**Supplementary Material**

Characteristics and risk factors of medication incidents across stages of medication management in residential aged care: A longitudinal cohort study of 5,700 reported incidents

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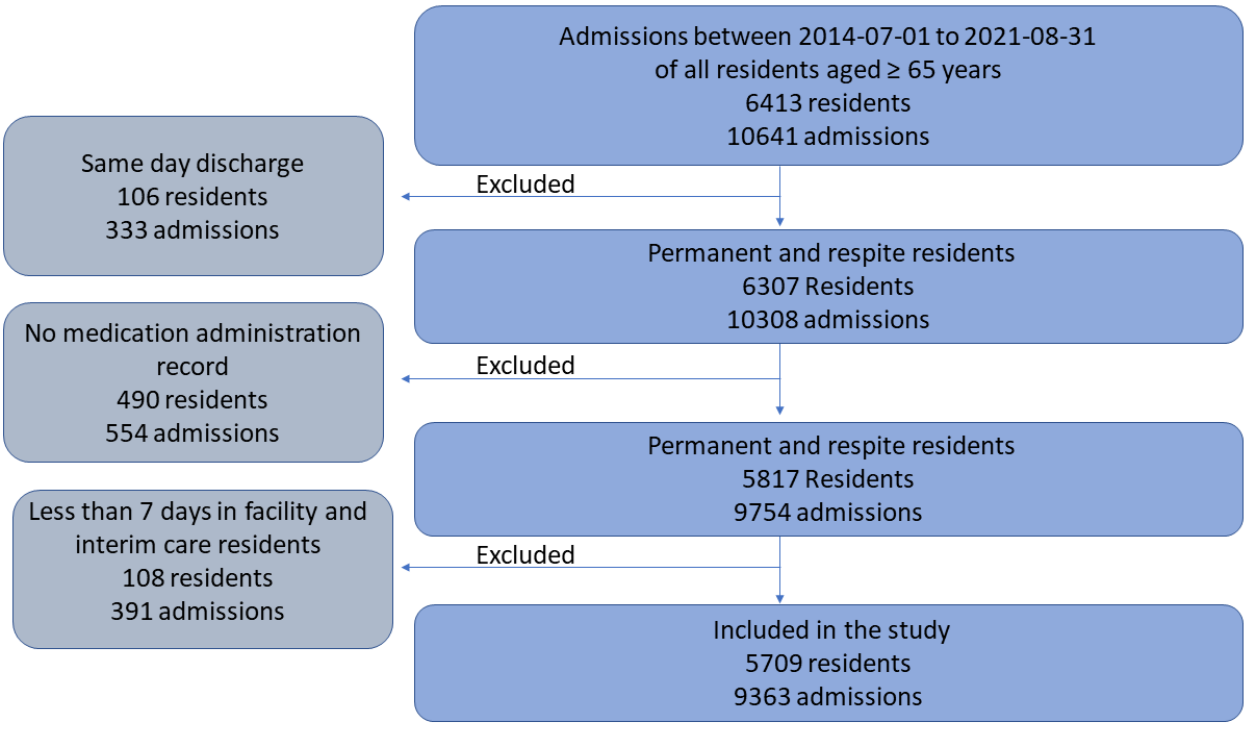
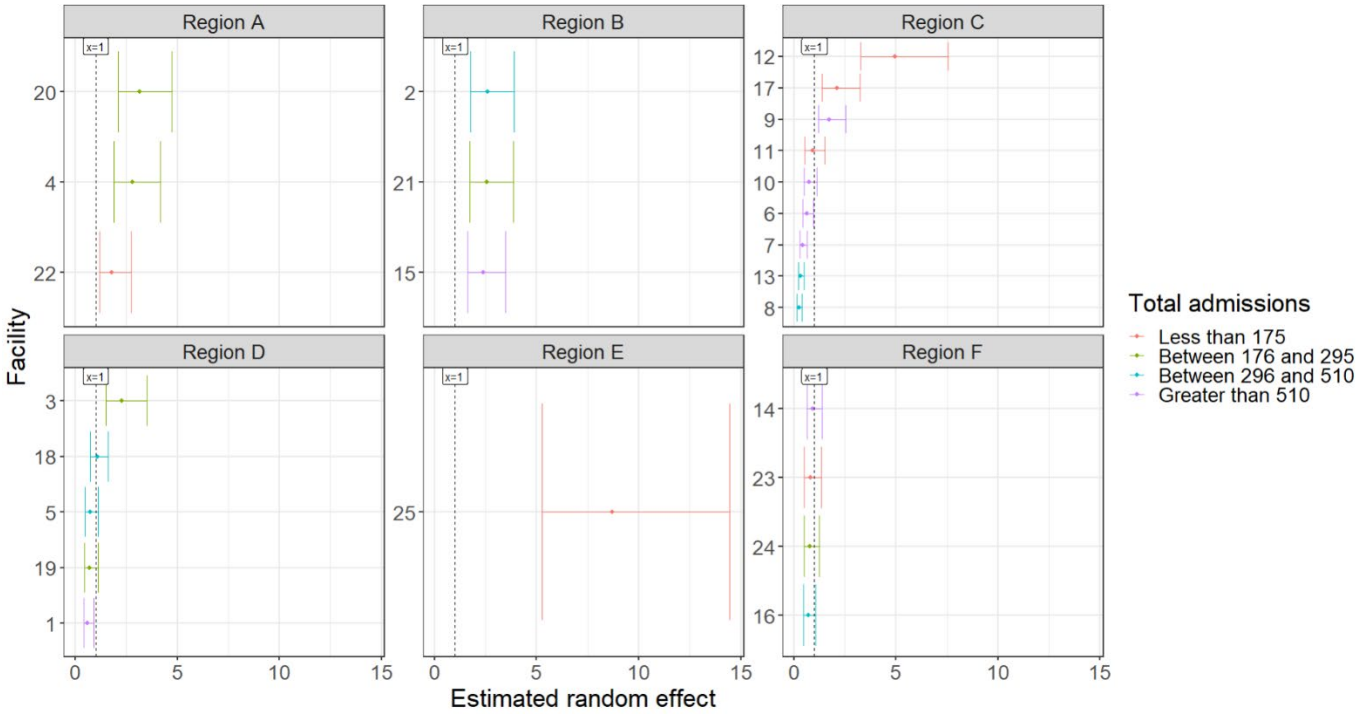



