**Effect of opioids and benzodiazepines on clinical outcomes in patients receiving palliative care; an exploratory analysis**

***Short title:*** Impact of drug class on clinical outcomes

**Abstract**

**Background:** Medications used to manage symptoms in patients receiving palliative care have associated, but poorly understood, harms. Drug-related harms influence patients’ compliance.

**Objective:** To explore the longitudinal relationship between oral morphine equivalent daily dose (MEDD) and oral diazepam equivalent daily dose (DEDD) with cognitive and gastrointestinal symptoms, performance status, quality of life and survival in patients receiving palliative care.

**Design:** Secondary longitudinal analysis of cancer decedents (n=235) from a palliative care randomised controlled trial with multiple outcome measures. At each time-point MEDD and DEDD were calculated. Multilevel modelling was used to investigate independent associations between MEDD and DEDD, and cognitive and gastrointestinal symptoms, quality of life, performance status and survival.

**Setting/Subjects:** Participants were recruited from a specialist palliative care programme in Southern Adelaide, were expected to live ≥48 hours, had pain in the previous three months and a baseline Folstein Mini-Mental Status Examination score >25.

**Results:** Symptoms, performance status, and quality of life worsened over time. In the adjusted multilevel analysis statistically significant relationships remained between worsening performance status (MEDD, p=0.001; DEDD, p<0.001), gastro-intestinal effects (DEDD, p<0.001) and quality of life (MEDD, p<0.0.022).

**Conclusions:** Commonly used palliative medications were associated with deteriorating performance status. The lack of association between MEDD with gastrointestinal or cognitive symptoms underlines that these associations are not inevitable with close attention. This analysis highlights the importance of including other medications as confounders when exploring medication-related harms. An understanding of the risk-benefit balance of medications is needed to maximise net benefit for patients.

***Key words***

Opioids, benzodiazepines, palliative, cancer, symptoms, disease trajectory, survival, quality of life

**Background**

Patients accessing palliative care services receive many medications, each with benefits and harms.[1-4](#_ENREF_1) Drug-related harms may influence patients’ compliance even if there is benefit.[2](#_ENREF_2),[5-8](#_ENREF_5) Opioids and benzodiazepines are frequently prescribed and co-prescribed for symptom management but have toxicities such as gastrointestinal and cognitive impairment.[9-15](#_ENREF_9) Long-term opioids and benzodiazepines might be associated with poorer survival, although no causative link has been shown.[16-21](#_ENREF_16) Although the effect of opioids and benzodiazepines has been studied, the interaction between these drug classes on clinically important outcomes (such as gastrointestinal and cognitive symptoms, performance status, quality of life and survival) has not been assessed.[5](#_ENREF_5),[6](#_ENREF_6) Furthermore, toxicities have been previously explored at an individual medication-class level only.[5](#_ENREF_5),[6](#_ENREF_6)

**Aim**

To explore the longitudinal relationship between oral morphine equivalent daily dose (MEDD) and oral diazepam equivalent daily dose (DEDD) with cognitive impairment, gastrointestinal symptoms, performance status, quality of life (QoL) and survival in patients receiving palliative care.

**Methods**

**Study design**

This study is a secondary analysis of participants in the Palliative Care Trial.[22](#_ENREF_22),[23](#_ENREF_23) This was a prospective, 2x2x2 factorial, unblinded, cluster randomised controlled trial of academic detailing, educational outreach visits and case conferencing for palliative care patients with advanced disease and a history of pain.[22](#_ENREF_22),[23](#_ENREF_23) [5](#_ENREF_5) Inclusion criteria included: expected prognosis ≥48 hours, pain in the previous three months. Exclusion criteria included baseline Folstein Mini-Mental Status Examination score ≤24.[24](#_ENREF_24) All participants were reviewed at referral, fortnightly for 3 months, and then monthly until death. Medications and doses were recorded at each visit.[6](#_ENREF_6)

**Sample for this secondary data analysis**

Included participants had a diagnosis of cancer, symptom data recorded at baseline and at least 1 follow-up visit and a known date of death.

**Variables used in this secondary data analysis**

Data included in this secondary data analysis are shown in table 1.

