, hospice disenrollment and death	27166	SEER Register, any patient in 2002 with cancer who died and received hospice care in 6m prior to death	Prevalence Management of cancer symptoms	*
(Miller et al., 2001) USA	Retrospective cohort	To evaluate whether Medicare hospice care provided in nursing homes is associated with lower hospitalisation rates	36,702	Systematic assessment of geriatric drug use via epidemiology database 1992-1996 (died before January 1998)	Prevalence Management of cancer symptoms	**
(Iritani et al., 2011) Japan	Retrospective cohort	To evaluate how dementia modified the cancer discovery process, pain reports and medication use at a large	134	Patients from surgical ward for cancer treatment (1993-2004; leukemia and skin cancer excluded)	Prevalence	-

		psychiatric hospital			Cancer diagnosis Management of cancer symptoms	
(Baillargeon et al., 2011) USA	Retrospective cohort	To examine the independent and aggregate effects of a pre-existing diagnosis of any major mental disorder on cancer stage at diagnosis, treatment and survival in adults with colon cancer	80,670	Medicare database (Jan 1993-Dec 2005) patients aged over 67 years colon cancer diagnosis	Prevalence Cancer diagnosis Cancer treatment decisions Cancer outcomes	***
(Beydoun et al., 2015) USA	Retrospective cohort	To assess over-time trends in Alzheimer's Disease (AD) prevalence among a US inpatient sample; to compare comorbidities between AD and non-AD admissions; to compare outcomes (mortality rate, length of stay and total charges) and trends of comorbidity	14,126 445 (weighted)	Nationwide inpatient sample (2002-2012) aged 60 or older and discharged (with notes)	Prevalence Management of cancer symptoms Cancer outcomes	*
(Bradley et al., 2008) USA	Retrospective chart review	To understand the patterns of care provided to nursing home cancer patients	1,907	Medicaid/Medicare data merged with Michigan Tumor Registry (1997-2000) nursing home residents aged 66 or older	Prevalence Cancer diagnosis Cancer treatment decisions	***

					Management of cancer symptoms Cancer outcomes	
(Chen et al., 2015) Taiwan	Retrospective cohort study	To determine the prevalence of medical conditions in patients with cancer and their impact on outcome	37,411	Longitudinal Health Insurance Database (Jan 2000-Jan 2008) adult patients over 20 years who visited health care facilities (insured patients)	Prevalence Cancer outcomes	*
(Mohammadi et al., 2015) Sweden	Prospective cohort study	To examine the impact of severe co-morbid disease history and survival in patients with myeloid leukemia or myeloma in Sweden	8,134	Swedish Cancer Registry (2002-2009) myeloid leukemia or myeloma patients aged over 18 years	Prevalence Cancer outcomes	***
(Daskivich et al., 2011) USA	Retrospective cohort	To determine the long-term risks of non-prostate cancer mortality associated with specific comorbidities	1,598	Patients with prostate cancer at two veterans hospitals (1997-2004)	Prevalence Cancer outcomes	**
(Erichsen et al., 2013) Denmark	Retrospective cohort	To study the interaction between comorbidity and colorectal cancer, and subsequent risk of death.	56,963	Danish Cancer Registry colorectal cancer patients (1995-2010)	Prevalence Cancer outcomes	***
(Louwman et al., 2005) Netherlands	Prevalence study	To describe the prevalence of serious comorbidity and impact of comorbidity on treatment and prognosis in breast cancer	8,966 Breast	Cancer Registry (1995-2001) all new breast cancer patients	Prevalence Cancer Outcomes	***