Supplementary Figure 1: Study sample selection




Supplementary Figure 2: Facility level variability extracted from the multilevel model (i.e. facility level random effect).

Supplementary Table 1: Initial classification system used for classifying medication incidents

| Initial coding structure of the incidents | Number of incidents |
|---|---|
| Other | 2188 |
| Pharmacy dispensing / labelling error | 974 |
| Medication not administered | 889 |
| Medication not administered but signed for | 479 |
| Medication administered but not signed for | 321 |
| Medication administered at wrong time /day | 175 |
| Wrong dose of correct medication administered | 166 |
| Medication system information error | 150 |
| Wrong medication administered | 141 |
| Medication administered to wrong person | 110 |
| Incorrect storage of medication | 56 |
| Missing patch cause unknown | 39 |
| Medication administered when allergy present | 18 |
| Time sensitive medication not administered on time | 2 |
| Grand Total | 5708 |

Supplementary Table 2: Definitions of the medication management stages used in the study

| Stage | Definition [a] |
|---|---|
| Prescribing of medication | Activities involved in transferring the intention to prescribe via a prescription or medicine order to others involved in the medication management cycle |
| Supply of medication | Process of issuing the correct medicine with appropriate labelling to ensure the person administering the medicine understands the prescriber's intent |
| Storage and accountability of medication | Stage of receiving and storing the medicine safely with accountability. |
| Administration of medication (including adverse drug reaction) | Process of confirming that the correct medicine has been administered as prescribed. |
| Monitoring of response to medication | The process of monitoring the response to the medicine; this includes self-monitoring by the patient and clinical monitoring by the health care professional |
| Providing consumer advice and information related to the medication | Providing appropriate information to the patient and care professional about the medicine, including how to store and use it properly |

[a] Definitions were adopted from *Australian Pharmaceutical Advisory Council. Guiding principles to achieve continuity in medication management. Commonwealth Department of Health and Ageing, Canberra. 2005*.

