**Additional file 1**

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# Appendix 1. MEDLINE search strategy

Database: Ovid MEDLINE(R) <1948 to April Week 23 2016>, Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations <April 21, 2016> Search Strategy:
--------------------------------------------------------------------------------
1 (perioperative or peri-operative).mp.
2 (preoperative or pre-operative).mp.
3 (preadmission or pre-admission).mp.
4 or/1-3
5 (geriatrics or geriatric).mp.
6 (elderly or senior? or (old adj age) or (older adj adult?)).mp.
7 Health Services for the Aged/
8 or/5-7
9 Geriatric Assessment/
10 assessment?.mp.
11 or/9-10
12 4 and 8 and 11
13 (animals not (humans and animals)).sh.
14 12 not 13

# Appendix 2. Order preference for combining data types in meta-analyses

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of Data** | **Example of Data Types** | **Pooling Preference Across Dichotomized Data** | **Pooling Preference Across All Data Types** |
| Raw Data | Sex, Presence of Absence of a Medical Disease | 2 | 3 |
| Unadjusted Odds Ratio | Sex, Presence of Absence of a Medical Disease | 3 | 4 |
| Adjusted Odds Ratio | Categorical or Continuous Data as Reported in a Multivariable Regression Model | 1 | 1 |
| Mean Difference | Age, Body Mass Index | Not applicable | 2 |
| Standardized Mean Difference | Combining Different Scales for Cognitive Impairment | Not applicable | 2 |

**Note:** Data reported as a mean difference or standardized mean difference was transformed into an odds ratio using the method of Sanchez-Meca et al., 2003, in the metafor package [1].

# Appendix 3. Data imputation methods

If only 95% confidence intervals were available to represent the variance of a mean value, the standard deviation was estimated as per the following equation [2]:

*Standard deviation = √number of patients in the group x (upper bound of the confidence interval – lower bound of the confidence interval)/(appropriate value from t-distribution x 2)*

Similar imputations were not conducted for hospital length of stay because the data distribution was likely to be right-skewed.

# Appendix 4. Cochrane risk of bias assessment for randomized trials

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Author, Year** | **Random sequence generation** | **Allocation concealment** | **Blinding of participants and personnel** | **Blinding of outcome assessment** | **Incomplete outcome data** | **Selective reporting** | **Other bias** |
| Papaioannou, 2005[3] | Low Risk | Unclear Risk | Unclear Risk | Unclear Risk | Low Risk | Low Risk | High Risk |
| Schmidt, 2015[4] | Low Risk | Unclear Risk | High Risk | High Risk | Low Risk | Low Risk | High Risk |