Table 1: Data collected at baseline and follow-up

|  |
| --- |
| Baseline only:   1. Demographic data (date of birth, gender, marital status) 2. Diagnosis and date of diagnosis 3. Date of referral to specialist palliative care 4. Date and place of death   Baseline and at each follow-up assessment:   1. Assessment date 2. Functional assessment - Australian-modified Karnofsky Performance Status (AKPS) [25](#_ENREF_25) \* 3. Quality of life - McGill Quality of Life Scale (QoL) [26](#_ENREF_26) \*\* 4. Severity of symptoms – *gastrointestinal scores*: anorexia, dry mouth, constipation; and *cognitive score*: difficulty concentrating, confusion and hallucinations; and weight loss - Memorial Symptom Assessment Scale [27](#_ENREF_27) \*\*\* 5. Medications - the name, dose and frequency of all medications the patient was taking \*\*\*\* |

\*Australian-modified Karnofsky Performance Status (AKPS): 0-100, lower numbers indicate a reduced performance status.

\*\*McGill QoL scores range from 0-10, based on a mean across all domains assessed by the measure, with 0 representing the worst QoL.

\*\*\*The Memorial Symptom Assessment Scale asks patients to rate the severity of each symptom from 0-4, with 4 being the worst. The three gastrointestinal symptoms were pooled for analysis (score 0-12, 12 being the worst). The same was done for the three cognitive symptoms (score 0-12, 12 being the worst).

\*\*\*\* Medication use was measured by calculating the oral morphine equivalent daily dose (MEDD) and the oral diazepam equivalent daily dose (DEDD).

NB: weight loss was not considered a gastrointestinal symptom as it is multifactorial

**Oral morphine equivalent daily dose (MEDD) and oral diazepam equivalent daily dose (DEDD).**

**Calculation of oral equivalence daily dose**

The palliative care formulary equi-potency conversions to MEDD and DEDD was used for this analysis (Table 2).[28](#_ENREF_28) There is a range of MEDDs given for each fentanyl patch dose.[28](#_ENREF_28),[29](#_ENREF_29) A potency ratio of 150:1 for fentanyl:morphine was used. [28](#_ENREF_28) As the bioavailability of the benzodiazepines used in the study was ≥80% (except midazolam), oral and parenteral were considered equipotent.[28](#_ENREF_28) All benzodiazepine doses from the primary dataset were converted to DEDD at each timepoint for comparison.

Table 2: Opioid and benzodiazepine conversions used in this analysis for oral morphine equivalent daily doses (MEDD) and oral diazepam equivalent daily doses (DEDD)

|  |  |  |
| --- | --- | --- |
| **Opioid and route** | **Dose** | **Oral morphine equivalent** |
| Oral codeine | 100 mg | 10mg |
| Oral tramadol | 100 mg | 10mg |
| Oral oxycodone | 5 mg | 10mg |
| Subcutaneous morphine | 5 mg | 10mg |
| Oral methadone | 1 mg | 10mg |
| Epidural morphine | 0.1 mg | 10mg |
| Subcutaneous fentanyl | 0.07 mg | 10mg |

|  |  |  |
| --- | --- | --- |
| **Benzodiazepine** | **Dose** | **Oral diazepam equivalent** |
| Alprazolam | 2mg | 10mg |
| Clonazepam | 0.5mg | 10mg |
| Lorazepam | 1mg | 10mg |
| Midazolam (s/c) | 5mg | 10mg |
| Nitrazepam | 10mg | 10mg |
| Oxazepam | 30mg | 10mg |
| Temazepam | 20mg | 10mg |
| Zolpidem | 20mg | 10mg |

Midazolam was only administered s/c. The other benzodiazepines have approximate dose equivalence oral or s/c, thus the same conversion was used for both routes.

**All medications**

For all medications, unclear, ‘as required’, or documented doses were excluded. The route of administration was assumed to be oral unless stated otherwise. Where there was a range the lower dose was used.

**Data analysis**

Each clinical outcome variable was modelled separately with multilevel modelling techniques. A basic pattern of change over time was modelled; statistically significant fixed slope estimates were taken as evidence of a change over time. Individual multilevel models were then undertaken for each covariate to explore the association. For the primary analysis, to explore the effect of MEDD and DEDD on the clinical outcome variables, individual multilevel models were undertaken. The models were further controlled for covariates with a univariate association (p<0.10), along with age and gender. The statistical significance was tested with a t-test (estimate/standard error) and a p-value of <0.05. Key characteristics were compared using t-tests or chi-square tests. All analyses were undertaken on STATA SE (StataCorp.2015. Stata Statistical Software:Release-14. College Station,TX:StataCorp LP).