Supplementary Table 3: Frequency of incident types reported within different stages of the medication management cycle.

| **Stage of the medication cycle and incident types** | **Frequency** | **Percentage (%)** |
|---|---|---|
| Administration of medication | 3023 | 53.0 |
| Omitted medication | 1494 | 49.4 |
| Documentation of administration absent or incorrect (new) | 496 | 16.4 |
| Delayed dose | 201 | 6.6 |
| Other medication administration incident | 193 | 6.4 |
| Wrong dose | 178 | 5.8 |
| Wrong medication administered | 143 | 4.7 |
| Wrong resident identification | 115 | 3.8 |
| Duplicate medication administered | 47 | 1.6 |
| Medication administered without an order | 30 | 1.0 |
| Expired medication or vaccine administered | 23 | 0.8 |

| | | |
|---|---|---|
| Medication administered despite known allergy or previous reaction | 22 | 0.7 |
| Incorrect self-administration by resident | 17 | 0.6 |
| Wrong frequency / rate | 17 | 0.6 |
| Diverted / attempted to divert medication | 14 | 0.5 |
| Wrong method of preparation | 11 | 0.4 |
| Wrong strength | <10 | |
| Wrong route | <10 | |
| New / unanticipated adverse drug reaction | <10 | |
| Wrong / omitted user applied labelling (new) | <10 | |
| Wrong formulation | <10 | |
| Wrong device / device setting | <10 | |
| Inadequate documentation of a known adverse drug reaction (new) | <10 | |
| Medication administered despite known allergy or previous reaction | <10 | |
| Supply of medication | 1546 | 27.1 |
| Pharmacy dispensing / labelling error | 974 | 63.0 |
| Failure to order / maintain stock of medication | 340 | 22.0 |
| Delayed or not dispensed | 73 | 4.7 |
| Wrong quantity | 45 | 2.9 |
| Other medication supply incident | 42 | 2.7 |
| Wrong method of supply | 13 | 0.8 |
| Unauthorised supply of medication (new) | 10 | 0.6 |
| Wrong dose | <10 | |
| Wrong medication | <10 | |
| Omitted medication | <10 | |
| Wrong / omitted medication label | <10 | |
| Wrong frequency / rate | <10 | |
| Manufacturer / supplier shortage - no alternative available (new) | <10 | |
| Wrong formulation | <10 | |
| Wrong resident identification | <10 | |
| Expired medication supplied | <10 | |
| Wrong strength | <10 | |
| Expiry date omitted | <10 | |
| Incorrect storage of medication | <10 | |
| Monitoring of response to medication | 548 | 9.6 |
| Delay or failure to monitor | 481 | 87.8 |
| Failure to discontinue treatment | 39 | 7.1 |
| Missing patch cause unknown | 15 | 2.7 |
| Failure to follow up | <10 | |

| | | |
|---|---|---|
| Other medication monitoring incident | <10 | |
| Storage and accountability of medication | 254 | 4.4 |
| S8 / rs4(dda) count incorrect | 142 | 55.9 |
| Incorrect storage of medication | 89 | 35.0 |
| S8 / rs4(dda) count omitted | 19 | 7.5 |
| Storage of resident's own medication (new) | <10 | |
| Consumer advice and information - medication | 220 | 3.9 |
| Medicine profile error (new) | 154 | 70.0 |
| Delay or failure to transfer information | 40 | 18.2 |
| Transcription error | 21 | 9.5 |
| Other medication advice incident | <10 | |
| Prescribing of medication | 117 | 2.1 |
| Transcription error | 35 | 29.4 |
| Invalid or incomplete order | 23 | 19.3 |
| Wrong dose | 16 | 13.4 |
| Medication not prescribed or charted | 14 | 11.8 |
| Wrong frequency / rate | 10 | 8.4 |
| Medication prescribed to resident with known allergy or adverse reaction | <10 | |
| Other medication prescribing incident | <10 | |
| Medication prescribed when contraindicated due to medication interaction (new) | <10 | |
| Wrong medication | <10 | |
| Wrong route | <10 | |
| Wrong formulation | <10 | |
| Wrong resident identification | <10 | |
| Wrong quantity | <10 | |