# Appendix 5. Newcastle-Ottawa scale for evaluating the quality of cohort studies

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Author, Year** | **Representative exposed cohort** | **Selection of the non- exposed cohort** | **Ascertainment of exposure** | **Demonstration that outcome of interest was not present at start of study** | **Comparability of cohorts on the basis of the design or analysis** | **Assessment of outcome** | **Follow-up long enough for outcomes to occur** | **Adequacy of follow up of cohorts** |
| Amemiya, 2007[5] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Audisio, 2008[6] | \* | \* | \* | \* | \*\* | \* | \* |   |
| Aykut, 2013[7] | \* | \* | \* | \* |   | \* |   |   |
| Badgwell, 2013[8] | \* | \* | \* | \* | \* | \* | \* | \* |
| Betomvuko, 2015[9] | \* | \* | \* | \* |   | \* | \* |   |
| Blakoe, 2015[10] | \* | \* | \* |   |   | \* |   | \* |
| Clement, 2011[11] | \* | \* | \* |   |   |   |   |   |
| Courtney-Brooks, 2012[12] | \* | \* | \* | \* |   | \* | \* |   |
| Dales, 1993[13] | \* | \* | \* | \* |   | \* |   |   |
| Dasgupta, 2009[14] | \* | \* | \* |   | \* | \* |   |   |
| Fukuse, 2005[15] | \* | \* | \* |   | \* |   | \* |   |
| Gerson, 1985[16] | \* | \* | \* | \* | \* | \* |   |   |
| Gerude, 2014[17] | \* | \* | \* | \* | \* | \* | \* |   |
| Goto, 2007[18] | \* | \* | \* | \* | \* | \* |   | \* |
| Green, 2012[19] | \* | \* | \* | \* | \*\* | \* | \* |   |
| Hoogerduijn, 2014[20] | \* | \* | \* | \* | \* | \* | \* | \* |
| Huisman, 2014[21] | \* | \* | \* | \* | \* | \* | \* |   |
| Javierre, 2012[22] | \* | \* | \* | \* |   | \* |   |   |
| Kenig, 2015[23] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Kim, 2013[24] | \* | \* | \* |   | \* | \* |   |   |
| Kim, 2014[25] | \* | \* | \* | \* | \*\* | \* |   | \* |
| Kim, 2016[26] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Kothari, 2011[27] | \* | \* | \* | \* |   | \* | \* | \* |
| Kristjansson, 2010[28] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Kwon, 2012[29] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Lasithiotakis, 2013[30] | \* | \* | \* | \* |   | \* | \* |   |
| Lawrence, 2004[31] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Legner, 2004[32] | \* | \* | \* | \* | \*\* |   | \* |   |
| Makary, 2010[33] | \* | \* | \* | \* | \* | \* | \* |   |
| Min, 2015[34] | \* | \* | \* | \* | \* | \* | \* | \* |
| Pirracchio, 2010[35] | \* | \* | \* | \* | \* | \* | \* |   |
| Reinohl, 2015[36] | \* | \* | \* | \* | \* | \* | \* |   |
| Robinson, 2012[37] | \* | \* | \* |   |   | \* |   |   |
| Rogers, 1989[38] | \* | \* | \* |   | \*\* | \* | \* | \* |
| Suh, 2014[39] | \* | \* | \* |   | \*\* | \* | \* | \* |
| Sundermann, 2014[40] | \* | \* | \* | \* | \* | \* | \* |   |
| Tamburino, 2011[41] | \* | \* | \* | \* | \* | \* | \* | \* |
| Tan, 2012[42] | \* | \* | \* | \* |   | \* | \* |   |
| van Venrooij, 2009[43] | \* | \* | \* | \* | \* | \* | \* |   |
| Wenaweser, 2011[44] | \* | \* | \* | \* | \*\* | \* | \* | \* |
| Williams, 2013[45] | \* | \* | \* | \* | \*\* | \* |   | \* |
| Zhang, 2012[46] | \* | \* | \* | \* |   | \* |   |   |

**Newcastle-Ottawa scale for evaluating the quality of cohort studies**

*Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.*

**Selection**

1. Representativeness of the exposed cohort

a) truly representative of the average older adult in the community **\***

b) somewhat representative of the average older adult in the community **\***

c) selected group of users (e.g., nurses, volunteers)

d) no description of the derivation of the cohort

2. Selection of the non-exposed cohort

a) drawn from the same community as the exposed cohort **\***

b) drawn from a different source

c) no description of the derivation of the non-exposed cohort

3. Ascertainment of exposure

a) secure record (e.g., surgical records) **\***

b) structured interview **\***

c) written self-report

d) no description

4. Demonstration that outcome of interest was not present at start of study

a) yes **\***

b) no

**Comparability**

1. Comparability of cohorts on the basis of the design or analysis

a) study controls for age\*

b) study controls for any additional factor (e.g., cognitive impairment, baseline comorbidities)**\***

**Outcome**

1. Assessment of outcome

a) independent blind assessment\*

b) record linkage\*

c) self-report

d) no description

2. Was follow-up long enough for outcomes to occur

a) yes (follow-up ≥2 days)\*

b) no

3. Adequacy of follow up of cohorts

a) complete follow up - all subjects accounted for\*

b) subjects lost to follow up unlikely to introduce bias - small number lost - < 10% or description provided of those lost\*

c) follow up rate <90% and no description of those lost

d) no statement

# Appendix 6. Table of characteristics of prospective studies reporting prognostic factors associated with postoperative complications among older adults undergoing elective surgery