**Results**

Of the 461 trial participants,[22](#_ENREF_22),[23](#_ENREF_23) those with incomplete baseline measures (n=59), <1 set of follow-up measures (n=77), a non-cancer diagnosis (n=26) or no recorded date of death (n=64) were excluded leaving a final sample of 235 (Table 3), with 1433 study assessments.

Table 3: Characteristics of the participants

|  |  |
| --- | --- |
|  | Mean (sd), Median (Min, Max)  or n (%) |
| **Age** | 70.2 (12.0) |
| **Gender**  Male  Female | 117 (50%)  118 (50%) |
| **Marital Status**  Never married  Widowed  Divorced  Separated  Married/De Facto  Missing | 5 (2%)  51 (22%)  12 (5%)  5 (2%)  158 (67%)  10 (4%) |
| **Baseline** |  |
| AKPS | 63.3 (13.1), 60 (20, 90) |
| Quality of Life | 6.1 (1.9), 6 (0, 10) |
| Number of drugs | 7.2 (3.5), 7 (1, 22) |
| OME dose | 45.2 (114.5), 0 (0, 1280) |
| ODE dose | 1.1 (2.7), 0 (0, 15) |
| **Last study visit** |  |
| AKPS | 51.0 (15.7), 50 (10, 90) |
| Quality of Life | 4.9 (2.3), 5 (0, 10) |
| Number of drugs | 9.6 (3.9), 9 (2, 23) |
| OME dose | 121.4 (202.1), 40 (0, 1200) |
| ODE dose | 2.6 (6.3), 0 (0, 45) |
| **Place of Death** |  |
| Hospice | 86 (36.6) |
| Hospital | 69 (29.4) |
| Patient's own home | 34 (14.5) |
| Aged care facility | 17 (7.2) |
| Relative/close friend's home | 1 (0.4) |
| Missing/ Unknown | 28 (11.9) |

**Oral morphine equivalent daily dose (MEDD) and oral diazepam equivalent daily dose (DEDD).**

At baseline, 96 participants (41%) were taking opioids and 43 (18%) were taking benzodiazepines (19 (8%) were taking both). At the final assessment, 153 (65%) were taking opioids and 70 (30%) were taking benzodiazepines (49 (21%) were taking both).

MEDD increased (p<0.001) over the study 45.2 (114.5) mg to 121.4 (202.1) mg. DEDD increased (p<0.001) from baseline 1.1 (2.7) mg to final 2.6 (6.3) mg.

**Clinical outcome measures**

Univariable analyses are shown in Table 4.

**Cognitive symptom scores**

At baseline the mean cognitive score (0=no symptoms; 12=maximum possible score) was 0.6 (1.2) and increased to 1.2 (1.7) (p<0.001). Increased MEDD and DEDD, were not related to worsening cognition after adjustment (Table 5).

**Gastrointestinal symptom scores**

The mean gastrointestinal symptom score (0=no symptoms; 12=maximum possible score) increased over the study period (3.0 [2.4] baseline; 3.2 [2.2] last assessment (p<0.001). After adjustment, DEDD was associated but not MEDD (Table 5).

**Australian-modified Karnofsky Performance Status**

Mean baseline AKPS score (range 0-100; 0 being “dead”) of 63.3 (13.1) deteriorated to 51.0 (15.7) (p<0.001); a change from “self-caring with occasional assistance” to “considerable assistance and frequent medical care”.[25](#_ENREF_25) In the final model, worsening impairment of functional performance was associated with increasing MEDD and DEDD (Table 5).

**Quality of Life**

Mean McGill QoL scores (range 0-10; 0 being the worst) deteriorated from baseline (6.1 [1.9]) to last assessment (4.9 [2.3]; p<0.001). After adjustment, MEDD remained statistically significantly associated with worsening QoL, but not DEDD (Table 5).

**Time to death**

The mean survival from referral was 167.3 (SE 8.3) days. Once adjusted, higher MEDD and DEDD were not associated with shorter time to death (Table 5).