Supplementary Table 4: Reported incidents for most common incident types

| Stage | Incident type | Incident number | Example |
|---|---|---|---|
| Administration of medication | Omitted medication | 226158 | During the morning medication I found that Tab Oxycontin 15mg for Saturday morning dose. But other tablets were administered. |
| | | 238048 | Medication was left on the sink as per resident's request. Informed by RN that medication was not taken. |
| | Documentation of administration absent or incorrect | 482798 | Unsure whether non packed medications were administered. as not signed for. |
| | | 631495 | Accidently sign in for medicines (Midazolam, Serenace, Morphine), medicines not given to the resident, nil impact on a resident |

| | | | |
|---|---|---|---|
| | Delayed dose | 839010 | Carer accidently gave bed time medication which are Targin 15/7.5mg and Laxative + Senna at dinner time. |
| | | 1121220 | Insulin administered post lunch instead of after breakfast. |
| Supply of medication | Pharmacy dispensing / labelling error | 947963 | Identified by RN checking that the pharmacy has packed frusemide BD twice appearing in both blisters number 1 of 5 and 2 of 4. |
| | | 914359 | Tambocor 100 mg tablet was not packed in today's 0800 column however, it was packed for other days. |
| | Failure to order / maintain stock of medication | 1011090 | Insulin not ordered therefore unable to give prescribed dose |
| | | 969072 | RN did not order Exelon patch on time as it was ordered at 1540 on 05/04/20 and delivered next day evening time. Due to this unable to apply patch on 06/04/20 AM. |
| | Delayed or not dispensed | 1147241 | Pharmacy have not supplied the medication in time. Pharmacist stated they have not received the medication chart . But according to progress note from 21/1/21 . Medication chart was faxed to pharmacy. |
| | | 980335 | Pharmacy unable to supply oxytrol patch since 21/3/2020 |
| Monitoring of response to medication | Delay or failure to monitor | 1110158 | Resident transdermal patch was dislodged and found in the bed. |
| | | 1104686 | Norspan patch was missing when checked. |
| | Failure to discontinue treatment | 312388 | Medication administered when supposed to be withhold. |
| | | 582149 | Medication administered by staff but ceased on medication chart |
| | Missing patch cause unknown | 1220014 | Patch is due to be changed today, yesterday being the 6th day. It was checked on 2/5 but gone missing when checked on 3/5. Aggressive incident raised by staff on 2/5 when .... was being assisted with ADLs - unknown whether this has correlation to the loss. No previous loss recorded when ... was on 2 patches (25 mcg and 5 mcg). |
| | | 1268520 | Patch checked BD, but found missing when checked in the morning. Re-applied the patch after clean the skin. Continue with BD norspan patch. |
| Storage and accountability of medication | S8 / rs4(dda) count incorrect | 239290 | S8 Dilaudid Liquid count incorrect. Facility Manager and Clinical Leader reviewed S8 books. Error 18/02/2015 where count was documented incorrectly by 9mls. Error 23/03/2015 where count was documented incorrectly by 19mls. 02/07/2014 count by |

| | | | |
|---|---|---|---|
| | | | Pharmacy incorrect by 55mls. 15/04/2014 incorrect count attributed as above, plus RN advised the S8 bottle was found in the cupboard leaking 23/03/2015 |
| | | 443648 | Incorrect balance of S8 medication with actual balance. As RNs where taking out the medication, the imbalance was noted. Earlier at handover, the night RN stated that no pain relief had been provided during the night. |
| | Incorrect storage of medication | 450524 | S8 drug was packed on its own, but was found in the medication trolley. |
| | | 707246 | Medication to be refrigerated. Medication found in Treatment Room on shelf inside dining room not in fridge. Medication clearly marked with large sticker stating, "Refrigerate". |
| | S8 / rs4(dda) count omitted | 450797 | Care staff reported that the tablet from Thursday was missing/ punched out. Resident only has 2 tablets, 1tablet at breakfast and 1 tablet at bedtime |
| | | 496027 | S8 checked this evening 03/09/2017 AT 2000 with RN found only 79 tablets of endone 5mg 1/2 tab in the blister instead of 80. |
| Consumer advice and information - medication | Medicine profile error (new) | 266118 | Nil wrong medications were given, pharmacy error was picked up before by RN. Spoke with pharmacy regarding the issue of x2 respite admissions and medication profiles not matching. Mrs ..... profile was not sent to be linked and Mr ..... profile was coming up with Mrs .... medications. RN is administering medications to both respite residents as per med chart until pharmacy update medication profiles. |
| | | 410010 | Medication (Lorstat) packed as 2 tablets for Saturday dinner round but resident is only charted for 1 tablet. Oxybutynin 5mg charted as 5mg daily but system indicates to give half a tablet only. |
| | Delay or failure to transfer information | 758904 | INR result 2.3 instructed to withheld at dinner time dose. medication has already administered before informing the carer or nurse. |
| | | 887388 | Resident returned from speacilaist appointment 14/08/19 with medication change that was not followed through. Notes on 14/08 indicate pharmacy and LMO faxed. |