Gupta & Lamont (2004) USA	Retrospective cohort	To determine the prevalence of dementia in older patients diagnosed with colon cancer and the influence of co-morbid dementia on presentation, diagnosis and treatment	17,507	SEER Register (1992-1999) patients over 67 years with colon cancer stage I-III (dementia diagnosis two years preceding cancer diagnosis)	Prevalence Cancer diagnosis Cancer treatment decisions Cancer outcomes	***
(Ording, Cronin-Fenton et al., 2013) Denmark	Retrospective cohort study	To estimate the different between overall mortality rate and the expected mortality rate, effect of breast cancer on mortality rate and comorbidity	47904 n = 237938 matched control	Breast cancer patients aged 45-85 diagnosed during 1994-2008 Civil Registration System	Prevalence Cancer outcomes 0.5% n231 dementia in breast cancer; 0.4% n1028 non-cancer matched group Mortality rate risk during first year since diagnosis: 5.0 CI 3.6-6.8 (no p value) stage distribution skewed towards later stage diagnosis for breast and dementia patients compared with breast cancer patients without dementia'	***
(Patnaik et al., 2011) USA	Retrospective cohort	To measure associations between specific comorbidities and overall survival/all-cause mortality in older women with breast cancer	64,034	SEER Register (1992-2000) females over 66 years	Prevalence Cancer outcomes	***
(Raji et al., 2008) USA	Retrospective cohort	To examine the effect of a pre-existing diagnosis of dementia on deaths from cancer (colon, breast,	31,935 breast 47, 235 prostate 26,891 colon	SEER Register (1994-1999) patients over 68 years	Prevalence Cancer diagnosis	***

		prostate)			Cancer outcomes	
(Tammemagi et al., 2003) USA	Retrospective cohort	To evaluate the effect of comorbidities individually and collectively on the survival of lung cancer patients and what extent existent effects are mediated through differences in receipt of cancer treatments	1,115	Jospehine Ford Cancer Tumor Registry (Jan 1995-Dec 1998, follow up 2000)	Prevalence Cancer diagnosis Cancer outcomes	*

Table 2 Prevalence of cancer-dementia from included studies, organised by cancer type

Study	Country	Cancer type	Participant setting	Date range included in analyses (diagnosis of cancer)	Age range specified in years	Prevalence of co-morbid dementia % (n= sample size)
(Bouchardy et al., 2003)	Switzerland	Breast	Geneva Cancer Registry	1989-1999	80 or older	12.9 (n=42/326)* *20% total sample had no comorbidity data
(Gorin et al., 2005)	USA	Breast (female only)	SEER register	1992-1999	64 or older	3.8 (n=1,935/54,460)
(Louwman et al., 2005)	Netherlands	Breast	Eindhoven Cancer Registry	1995-2001	None specified or median/mean reported	1.56 (n=140/8,966)
(Ording, Garne, et al., 2013)	Denmark	Breast (female only)	Danish National Registry of Patients, Central Denmark region	2000-2011	None specified (median age 62)	0.5 (n=46/9,329) Non cancer controls 0.4 (n=1,028/237,938)

(Ording, Cronin-Fenton, et al., 2013)	Denmark	Breast (female only)	Danish Cancer Registry	1994-2008	45-85	0.5 (n = 231/47,904)
(Patnaik et al., 2011)	USA	Breast (female only)	SEER register	1992-2000	66 or older	1.4 (n =887/64,034)
(Schonberg et al., 2012)	USA	Breast (female only)	Three health centres in Massachusetts	1994-2004 follow-up Jun 2010	80 or older	12.3 (n=8/65)
(Siegelmann-Danieli et al., 2006)	USA	Breast (female only)	Institutional tumour registry of a medical centre	1971-2001	70 or older	4 (n=40/992)
(Tammemagi et al., 2003)	USA	Bronchogenic lung	Jospehine Ford Cancer Tumor Registry (Detroit, MI)	1995-1998 Follow-up Jan 2000	None specified or median/mean reported	2 (n=22/1,115)
(Baillargeon et al., 2011)	USA	Colon	SEER register	1993-2005	67 or older	9 (n=7,267/80,670)
(Erichsen et al., 2013)	Denmark	Colorectal	Danish Cancer Registry	1995-2010	None specified	1 (n=594/56,963)
					(median age 72 years)	Non cancer controls