Table 4: Univariate estimates for covariates

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Cognitive symptom score** | | **Gastrointestinal symptom score** | | **AKPS** | | **QoL** | | **Time to death** | |
| **Covariate** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** |
| Age | 0.002 (0.003) | 0.319 | 0.009 (0.008) | 0.319 | -0.181 (0.031) | <0.001 | 0.002 (0.005) | 0.591 | -0.029 (0.468) | 0.951 |
| Gender (Female) | -0.212 (0.057) | <0.001 | 0.148 (0.208) | 0.478 | -33.388 (0.735) | <0.001 | 0.567 (0.104) | <0.001 | 16.308 (11.08) | 0.142 |
| Number of drugs | 0.014 (0.007) | 0.054 | 0.051 (0.018) | 0.005 | -0.857 (0.090) | <0.001 | -0.073 (0.013) | <0.001 | -12.486 (0.918) | <0.001 |
| AKPS | -0.026 (0.002) | <0.001 | -0.043 (0.004) | <0.001 |  |  | 0.059 (0.004) | <0.001 | 2.923 (0.204) | <0.001 |
| Quality of Life | -0.154 (0.013) | <0.001 | -0.281 (0.027) | <0.001 | 2.523 (0.158) | <0.001 |  |  | 13.639 (1.456) | <0.001 |
| Weight loss | 0.176 (0.029) | <0.001 | 0.717 (0.056) | <0.001 | -1.618 (0.347) | <0.001 | -0.521 (0.053) | <0.001 | 0.643 (3.042) | 0.833 |
| Time from assessment visit to death | -0.002 (0.001) | <0.001 | -0.002 (0.001) | <0.001 | 0.034 (0.003) | <0.001 | 0.003 (0.001) | <0.001 |  |  |
| Time from referral to assessment date | -0.001 (0.001) | 0.185 | 0.001 (0.001) | 0.151 | -0.001 (0.001) | 0.367 | -0.002 (0.001) | 0.468 |  |  |

The estimates are interpreted as the mean unadjusted absolute increase in score per unit increase in the covariate. Australian-modified Karnofsky Performance Status (AKPS), quality of life (QoL).

**Table 5: Multilevel models for Oral morphine equivalent daily dose (MEDD) and oral diazepam equivalent daily dose (DEDD)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Cognitive symptom score\*** | | **Gastrointestinal symptom score\*** | | **AKPS\*\*** | | **QoL\*\*\*** | | **Time to death\*\*\*\*** | |
|  | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** | **Estimate (SE)** | **p-value** |
| **MEDD**  Unadjusted  Adjusted  Adjusted plus DEDD | 0.001 (0.001)  0.001 (0.001)  0.001 (0.001) | **0.029**  0.721  0.730 | 0.001 (0.001)  0.001 (0.001)  -0.001 (0.001) | **<0.001**  0.753  0.791 | -0.015 (0.002)  -0.009 (0.002)  -0.009 (0.002) | **<0.001**  **<0.001**  **<0.001** | -0.002 (0.001)  -0.001 (0.001)  -0.001 (0.001) | **<0.001**  **0.022**  **0.022** | -0.079 (0.022)  -0.022 (0.023)  -0.022 (0.023) | **0.001**  0.334  0.332 |
| **DEDD**  Unadjusted  Adjusted  Adjusted plus MEDD | 0.015 (0.006)  0.002 (0.005)  0.001 (0.005) | **0.009**  0.777  0.786 | -0.008 (0.011)  -0.042 (0.011)  -0.042 (0.011) | 0.461  **<0.001**  **<0.001** | -0.501 (0.076)  -0.347 (0.071)  -0.354 (0.070) | **<0.001**  **<0.001**  **<0.001** | -0.037 (0.012)  -0.002 (0.011)  -0.002 (0.011) | **0.002**  0.871  0.823 | -1.381 (0.701)  0.295 (0.689)  0.314 (0.686) | **0.050**  0.669  0.648 |

The estimates are interpreted as the mean unadjusted absolute increase in score per unit increase in the covariate. \*Adjusted for age, gender, number of drugs, Australian-modified Karnofsky Performance Status (AKPS), quality of life (QoL), weight loss and time from assessment to death. \*\* Adjusted for age, gender, number of drugs, QoL, weight loss and time from assessment to death. \*\*\*Adjusted for age, gender, number of drugs, AKPS, weight loss and time from assessment to death. \*\*\*\* Adjusted for age, gender, number of drugs, AKPS and QoL. To assess for the interaction of drugs, MEDD and DEDD were each also adjusted for each other. Adjusted values which reached significance (p<0.05) are in bold.