| | | | |
|---|---|---|---|
| | Transcription error | 392946 | Pharmacy have entered in 10mg/ml Lexapro which does not match either primary chart or medication supplied by pharmacy |
| | | 561227 | pharmacy did not allocate the time for movical, therefore medication did not appear on mobile APP |
| Prescribing of medication | Transcription error | 1019537 | Dr …. changes to the old PMC which does not reflect current med chart. |
| | | 1170313 | GP charted all his medication while discharged from hospital but not ceased old order. |
| | Invalid or incomplete order | 577606 | Medication order not signed by LMO |
| | | 1033263 | Dr …. crossed psychotropic medication on the medication chart, without stop date and any documentation onto progress notes. Also Dr did not communicate medication changes he attended to the RN on duty |
| | Wrong dose | 1255211 | Frusmide charted twice in medication chart and informed Dr ….. and adjusted, emailed to pharmacy |
| | | 1265814 | Dr has double entries for insulin directions. Dr emailed to amend and cease one entry for each dosage. |

Supplementary Table 5: Medication incidents that required resident to be treated or monitored by hospital, GP or staff.

| | Impact on resident | | | |
|---|---|---|---|---|
| Stage | Resident sent to hospital for treatment / monitoring | Resident required GP attention | Resident required monitoring by staff | Total |
| **Administration of medication** | **13** | **76** | **453** | **542** |
| Omitted medication | 3 | 34 | 181 | 218 |
| Wrong resident identification | 2 | 9 | 59 | 70 |
| Wrong medication administered | 5 | 4 | 61 | 70 |
| Wrong dose | 2 | 13 | 51 | 66 |
| Delayed dose | | 3 | 36 | 39 |
| Duplicate medication administered | | 6 | 12 | 18 |
| Other medication administration incident | | 1 | 16 | 17 |
| Medication administered despite known allergy or previous reaction | 1 | 3 | 10 | 14 |

| | | | | |
|---|---|---|---|---|
| Documentation of administration absent or incorrect (new) | | | 9 | 9 |
| Medication administered without an order (new) | | 1 | 6 | 7 |
| Incorrect self administration by resident | | 2 | 4 | 6 |
| Wrong frequency / rate | | | 4 | 4 |
| Wrong route | | | 1 | 1 |
| Wrong strength | | | 1 | 1 |
| Inadequate documentation of a known adverse drug reaction (new) | | | 1 | 1 |
| New / unanticipated adverse drug reaction | | | 1 | 1 |
| **Supply of medication** | **2** | **23** | **74** | **99** |
| Pharmacy dispensing / labelling error | 2 | 14 | 33 | 49 |
| Failure to order / maintain stock of medication | | 4 | 23 | 27 |
| Delayed or not dispensed | | 3 | 11 | 14 |
| Wrong medication | | 2 | 1 | 3 |
| Other medication supply incident | | | 2 | 2 |
| Wrong frequency / rate | | | 1 | 1 |
| Wrong quantity | | | 1 | 1 |
| Wrong / omitted medication label | | | 1 | 1 |
| Unauthorised supply of medication (new) | | | 1 | 1 |
| **Monitoring of response to medication** | | **9** | **49** | **58** |
| Delay or failure to monitor | | 6 | 36 | 42 |
| Failure to discontinue treatment | | 2 | 12 | 14 |
| Other medication monitoring incident | | | 1 | 1 |
| Failure to follow up | | 1 | | 1 |
| **Consumer advice and information - medication** | | **3** | **9** | **12** |
| Delay or failure to transfer information | | 3 | 7 | 10 |
| Medicine profile error (new) | | | 2 | 2 |
| **Storage and accountability of medication** | | **1** | **5** | **6** |
| S8 / rs4(dda) count incorrect | | | 3 | 3 |
| Incorrect storage of medication | | 1 | 1 | 2 |
| Storage of resident's own medication (new) | | | 1 | 1 |
| **Prescribing of medication** | | **3** | **4** | **7** |
| Wrong dose | | 2 | | 2 |
| Wrong route | | | 1 | 1 |
| Transcription error | | | 1 | 1 |
| Medication not prescribed or charted | | | 1 | 1 |
| Invalid or incomplete order | | 1 | | 1 |
| Medication prescribed to resident with known allergy or adverse reaction | | | 1 | 1 |
| **total** | **15** | **115** | **594** | **724** |