						0.8 (n=2,297/271,67)
(Gross et al., 2006)	USA	Colorectal	SEER register	1993-1999	67 or older	2.9 (n=1,038/35,755)
(Gupta & Lamont, 2004)	USA	Colon	SEER register	1992-1999	67 or older	6.8 (n= 1,184/17,507)
(O'Rourke et al., 2008)	USA	Oesophageal	Veteran hospital patients (Portland, WA)	1989-2003	None specified (mean age 65.2)	4.37 (n=7/160)
(Tetsche et al., 2008)	Denmark	Ovarian	University hospital database serving four counties	1995-2004	None specified (median age 63)	0.2 (n=4/1,995)
(Mohammadi et al., 2015)	Sweden	Acute or chronic Myeloid leukaemia (AML/CML) and myeloma	Swedish Cancer Registry	2002-2009	18 or older (median age 67 AML/CML and 72 myeloma at diagnosis)	1.03 (n=84/8,134)
(D'Amico, Braccioforte, Moran, & Chen, 2010)	USA	Prostate	Chicago prostate cancer centre – patients undergoing brachytherapy treatment only	1997-2007	None specified, (mean age 69.8)	0.3 (n=24/6,647)

(Daskivich et al., 2011)	USA	Prostate	California Cancer Registry, Two veterans hospitals (Los Angeles, CA)	1997-2004	None specified or median/mean reported	3.07 (n=49/1,598)
(Nguyen-Nielsen et al., 2013)	Denmark	Prostate	Danish National Registry of Patients, Central Denmark region	2000-2011	None specified (median age 73)	0.6 (n=46/7,654)
(Ording et al., 2016)	Denmark	Prostate	Danish Cancer Registry	1995-2011	None specified (median age 72)	0.6 (n = 294/45,326) Non cancer controls 0.6 (1,323/225,106)
(Koroukian, Murray, & Madigan, 2006)	USA	Breast, colorectal and prostate	Ohio Cancer Incidence Surveillance System	Aug 1999-Nov 2001	65 or older	Breast 12.9 (n=123/952) Colorectal 20.4 n=261/1,276) Prostate 28.4 (n=92/324)

(Raji et al., 2008)	USA	Breast, colon and prostate	SEER register	1994-1999	68 or older	7 (n=7,453/106,061) Breast: 7.4 (n=2,369/31,935) Colon: 10 (n=2,691/26,891) Prostate: 5.1 (n=2,393/47,235)
(Zeber et al., 2008)	USA	Lung, colorectal, prostate and head and neck	Veterans Health Administration national database (99.6% sample male)	Oct 2004-Sep 2005	Aged 70 or older (mean age 77.8)	6% (n=10779/194,797)
(Beydoun et al., 2015)	USA	Lymphoma, metastatic and non-metastatic cancer	Nationwide Inpatient Sample* *weighted sample	2000-2012	60 or older	Lymphoma *1.1 (n=15,5391/14,126,445) Metastatic cancer *3 (n=423,793/14,126,445) Non-metastatic cancer *3 (n=423,793/14,126,445)

(Attner, Lithman, Noreen, & Olsson, 2010)	Sweden	Multiple; main 18% prostate	Cancer Register of Southern Sweden	2005-2009	None specified or median/mean reported	1.3 (n=253/19,756)
(Bradley et al., 2008)	USA	Multiple; main 17% colon/rectum	Nursing home residents: Michigan Tumor Registry (linked with Medicare/Medicaid database)	1997-2000	66 or older	Non cancer controls 1.9 (n=2,732/147,324)
(Chen et al., 2015)	Taiwan	Multiple; main 16.5% colorectal	Longitudinal Health Insurance Database 2005	2000-2008	20 or older (mean/median not reported)	2.2 (n = 831/37,411)
(Derogatis, Morrow, Fetting, & et al., 1983)	USA	Multiple; main 20% lung	Three medical centres (2 in NY, 1 in Baltimore, MD)	9months 1980-1981	19 or older (mean age 50.3)	1.4 (n=3/215)
(Jorgensen et al., 2012)	Denmark	Multiple; main 32% colorectal	Danish Cancer Registry in a Danish province	1996-2006	70 or older	0.85 (n=54/6,325) Non cancer controls 1.16 (n=294/21,868)