**Discussion**

In this study of palliative care patients enrolled in a service delivery clinical trial, cognitive impairment, gastrointestinal symptoms, functional status, and QoL worsened towards death. Cognitive and gastrointestinal symptom scores were low throughout. Higher MEDDs and DEDDs were associated with deterioration of AKPS, higher MEDD was associated with reduction in quality of life and higher DEDD was associated with worse gastrointestinal symptoms. There was no association with survival.

In a study of palliative care patients in the last 2 days of life the median MEDD of 40 mg/d, was similar to those in this study.[30](#_ENREF_30) However, a group of unselected terminally ill cancer patients, the was higher (median DEDD, 10-25 mg/d), although this was the day before death.[30](#_ENREF_30),[31](#_ENREF_31)

The low cognitive symptom scores could be a feature of the trial eligibility (Folstein Mini-Mental Status Examination score >24) and may represent a selected group at lower risk of cognitive deterioration. An apparent relationship between cognitive impairmet and increased MEDD and DEDD, disappeared following adjustment; we understand little about the interplay between prescribed medications and the natural history of the disease itself.

A study of unselected opioid-treated people with cancer reported 15% with definite, and 18% possible cognitive dysfunction, associated with >400 mg/d MEDD; much higher doses than in our study.[32](#_ENREF_32) Perhaps MEDD or DEDD and cognitive symptoms were unrelated because the patient population was selected for better cognitive function, and/or the optimal dose monitoring in a trial context. Perhaps cognitive symptoms were under-estimated, although the item "difficulty concentrating", should detect even mild impairment. Opioids have been variably associated with cognitive impairment and delirium in cancer inpatients,[12](#_ENREF_12),[13](#_ENREF_13) and hallucinations [11](#_ENREF_11) or not [33](#_ENREF_33),[34](#_ENREF_34) depending on the population, opioid or assessment tool used.

DEDD and cognitive symptoms were not associated despite previously noted association with delirium.[12](#_ENREF_12),[13](#_ENREF_13) This may be due to a lower susceptibility or the low DEDD (<3mg). Elderly patients admitted to hospital with normal cognition have a lower risk of developing cognitive impairment.[15](#_ENREF_15) In elderly patients benzodiazepines were not associated with cognitive dysfunction in some studies,[35](#_ENREF_35),[36](#_ENREF_36) but were in another with larger doses; ≥5mg DEDD.[15](#_ENREF_15)

The worsening of gastrointestinal symptom scores was unlikely to be clinically relevant and maybe low in the trial context. DEDD was associated with gastrointestinal scores but not MEDD despite these being well-recognised side-effects.[11](#_ENREF_11),[14](#_ENREF_14),[37-40](#_ENREF_37) An unselected case note study showed an association with constipation,[37](#_ENREF_37) again suggesting these trial participants, with vigilant management, are not representative. Benzodiazepine associated constipation has been reported in the elderly in nursing homes.[41](#_ENREF_41)

AKPS was associated with an increasing MEDD and DEDD. Associations between opioid side-effects,[42](#_ENREF_42) and decreasing quality of life have been reported in non-cancer conditions,[7](#_ENREF_7),[43](#_ENREF_43),[44](#_ENREF_44) and benzodiazepine exposure was associated with decreasing functional status in older people.[45](#_ENREF_45) No study adjusted for the effect of other drugs nor had a control arm.

Once adjusted, MEDD or DEDD and time to death were unrelated. Previously reported associations were not adjusted for stage of disease or severity of pain.[19](#_ENREF_19),[46](#_ENREF_46) However duration and dose may be important to consider further.[47](#_ENREF_47) [21](#_ENREF_21) We saw no dose relationship, but average survival was under six months.

**Limitations**

This was an exploratory analysis. The trial eligibility criteria are likely to affect generalisability, particularly regarding cognitive impairment, gastrointestinal symptoms and opioid dose. Complete removal of the effect of pre-existing deteriorating performance was not possible.