Supplementary Table 6: Temporal patterns in reported medication incidents

| Characteristic | Overall, N = 5,708[a] | Administration of medication, N = 3,023[a] | Supply of medication, N = 1,546[a] | Monitoring of response to medication, N = 548[a] | Storage and accountability of medication, N = 254[a] | Consumer advice and information - medication, N = 220[a] | Prescribing of medication, N = 117[a] |
|---|---|---|---|---|---|---|---|
| **Days of the week** | | | | | | | |
| Monday | 849 (15%) | 448 (15%) | 261 (17%) | 73 (13%) | 28 (11%) | 21 (9.5%) | 18 (15%) |
| Tuesday | 842 (15%) | 461 (15%) | 206 (13%) | 95 (17%) | 27 (11%) | 23 (10%) | 30 (26%) |
| Wednesday | 936 (16%) | 524 (17%) | 239 (15%) | 76 (14%) | 42 (17%) | 40 (18%) | 15 (13%) |
| Thursday | 910 (16%) | 468 (15%) | 272 (18%) | 68 (12%) | 44 (17%) | 38 (17%) | 20 (17%) |
| Friday | 856 (15%) | 446 (15%) | 229 (15%) | 87 (16%) | 47 (19%) | 31 (14%) | 16 (14%) |
| Saturday | 679 (12%) | 358 (12%) | 169 (11%) | 72 (13%) | 37 (15%) | 33 (15%) | 10 (8.5%) |
| Sunday | 636 (11%) | 318 (11%) | 170 (11%) | 77 (14%) | 29 (11%) | 34 (15%) | 8 (6.8%) |
| **Time of the day** | | | | | | | |
| Morning (6 am to 11:59 am) | 2,492 (44%) | 1,239 (41%) | 734 (47%) | 313 (57%) | 75 (30%) | 96 (44%) | 35 (30%) |
| Afternoon (12:00pm to 5:59 pm) | 1,894 (33%) | 1,080 (36%) | 465 (30%) | 144 (26%) | 98 (39%) | 65 (30%) | 42 (36%) |
| Evening (6:00 pm to 11:59 pm) | 1,144 (20%) | 633 (21%) | 296 (19%) | 79 (14%) | 70 (28%) | 48 (22%) | 18 (15%) |
| Night (12:00 am to 5:59 am) | 178 (3.1%) | 71 (2.3%) | 51 (3.3%) | 12 (2.2%) | 11 (4.3%) | 11 (5.0%) | 22 (19%) |

Supplementary Table 7: Univariable model which included random intercepts for facility and resident level along with offset for length of stay

| Variable | Rate | Standard error | 95% CI | p-value | Included in the multivariable model and for stepwise elimination |
|---|---|---|---|---|---|
| *Demographics* | | | | | |
| **Entry type: Respite** | **1.406** | **0.063** | **(1.243, 1.590)** | **<0.01** | * |
| Gender: Male | 0.948 | 0.052 | (0.856, 1.051) | 0.311 | * |
| **Age at admission** | **0.986** | **0.003** | **(0.980, 0.993)** | **<0.01** | * |
| *Comorbidities* | | | | | |
| **Circulatory disease, any** | **1.204** | **0.076** | **(1.036, 1.398)** | **0.015** | * |
| **Cerebrovascular accident** | **1.15** | **0.055** | **(1.032, 1.282)** | **0.012** | * |
| **Endocrine, any** | **1.239** | **0.05** | **(1.123, 1.367)** | **<0.01** | * |
| **Diabetes** | **1.253** | **0.055** | **(1.124, 1.396)** | **<0.01** | * |
| Thyroid disorder | 1.072 | 0.076 | (0.923, 1.244) | 0.364 | * |
| **Chronic respiratory disease** | **1.203** | **0.062** | **(1.065, 1.359)** | **0.003** | * |
| Neoplasms/cancer | 1.065 | 0.053 | (0.959, 1.182) | 0.237 | * |
| **Dementia** | **0.819** | **0.049** | **(0.745, 0.902)** | **<0.01** | * |
| **Parkinson's disease** | **1.723** | **0.095** | **(1.430, 2.076)** | **<0.01** | * |
| **Depression, mood & affective disorders** | **1.214** | **0.049** | **(1.102, 1.337)** | **<0.01** | * |
| **Anxiety & stress-related disorders** | **1.202** | **0.052** | **(1.085, 1.332)** | **<0.01** | * |
| **PUD & GORD** | **1.188** | **0.052** | **(1.073, 1.315)** | **<0.01** | * |
| Renal disease | 1.096 | 0.063 | (0.969, 1.239) | 0.144 | * |
| Arthritis | 1.063 | 0.05 | (0.964, 1.172) | 0.217 | * |
| Osteoporosis | 0.964 | 0.054 | (0.867, 1.073) | 0.507 | * |
| Gout | 1.104 | 0.094 | (0.919, 1.327) | 0.288 | * |
| **History of fracture** | **1.111** | **0.051** | **(1.004, 1.228)** | **0.041** | * |
| Hearing impairment | 0.898 | 0.057 | (0.803, 1.003) | 0.057 | * |
| Visual impairment | 0.915 | 0.064 | (0.807, 1.038) | 0.167 | * |
| **Number of comorbidities** | **1.07** | **0.011** | **(1.047, 1.094)** | **<0.01** | |
| **Number of days with more than 5 medications** | **1.894** | **0.012** | **(1.824, 1.968)** | **<0.01** | * |