(Legler et al., 2011)	USA	Multiple; main over 25% lung	SEER register	2002 (deceased patients and received hospice care in last 6 months of life)	None specified (mean age at death 78)	18.8 (n=5,107/27,166)
(Minagawa, Uchitomi, Yamawaki, & Ishitani, 1996)	Japan	Multiple; main 22% stomach	Palliative care unit at a hospital	Admitted during May 1994-Apr 1995	None specified (mean age 67.2)	10.7 (n=10/93
(Gozalo, Miller, Intrator, Barber, & Mor, 2008)	USA	Not specified	Nursing home residents in Florida and Medicare eligible	Deaths in the second half of 1999	65 or older	6.15 (n=355/5,774)
(Miller et al., 2001)	USA	Not specified	Systematic Assessment of Geriatric Drug Use via Epidemiology database (5 US states)	1992-1996 (patients died before Jan 1998)	None specified (mean age 84)	Hospice 32 (n=2,836/9,202) Non cancer controls 16 (n=1,478/9,202)
(Miller et al., 2002)	USA	Not specified	Systematic Assessment of Geriatric Drug Use via Epidemiology database (5 US states)	1992-1996 (patients died before Apr 1997)	None specified or median/mean reported	Hospice 43.2 (n=306/709) Non cancer controls 28.5 (n=202/709)

Table 3 differences in cancer staging and treatment decisions in people with and without com-morbid dementia

Study	Cancer type	Setting	Unknown cancer stage (%)*		Differences in cancer staging (%)[A]			Impact of dementia on cancer diagnosis[A][B]	Impact of dementia on cancer treatment decisions	Impact of dementia on management of cancer symptoms
								OR (confidence intervals) unless otherwise stated	OR (confidence intervals) unless otherwise stated	OR (confidence intervals) unless otherwise stated
			Dementia	Cancer only	Stage	Dementia	Cancer only			
(Baillargeon et al., 2011)	Colon	SEER register	***24.3***	***6.2***	I II III IV	17.6 25.9 17.2 15	21.9 31.4 23.1 17.5	Diagnosed with cancer at autopsy 8.1% (with dementia) 1.1% (without dementia)	No treatment(all stages) Adj RR 2.47 (2.08-2.93) 13.3% (with dementia) 2.6% (without dementia) No chemotherapy treatment (stage III) Adj RR 3.23 (2.66-3.91) 78.9% (with dementia) 38.7% (without dementia)	-

Bradley et al (2008)	Multiple	Nursing home residents	-	-	-	-	-	Late or un-staged cancer 0.97 (0.75-1.25)	Cancer-directed surgery 1.30 (0.71-2.35)	-
(Burke et al., 1994)	Multiple	University hospital	-	-	-	-	-	Undiagnosed malignancies during autopsy 21.1% (with dementia; n =15/71) 15.7% (without dementia; n=90/575)	-	-
(Beydoun et al., 2015)	Multiple	Nationwide Inpatient Sample of patients with Alzheimer's	-	-	-	-	-	-	-	Length of hospital stay Lymphoma -0.11 days p=0.66 Metastatic cancer **+0.78 days** p<.001 Non-metastatic cancer +0.04 days p=0.81 Total charge of stay Lymphoma +$422 p=0.81 Metastatic cancer **+$8801** p<.001 Non-metastatic cancer **+$1761** p=0.05
(Fleming et al., 2014)	Colorectal	4 State cancer registries	-	-	-	-	-	-	Stage III colon 1/8 with dementia received chemotherapy Stage I-III colorectal	-