**Future work**

A better understanding of drug-drug interactions is needed in unselected patients. Routine testing of cognitive function may identify a sub-group at greater risk of opioid or benzodiazepine related delirium and help target prevention.

**Conclusion**

Opioids and benzodiazepines were associated with deteriorating performance status and quality of life but not survival. DEDDs were associated with gastro-intestinal symptoms. Low cognitive scores may reflect the trial exclusion criteria.

Adjustment for other variables including other medications, stage of disease and severity of symptoms is important. A better understanding of the risk-benefit balance of medications, including drug-drug interactions, is needed to maximise net benefit for patients.

**Acknowledgments**

Patients who participated in this study and staff who ran the study.

**Funding**

Australian Department of Health and Ageing Palliative Care Branch as part of the National Palliative Care Strategy

**Declaration of Conflicting Interests**

The authors declare that there is no conflict of interest

**Ethics approval and consent to participate**

The Palliative Care Trial was approved by all relevant independent Human Research Ethics Committees. The trial was registered with the ISRCTN on 23rd July 2003 before the first participant was enrolled, trial registration number 81117481

[<http://www.controlled-trials.com/isrctn/trials/81117481/0/81117481.html>]. No further ethical approval was necessary for this secondary analysis of anonymised data [<http://www.hra.nhs.uk>].

As this was a secondary data analysis, it was not registered as a clinical trial.

**Availability of data and material**

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

**Authors' contributions**

JB drafted the initial manuscript. VA led on the statistical analysis. All authors contributed to the study design and were responsible for the writing and approval of the final report.

**Online supplement**

**Sensitivity analysis for those with a date of death compared with those who did not**

A sensitivity analysis was undertaken on the participants who had no date of death compared to those who had a date of death. The mean time from referral to last study assessment was shorter (141.4 [117.0] days) for those who had a date of death compared to those who did not (243.5 [176.5] days). On average, those without a date of death were in the study 102 days longer and had more study visits (5.1 [3.9], median 4 [2-12], max 25 *vs* 7.2 [5.4], median 6 [2-17], max 24; p<0.001). The age was similar (70.2 [12.0] *vs* 71.8 [11.5]; p=0.350). More men had a date of death (50% vs 44%) but this did not reach statistical significance. Those with a date of death had lower AKPS at their last assessment (51.0 [15.7] *vs* 61.7 [11.9]; p<0.01). The differences between the groups were consistent with participant survival to the end of the study rather than missing data regarding dates of death. Based on this, the inclusion criterion that participants without a date of death were excluded was retained.

**References**

1. Currow DC, Stevenson JP, Abernethy AP *et al*: Prescribing in palliative care as death approaches. *J Am Geriatr Soc* 2007, 55(4):590-595.

2. Todd A, Nazar H, Pearson H *et al*: Inappropriate prescribing in patients accessing specialist palliative day care services. *International journal of clinical pharmacy* 2014, 36(3):535-543.

3. Domingues D, Carneiro R, Costa I *et al*: Therapeutic futility in cancer patients at the time of palliative care transition: An analysis with a modified version of the Medication Appropriateness Index. *Palliat Med* 2015, 29(7):643-651.

4. Kuo A, Wyse BD, Meutermans W, Smith MT: In vivo profiling of seven common opioids for antinociception, constipation and respiratory depression: no two opioids have the same profile. *Br J Pharmacol* 2015, 172(2):532-548.

5. Agar M, Currow D, Plummer J *et al*: Changes in anticholinergic load from regular prescribed medications in palliative care as death approaches. *Palliat Med* 2009, 23(3):257-265.

6. Agar M, To T, Plummer J *et al*: Anti-cholinergic load, health care utilization, and survival in people with advanced cancer: a pilot study. *J Palliat Med* 2010, 13(6):745-752.

7. Salahudeen MS, Hilmer SN, Nishtala PS: Comparison of anticholinergic risk scales and associations with adverse health outcomes in older people. *J Am Geriatr Soc* 2015, 63(1):85-90.

8. Ferreira DH, Silva JP, Quinn S *et al*: Blinded Patient Preference for Morphine Compared to Placebo in the Setting of Chronic Refractory Breathlessness--An Exploratory Study. *J Pain Symptom Manage* 2016, 51(2):247-254.