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Study** | **Number of Patients** | **Age Range (years)** | **% Female** | **Type of Surgery** | **Exclusion Criteria at Baseline** | **Number of Patients with Complications** | **Complication(s)** |
|
| **N** | **%** |
| Audisio, 2008[6]  | 460 | 70-95 | 65.9 | Breast, gastro-intestinal, genitourinary, other | MMSE <18 | 171 | 37.8 | Wound infection, respiratory morbidity, nutritional problem, other |
| Aykut, 2013[7] | 48 | >70 | 54.2 | Cardiac | Severe cognitive impairment (MoCA <19) | NR | NR | Atelectasis, prolonged mechanical ventilation, pleural effusion, pneumothorax, diaphragmatic dysfunction, pneumonia, pneumothorax, spirometry |
| Clement, 2011[11] | 1343 | 80-93 | 59.2 | Orthopedic | Inflammatory conditions | NR | NR | Transfusion, confusion, pneumonia, UTI, myocardial infarction, admission to a high dependency unit, re-admission, infection of prosthesis, DVT |
| Courtney-Brooks, 2012[12] | 37 | 65-95 | 100 | Gynecologic | History of Parksinon's disease, history of prior stroke, MMSE ≤18, either sinemet or donepezil as a current medication, an inability to walk 15ft or a known neurologic disorder affecting grip strength | 10 | 27 | Superficial and deep incisional surgical site infection (SSI), organ/space SSI, wound dehiscence, pneumonia, unplanned intubation for respiratory/cardiac failure, PE, ventilator support >48h, progressive renal insufficiency, acute renal failure requiring dialysis, UTI, stroke, coma>24h, peripheral nerve injury, cardiac arrest requiring CPR, myocardial infarction, bleeding requiring >4 units PRBCs within the first 72h after surgery, graft/prosthesis/flap failure, DVT or sepsis |
| Dales, 1993[13] | 15 | ≥75 vs. <50 | NR | Thoracic | NR | 8 | 53.3 | Atelectasis, pneumonia, empyema, hemothorax, PE, air leak, effusion, mechanical ventilation ≥72hrs, bronchopleural fistula, tension pneumothorax, pCO2>50mmHg at 24hrs, lobar gangrene |
| Dasgupta, 2009[14] | 125 | 70-92 | 58 | Orthopedic, vascular, abdominal, neurosurgical | Day surgical procedures, active cancer (defined as having surgery for a possible malignancy or receiving treatment for cancer, undecided as to whether they would have surgery, no working understanding of English, not cleared for surgery for unstable medical reasons, enrolled in RCT of new pharmacologic agents | 31 | 24.8 | Cardiac or pulmonary complications, delirium |
| Fukuse, 2005[15] | 120 | 60-84 | 40 | Thoracic | NR | 20 | 16.7 | Prolonged air leak, persistent air leak for >7 days requiring intercostal drainage, chylothorax, delirium, arrhythmias, pneumonia, atelectasis, pyelothorax |
| Gerson, 1985[16] | 155 | ≥65 | 51 | Abdominal, noncardiac thoracic | Atrial fibrillation, surgery cancelled | 23 | 23 | Cardiac death, ventricular tachycardia, ventricular fibrillation, myocardial infarction, congestive heart failure |
| Gerude, 2014[17] | 67 | 75-93 | 46.3 | ENT | Inability to walk; inability to answer questions due to hearing, cognitive, or speech deficits; impossibility of undergoing anthropometric measurement | 30 | 44.8 | Pneumonia, UTI, cerebrovascular disease, myocardial infarction, wound infection, wound dehiscence, wound bleeding, salivary fistula |
| Goto, 2007[18] | 720 | ≥60 | 68.2 | Cardiac | NR | 22 | 3 | Stroke |
| Green, 2012[19] | 159 | ≥60 | 50 | Cardiac | NR | NR | NR | In-hospital life-threatening and major bleeding events |