									Receive chemotherapy 0.11 (0.013-0.898)	
(Fu et al., 2004)	Multiple	Academic medical centre	-	-	-	-	-	8% (n = 4/52) had undiagnosed malignancies during autopsy [no control group]	-	-
(Gupta & Lamont, 2004)	Colon	SEER register	**24.4**	**7.4**	I II III IV	21.1 37.7 20.8 20.5	20.8 35.3 23.6 20.4	Diagnosed with cancer at autopsy 2.31 (1.79-3.00) Un-staged cancer 2.12 (1.77-2.55) Less invasive diagnostic testing 2.02 (1.63-2.51)	Surgical resection (stage I-III) 0.43 (0.33-0.70) Chemotherapy (following resection) 0.21 (0.13-0.36)	-
(Gorin et al., 2005)	Breast	SEER register	-	-	In situ I II III	**6.3** **35.5** **47.4** **10.8**	**12.1** **47.6** **33.7** **6.6**	Tumour size larger than 3cm **26.6%** (with dementia) **13.1%** (without dementia)	No treatment decision recorded 3.7% dementia 0.9% no dementia Any treatment 0.55 (0.42-0.74) Surgery 0.60 (0.46-0.81) Radiation (after breast conserving surgery) 0.31 (0.23-0.41) Chemotherapy 0.44 (0.34-0.58)	-

(Iritani et al., 2011)[$]	Multiple	Surgical ward, psychiatric hospital	-	-	I-II III-IV	38 62	39 61	Diagnosed through seeking medical consultation **8%** (with dementia) **63%** (without dementia Cancer as chance discovery **21%** (with dementia) **48%** (without dementia) Unexpected unfolding of clinical symptoms **44%** (with dementia) **16%** (without dementia)	-	Reporting pain (nurse records) **22%** with dementia **76%** without dementia Received pain medication at cancer stage IV **13%** with dementia **41%** without dementia
(Kimmick et al., 2014)	Breast	National Program of Cancer Registry	-	-	-	-	-	-	Guideline concordant treatment 0.45 (0.24-0.83)	-
(Legler et al., 2011)	Multiple	SEER database	-	-	-	-	-	-	-	Emergency Room visit **9.3% v 6.7%** 1.26 (1.12-1.41) Inpatient admission **7.4% v 5.5%** 1.21 (1.05-1.40)

										Intensive Care Unit 1.1% v 0.9% 1.13 (0.81-1.59) Disenrollment from hospice **12.3% v 9.6%** 1.18 (1.05-1.32) Hospital death 1.3% v 1.6% 0.92 (0.7-1.21)
(Magaki et al., 2014)	Multiple	Academic medical centre	-	-	-	-	-	7% (6/86) had undiagnosed malignancies during autopsy [no control group]	-	-
(Miller et al., 2001)	Multiple	Geriatric drug use database	-	-	-	-	-	-	-	Hospice enrolment and hospitalization Cancer and dementia 1.05 (0.99-1.12) Cancer 0.9 (0.85-0.96) Dementia 1.02 (0.95-1.10)
(Miller et al., 2002)	Multiple	Geriatric drug use database	-	-	-	-	-	-	-	Hospice enrolment and treatment of daily pain Cancer and dementia 1.25 (0.91-1.71) Cancer 1.51 (1.14-2.00) Dementia 0.98 (0.64-1.51)