Supplementary Table 8: Observed Medication incident rates (per 1000 resident days) reported by entry type

| Incident type | Observed IR (per 1000 resident days) | |
|---|---|---|
| | Entry type | |
| | Permanent | Respite |
| All medication incidents | 1.700 (1.650, 1.750) | **2.610 (2.350, 2.870)** |
| Administration of medication | 0.882 (0.848, 0.916) | **1.540 (1.340, 1.740)** |
| Supply of medication | 0.467(0.443, 0.491) | **0.684 (0.549, 0.818)** |
| Monitoring of response to medication | **0.179 (0.163, 0.194)** | 0.055 (0.017, 0.094) |
| Storage and accountability of medication | 0.073 (0.064, 0.083) | **0.097 (0.046, 0.147)** |
| Consumer advice and information - medication | 0.062 (0.053, 0.071) | **0.159 (0.094, 0.224)** |
| Prescribing of medication | 0.035 (0.029, 0.042) | **0.076 (0.031, 0.121)** |

Supplementary Table 9: Facility level information

| Facility | Number of years of data considered for the study | Average respite proportion | Total admissions during study period | Number of beds available |
|---|---|---|---|---|
| 1 | 8 | Between 35-45% | 511 | >=124 |
| 2 | 8 | Greater than 55% | 318 | <62 |
| 3 | 8 | Greater than 55% | 175 | <62 |
| 4 | 8 | Between 35-45% | 247 | <62 |
| 5 | 8 | Between 45-55% | 390 | 103 <=x< 124 |
| 6 | 8 | Greater than 55% | 585 | >=124 |
| 7 | 8 | Greater than 55% | 1303 | >=124 |
| 8 | 8 | Between 35-45% | 412 | >=124 |
| 9 | 8 | Between 45-55% | 661 | >=124 |
| 10 | 8 | Greater than 55% | 831 | >=124 |
| 11 | 4 | Between 45-55% | 144 | >=124 |
| 12 | 8 | Between 35-45% | 116 | <62 |
| 13 | 8 | Between 45-55% | 502 | 103 <=x< 124 |
| 14 | 8 | Greater than 55% | 620 | 103 <=x< 124 |
| 15 | 8 | Greater than 55% | 559 | 103 <=x< 124 |
| 16 | 5 | Between 45-55% | 437 | 103 <=x< 124 |
| 17 | 5 | Between 35-45% | 118 | 62 <=x< 103 |
| 18 | 8 | Between 35-45% | 296 | >=124 |
| 19 | 8 | Greater than 55% | 256 | 62 <=x< 103 |
| 20 | 8 | Between 35-45% | 201 | 62 <=x< 103 |
| 21 | 8 | Between 45-55% | 243 | <62 |
| 22 | 8 | Less than 35% | 129 | <62 |
| 23 | 7 | Less than 35% | 69 | 62 <=x< 103 |
| 24 | 3 | Less than 35% | 178 | 62 <=x< 103 |
| 25 | 1 | Less than 35% | 62 | 62 <=x< 103 |