| Huisman, 2014[21] | 280 | 70-96 | 65 | Gastrointestinal, genitourinary, breast, ENT, other | NR | 135 | 48.2 | Clavien-Dindo classification |
| Javierre, 2012[22] | 874 | <70 vs. ≥70 | 37.4 | Cardiac | NR | 86 | 9.8 | Myocardial infarction |
| Kenig, 2015[23] | 75 | 65-93 | 44 | Abdominal | Perionteal carcinomatosis, only explorative laparoscopy/laparotomy | 38 | 51 | NR |
| Kim, 2013[24] | 141 | NR | 39.9 | General, urological, gynecological, thoracic, breast, ophthalmologic, ENT | NR | NR | NR | Delirium, pressure ulcers, pneumonia, UTIs |
| Kim, 2014[25] | 275 | ≥65 | 45.1 | Abdominal | Low risk of adverse outcome from surgery according to the ACC/AHA 2007 guidelines | 29 | 10.5 | Pneumonia, urinary tract infection, delirium, pulmonary embolus, unplanned ICU admission |
| Kim, 2016[26] | 197 | ≥69 | 51 | Vascular, orthopedic, urological, gynecological, ENT, other | NR | 30 | 15.2 | NR |
| Kothari, 2011[27] | 60 | ≥70 | 46.7 | Thoracic | Institutionalized patients that are not appropriate surgical candidate | 8 | 13 | Major complications |
| Kristjansson, 2010[28]  | 182 | 70-94 | 57.1 | Colorectal | NR | NR | NR | Genitourinary, respiratory, cardiac, delirium, wound infection, intraabdominal abscess, anastomotic leakage, stroke, other |
| Lasithoiotakis, 2013[30] | 57 | 64.2-81.8 | 50.9 | Abdominal | Acute cholecystitis, jaundice, cholangitits, hydrops, empyema, or pancreatitis at the time of surgery | 13 | 22.7 | Fever, bleeding, reoperation, pancreatitis, subdiaphragmatic abscess, arrhythmia, atelectasis, pulmonary edema, UTI |
| Makary, 2010[33] | 594 | ≥65 | 41.9 | Intra-abdominal vs non-intra-abdominal | MMSE <18; history of Parkinson's disease or stroke; taking sinemet, donepezil, or antidepressants | NR | NR | NSQIP definitions |
| Papaioannou, 2005[3] | 47 | ≥60 | 36.2 | Orthopedic, urologic, vascular, gynecologic | Illiteracy, severe auditory or visual disturbances, central nervous system disorders, alcoholism or drug dependence, treatment with tranquillizers or antidepressants, Parkinson's disease, MMSE ≤23 | 13 | 27.6 | Wound disruptions, respiratory infections, PE, urinary retention, ileus, hyponatremia |
| Robinson, 2012[37]  | 186 | ≥65 | 4.3 | Abdominal, cardiac, non-cardiac thoracic, vascular | Sensory impairment precluding delirium assessment, non-English speaking | 59 | 32 | Cardiac, respiratory, renal, neurologic, infection, sepsis, DVT, reoperation |
| Suh, 2014[39] | 60 | 70-85 | 100 | Gynecologic, general | NR | 18 | 30 | Wound dehiscence, delirium, hemorrhage, infection, vomiting, ileus, pulmonary problem, bowel perforation, fistula, urinary retention, electrolyte imbalance, glaucoma, mortality |
| Tan, 2012[42] | 83 | 75-93 | NR | Colorectal | Parkinsonism or taking levodopa or antidepressants | 22 | 26.5 | Life threatening or requiring significant deviation from standard management |
| van Venrooij, 2009[43] | 100 | ≥65 | 35 | Cardiac | Not able to keep a 3-day food record, not Dutch speaking | 25 | 25 | Organ failure, bleeding, infection |
| Williams, 2013[45]  | 148 | ≥70 | 34 | Cardiac | Severe neuropsychiatric condition causing inability to cooperate with the study procedures; surgery cancelled | NR | NR | Stroke, renal failure, prolonged ventilation, deep sternal wound infection, reoperation |
| Zhang, 2012[46] | 100 | 60-85 | 35.9 | Noncardiac thoracic | NR | 67 | 67 | Atrial fibrillation, paroxysmal SVT, atrial/ventricular premature contraction, heart failure, sputum retention, hypoxemia, pulmonary air leak, atelectasis |