(Monroe et al., 2012)	Multiple	Nursing home residents		-	-	-	-	-	-		-	Dementia severity (cognitive performance scale) and opioid medication administration -0.44 p = 0.001 (spearman's rank correlation) Dementia severity and pain behaviour (discomfort behaviour scale) -0.28 p = 0.029 (spearman's rank correlation)
(Monroe et al., 2013)	Multiple	Nursing home residents		-	-	-	-	-	-		-	Hospice enrolment and pain medication administration 3.9 (1.1-14.0) = = 0.037 Severe stage of dementia and pain medication administration (controlling for hospice enrolment) 0.3 (0.1-0.8) p=0.030
(Raji et al., 2008)	Breast, colon and prostate	SEER register	Breast	22.7	7.5	I II III IV	**28** **34.6** **8** **6.7**	**50.7** **31.2** **5.8** **4.9**	-		-	-
			Colon	2.5	6.4	I II III IV	**15.8** **27.8** **18.6** **15.3**	**21.3** **32.9** **22.1** **17.2**	-		-	-
			Prostate	27.9	9.6	I II III IV	**24.3** **33.3** **2.2** **12.3**	**29.1** **50.2** **3.6** **7.5**	-		-	-
(Siegelman-Danieli et al.,	Breast	Academic medical		-	-	I II	**1** **5**	- -	-		-	-

2006)		centre			III IV	**6** **9**	- -					
(Tammemagi et al., 2003)	Lung	Tumor register for American city	-	-	-	-	-	Later or un-staged diagnosis 2.01 (1.18-3.43) ***0.3%*** (stage I-II) ***2.6%*** (stage III-IV or un-staged)	-	-		

* All values in this column are significantly different p<0.001; [A] All bold values p<0.001; [B] All bold and italicised values p<0.01; [$]comparison group had psychiatric disorders; OR odds ratio

Table 4 Mortality risk and cancer-dementia

Study	Cancer type	Participant setting	Date range included in analyses	Survival	Risk of Mortality in cancer-dementia compared to cancer alone or non-cancer controls
(Beydoun et al., 2015)	Lymphoma; Metastatic cancer; Non-metastatic cancer	Nationwide Inpatient Sample (35 US states)	2002-2012 Analyses presented here were on patients discharged in 2012	-	Lymphoma MR on discharge 1.05 (0.68-1.63) p=0.83 Metastatic cancer MR on discharge 1.72 (1.29-2.28) p< 0.001 Non-metastatic cancer MR on discharge 1.08 (0.85-1.38) p=0.51
(Bradley et al., 2008)	Multiple; main 17% colon/rectal	Nursing home residents: Michigan Tumor Registry	1996-2000 Follow up until death or Dec 2003	48% total sample had died within 3 months of cancer diagnosis	Risk of death within 3 months of diagnosis OR 1.33 (1.04-1.70) p = 0.026 Relative risk of death within 3 months of diagnosis RR 1.10 (1.01-1.2) p=0.030
(Baillargeon et al., 2011)	Colon	SEER database	1993-2005	Analyses restricted to patients who survived at least 6 months No other information available	All-cause HR 1.45 (1.40-1.50) Cancer-specific HR 1.41 (1.34-1.48) (Greater than risk from any other psychiatric illness)
(Chen et al., 2013)	Multiple; main 16.5% colorectal	Longitudinal Health Insurance Database: patients who visited	2000-2008 Follow-up of at	Accounted for 39.3% of deaths [highest of all co-morbid conditions and compared with 11.5% if no comorbidity]	HR 5.02 (2.77-9.09) p <0.001