9. Ahmedzai SH, Boland J: Constipation in people prescribed opioids. *BMJ Clin Evid (Online)* 2010, 2010.

10. Boland J, Boland E, Brooks D: Importance of the correct diagnosis of opioid-induced respiratory depression in adult cancer patients and titration of naloxone. *Clinical medicine* 2013, 13(2):149-151.

11. Wiffen PJ, Derry S, Moore RA: Impact of morphine, fentanyl, oxycodone or codeine on patient consciousness, appetite and thirst when used to treat cancer pain. *Cochrane Database Syst Rev* 2014, 5:CD011056.

12. Grandahl MG, Nielsen SE, Koerner EA *et al*: Prevalence of delirium among patients at a cancer ward: Clinical risk factors and prediction by bedside cognitive tests. *Nordic journal of psychiatry* 2016:1-5.

13. Senel G, Uysal N, Oguz G *et al*: Delirium Frequency and Risk Factors Among Patients With Cancer in Palliative Care Unit. *Am J Hosp Palliat Care* 2015.

14. Erichsen E, Milberg A, Jaarsma T, Friedrichsen M: Constipation in specialized palliative care: factors related to constipation when applying different definitions. *Support Care Cancer* 2016, 24(2):691-698.

15. Foy A, O'Connell D, Henry D *et al*: Benzodiazepine use as a cause of cognitive impairment in elderly hospital inpatients. *J Gerontol A Biol Sci Med Sci* 1995, 50(2):M99-106.

16. Boland JW, Foulds GA, Ahmedzai SH, Pockley AG: A preliminary evaluation of the effects of opioids on innate and adaptive human in vitro immune function. *BMJ Support Palliat Care* 2014, 4(4):357-367.

17. Boland JW, McWilliams K, Ahmedzai SH, Pockley AG: Effects of opioids on immunologic parameters that are relevant to anti-tumour immune potential in patients with cancer: a systematic literature review. *Br J Cancer* 2014, 111(5):866-873.

18. Afsharimani B, Cabot P, Parat MO: Morphine and tumor growth and metastasis. *Cancer Metastasis Rev* 2011, 30(2):225-238.

19. Boland JW, Ziegler L, Boland EG *et al*: Is regular systemic opioid analgesia associated with shorter survival in adult patients with cancer? A systematic literature review. *Pain* 2015.

20. Skipworth RJ, Moses AG, Sangster K *et al*: Interaction of gonadal status with systemic inflammation and opioid use in determining nutritional status and prognosis in advanced pancreatic cancer. *Support Care Cancer* 2011, 19(3):391-401.

21. Ekstrom MP, Bornefalk-Hermansson A, Abernethy AP, Currow DC: Safety of benzodiazepines and opioids in very severe respiratory disease: national prospective study. *Bmj* 2014, 348:g445.

22. Abernethy AP, Currow DC, Hunt R *et al*: A pragmatic 2 x 2 x 2 factorial cluster randomized controlled trial of educational outreach visiting and case conferencing in palliative care-methodology of the Palliative Care Trial [ISRCTN 81117481]. *Contemporary clinical trials* 2006, 27(1):83-100.

23. Currow DC, Abernethy AP, Shelby-James TM, Phillips PA: The impact of conducting a regional palliative care clinical study. *Palliat Med* 2006, 20(8):735-743.

24. Folstein MF, Folstein SE, McHugh PR: "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of psychiatric research* 1975, 12(3):189-198.

25. Abernethy AP, Shelby-James T, Fazekas BS *et al*: The Australia-modified Karnofsky Performance Status (AKPS) scale: a revised scale for contemporary palliative care clinical practice [ISRCTN81117481]. *BMC Palliat Care* 2005, 4:7.

26. Cohen SR, Mount BM, Strobel MG, Bui F: The McGill Quality of Life Questionnaire: a measure of quality of life appropriate for people with advanced disease. A preliminary study of validity and acceptability. *Palliat Med* 1995, 9(3):207-219.

27. Portenoy RK, Thaler HT, Kornblith AB *et al*: The Memorial Symptom Assessment Scale: an instrument for the evaluation of symptom prevalence, characteristics and distress. *Eur J Cancer* 1994, 30A(9):1326-1336.