**Abbreviations:** ACC – American College of Cardiology; AHA – American Heart Association; ENT – otolaryngology; CPR – cardiopulmonary resuscitation;DVT – deep vein thrombosis; ICU – intensive care unit; MMSE – Mini–Mental State Examination; MoCA - Montreal Cognitive Assessment; NR – not reported; NSQIP – National Surgical Quality Improvement Program; PE – pulmonary embolism; PRBCs – packed red blood cells; RCT – randomized controlled trial; SSI - surgical site infection; SVT - Supraventricular tachycardia; UTI – urinary tract infection

# Appendix 7. Forest plots of study-level and pooled effect estimates for prognostic factors associated with postoperative complications among older adults undergoing elective surgery



**Figure 1.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a male patient (I2=66.24%).



**Figure 2.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient who smokes cigarettes (I2=0%).



**Figure 3.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with cognitive impairment (I2=0%).



**Figure 4a.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with frailty (I2=54.69%).



**Figure 4b.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with frailty undergoing abdominal surgery (I2=53.36%).



**Figure 5.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with polypharmacy (I2=0%).



**Figure 6.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with impairment in activities of daily living (I2=0%).



**Figure 7.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with impairment in instrumental activities of daily living (I2=0%).



**Figure 8.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with depressive symptoms as measured by the Geriatric Depression Screen (GDS) (I2=0%).



**Figure 9.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with diabetes mellitus (I2=0%).



**Figure 10.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with hypertension (I2=0%).



**Figure 11.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with a history of cerebrovascular disease (I2=83.39%).



**Figure 12a.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with a greater comorbidity score (I2=0%).



**Figure 12b.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with a greater Charlson comorbidity score (I2=0%).



**Figure 13.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient undergoing elective surgery under general anesthesia (I2=0%).



**Figure 14.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with ASA Score ≥3 (I2=0%).



**Figure 15.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with malnutrition (I2=31.02%).



**Figure 16.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with poor performance status (I2=0%).



**Figure 17.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with depression (I2=0%).



**Figure 18.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with poor mobility (I2=63.37%).



**Figure 19.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative complications in a patient with older age (I2=17.96%).

# Appendix 8. Forest plots of the study-level and pooled effect estimates of the prognostic factors associated with postoperative mortality among older adults undergoing elective surgery



**Figure 20.** Forest plot of the study-level effect measures and the summary effect measure for the odds of postoperative mortality in a male patient (I2=53.92%).



**Figure 21.** Forest plot of the study-level effect measures and the summary effect measure for the hazard ratio associated with postoperative mortality in a patient with diabetes mellitus (I2=45.26%).



**Figure 22.** Forest plot of the study-level effect measures and the summary effect measure for the hazard ratio associated with postoperative mortality in a patient with heart failure (I2=68.34%).

# Appendix 9. Forest plot of study-level and pooled effect estimates for prognostic factors associated with prolonged hospitalization among older adults undergoing elective surgery



**Figure 23.** Forest plot of the study-level effect measures and the summary effect measure for the odds of prolonged hospitalization associated with elective surgery in a patient with higher ASA score (I2=0%)

# Appendix 10. Forest plot of study-level and pooled effect estimates for prognostic factors associated with destination at discharge from hospital among older adults undergoing elective surgery



**Figure 24.** Forest plot of the study-level effect measures and the summary effect measure for the odds of not being discharged home following hospitalization for elective surgery in a patient with frailty (I2=67.46%).

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