		health care facility for cancer diagnosis	least 1 year		
(Daskivich et al., 2011)	Prostate	Two veteran hospitals	1997-2004	-	HR 2.9 (1.9-4.3) p<0.0001
(Erichsen et al., 2013)	Prostate	Danish Cancer Registry	1995-2010	0-1 years MR 1010 deaths per 1000 person-years 2-5 years MR 318 deaths per 1000 person years	interaction contrasts 0-1 years 538 deaths 2-5 years 72 deaths
(Louwman et al., 2005)	Breast (female)	Eindhoven Cancer Registry	1995-2001 Followed up until Jan 2004	At 70 years (crude survival) 1 year: 83% v 93% p<0.01 5 year: 27% v 68% p<0.01 (lower than even having 2 or more concomitant diseases – 35%)	HR 2.34 (1.6-3.5) p=0.0001
(Mohammadi et al., 2015)	AML, CML Myeloma	Swedish Cancer Registry	2002-2009 Followed until death, emigration or Dec 2012	Per 10 person years, dementia had higher rate of death than any other comorbidity whether cancer specific (all 3 types) or all-cause death	AML All-cause MRR 1.51 (0.97-2.33) AML specific MRR 1.75 (1.11-2.76) CML All-cause MRR 2.59 (1.28-5.26) CML specific MRR 1.19 (0.35-4.02) Myeloma All-cause MRR 1.61 (1.15-2.24) Myeloma specific MRR 1.87 (1.25-2.79)
(Ording, Cronin-Fenton, et al., 2013)	Breast (female)	Danish Cancer Registry	1994-2008 Followed until death, emigration	Interaction between breast cancer and dementia: Year 0-1: 148 deaths due to cancer and dementia (per 1000 person-years)	In first year of cancer diagnosis MRR 5.0 (3.6-6.8)

			or Dec 2011	Years 1-5: -7.6 (per 1000 person-years)	
(O'Rourke et al., 2008)	Oesophagus	Veteran hospital	1989-2003	-	HR 2.98 (1.35-6.60) (Other psychiatric illnesses did not predict shorter survival time)
(Patnaik et al., 2011)	Breast	SEER database	1992-2000 Follow up until death or Dec 2005	5-year survival rate 18.9% n= 168 (CI 16.4-21.6) compared to 74.9% if no comorbidities [not statistically analysed]	All-cause HR 1.96 (1.82-2.10) p <0.001

(Raji et al., 2008)	Breast, colon, prostate	SEER database	1994-1999 Follow up until death or Dec 2001	Breast Year 1 mortality Cancer specific: 3.8%(2.7-4.7) Year 1 mortality Non cancer 6%(4.8-7.3) Year 5 mortality Cancer specific: 4.8% (1.4-8.4) Year 5 mortality Non cancer 15.6% (11.2-20.2) Colon Year 1 mortality Cancer specific: 7.9%(5.8-10.1) Year 1 mortality Non cancer 7.7%(6.0-9.5) Year 5 mortality Cancer specific: 3.5% (-0.9-8.1) Year 5 mortality Non cancer 12.8%(8.4-17.4) Prostate Year 1 mortality Cancer specific: 0.8%(0.3-1.3) Year 1 mortality Non cancer 1.7%(1.0-2.5) Year 5 mortality Cancer specific: 2.8% (0.4-5.5) Year 5 mortality Non cancer 12.7%(8.4-17.2)	Breast Cancer specific HR 1.52 (1.37-1.68) Other causes HR 2.17 (2.03-2.32) Overall death HR 1.96 (1.85-2.07) Colon Cancer specific HR 1.44 (1.35-1.55) Other causes HR 1.80 (1.68-1.92) Overall death HR 1.56-1.72) Prostate Cancer specific HR 1.63 (1.47-1.81) Other causes HR 1.93 (1.81-2.06) Overall death HR 1.93 (1.83-2.04) (All analyses presented p<0.001)
(Tammemagi et al., 2003)	Bronchogenic lung	Jospehine Ford Cancer Tumor Registry	1995-1998	Median survival 0.12 years compared to overall 0.86 years (p<0.001) [over the five year follow-	HR 3.42 (2.24-5.23) p < 0.0001 [Univariate comorbidity]

		up]	
	Follow-up until Jan 2000		HR 1.10 (0.63-1.93 p=0.74 [adjusted for baseline co-variates, cancer treatment and all other comorbidities] Boostrap HR 3.74 (2.17-5.42) [adjusted for baseline co-variates]