28. Twycross RG, Wilcock A, Howard P: PCF5 : palliative care formulary; 2014.

29. Compendium eM: Durogesic DTrans 12 mcg/hr Transdermal Patch. 2015 [https://[www.medicines.org.uk/emc/medicine/17086]](http://www.medicines.org.uk/emc/medicine/17086%5d). Last accessed: 20/7/2016.

30. Morita T, Tsunoda J, Inoue S, Chihara S: Effects of high dose opioids and sedatives on survival in terminally ill cancer patients. *J Pain Symptom Manage* 2001, 21(4):282-289.

31. Radha Krishna LK, Poulose VJ, Goh C: The use of midazolam and haloperidol in cancer patients at the end of life. *Singapore medical journal* 2012, 53(1):62-66.

32. Kurita GP, Sjogren P, Ekholm O *et al*: Prevalence and predictors of cognitive dysfunction in opioid-treated patients with cancer: a multinational study. *J Clin Oncol* 2011, 29(10):1297-1303.

33. Van Arsdale A, Rosenbaum D, Kaur G *et al*: Prevalence and factors associated with cognitive deficit in women with gynecologic malignancies. *Gynecologic oncology* 2016, 141(2):323-328.

34. Barratt DT, Klepstad P, Dale O *et al*: Innate Immune Signalling Genetics of Pain, Cognitive Dysfunction and Sickness Symptoms in Cancer Pain Patients Treated with Transdermal Fentanyl. *PloS one* 2015, 10(9):e0137179.

35. Puustinen J, Nurminen J, Kukola M *et al*: Associations between use of benzodiazepines or related drugs and health, physical abilities and cognitive function: a non-randomised clinical study in the elderly. *Drugs & aging* 2007, 24(12):1045-1059.

36. van Vliet P, van der Mast RC, van den Broek M *et al*: Use of benzodiazepines, depressive symptoms and cognitive function in old age. *International journal of geriatric psychiatry* 2009, 24(5):500-508.

37. Clark K, Lam LT, Agar M *et al*: The impact of opioids, anticholinergic medications and disease progression on the prescription of laxatives in hospitalized palliative care patients: a retrospective analysis. *Palliat Med* 2010, 24(4):410-418.

38. Abramowitz L, Beziaud N, Labreze L *et al*: Prevalence and impact of constipation and bowel dysfunction induced by strong opioids: a cross-sectional survey of 520 patients with cancer pain: DYONISOS study. *Journal of medical economics* 2013, 16(12):1423-1433.

39. Oosten AW, Oldenmenger WH, Mathijssen RH, van der Rijt CC: A Systematic Review of Prospective Studies Reporting Adverse Events of Commonly Used Opioids for Cancer-Related Pain: A Call for the Use of Standardized Outcome Measures. *J Pain* 2015, 16(10):935-946.

40. Glare P, Walsh D, Sheehan D: The adverse effects of morphine: a prospective survey of common symptoms during repeated dosing for chronic cancer pain. *Am J Hosp Palliat Care* 2006, 23(3):229-235.

41. Fosnes GS, Lydersen S, Farup PG: Drugs and constipation in elderly in nursing homes: what is the relation? *Gastroenterology research and practice* 2012, 2012:290231.

42. Sloot S, Boland J, Snowden JA *et al*: Side effects of analgesia may significantly reduce quality of life in symptomatic multiple myeloma: a cross-sectional prevalence study. *Support Care Cancer* 2015, 23(3):671-678.

43. Mate KE, Kerr KP, Pond D *et al*: Impact of multiple low-level anticholinergic medications on anticholinergic load of community-dwelling elderly with and without dementia. *Drugs & aging* 2015, 32(2):159-167.

44. Ruxton K, Woodman RJ, Mangoni AA: Drugs with anticholinergic effects and cognitive impairment, falls and all-cause mortality in older adults: A systematic review and meta-analysis. *Br J Clin Pharmacol* 2015, 80(2):209-220.

45. Ried LD, Johnson RE, Gettman DA: Benzodiazepine exposure and functional status in older people. *J Am Geriatr Soc* 1998, 46(1):71-76.

46. Boland JW, Bennett MI: Opioids do not influence metastasis in experimental animal cancer models. *Pain* 2016, 157(5):1173.

47. Dev R, Hui D, Del Fabbro E *et al*: Association between hypogonadism, symptom burden, and survival in male patients with advanced cancer. *Cancer* 2014, 120(10):1586-1593.