Figure Captions

Figure 1 Flow diagram of studies included in this review

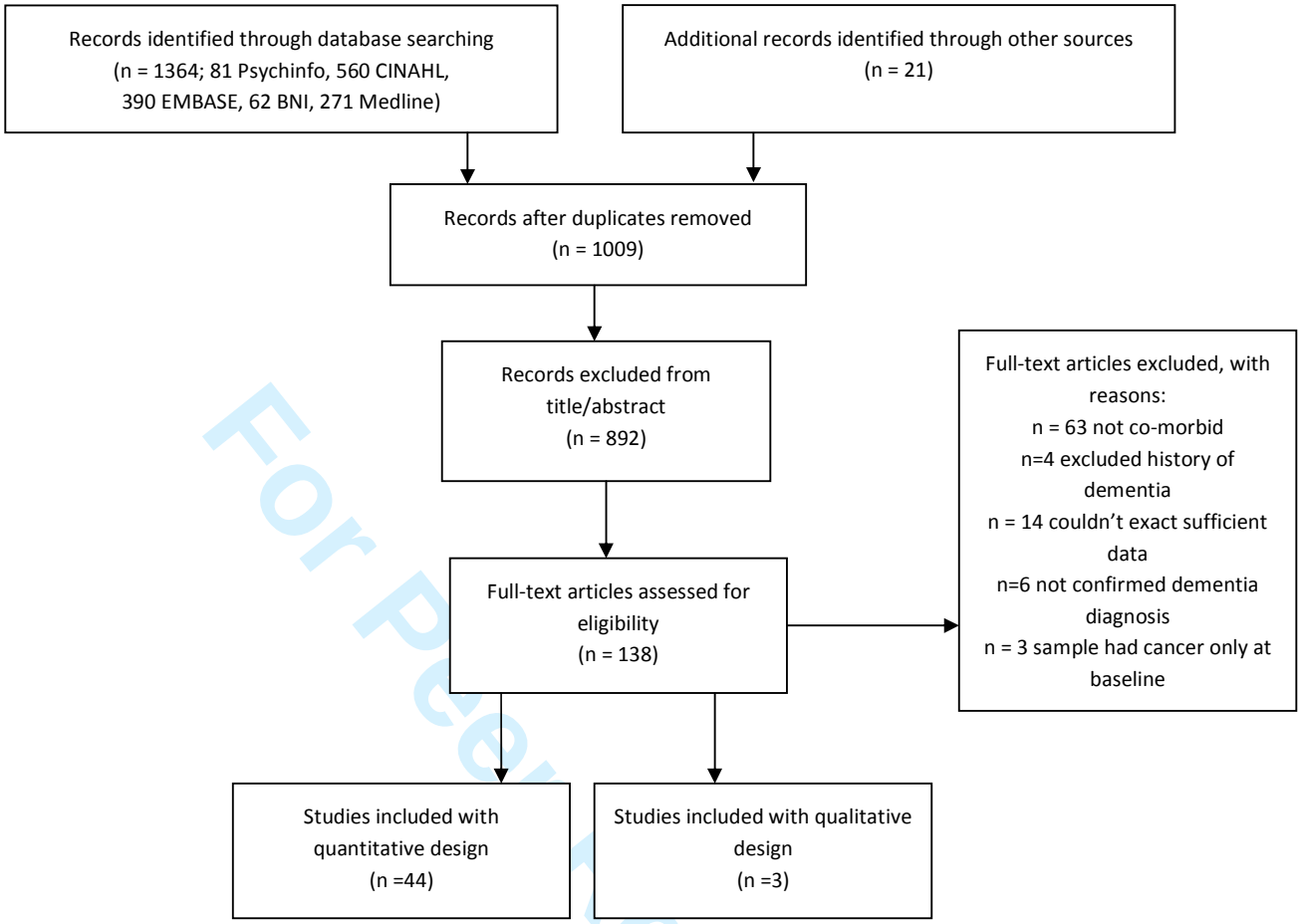

Figure 1 Flow diagram of studies included in this review