Background

Recent data, from Australia and internationally, show that between a third and a half of all hospital inpatients are receiving an antimicrobial at any point in time.[1–3] In Australia, much of the information on antimicrobial use has come from major city public hospitals, including surveys of the indications for antimicrobial use,[4,5] compliance with prescribing guidlines,[6] and investigating risk factors for inappropriate use.[1] Australian private hospitals are currently under-represented in antimicrobial prescribing survey data, with only one previous point prevalence survey (PPS) conducted in three large private hospitals.[2] However, there are approximately 280 acute care private hospitals in Australia, constituting 31% of all inpatient beds.[7]

Antimicrobial prescribing practices may vary significantly across different hospital types and be influenced by the types of patients admitted and the resources available. A previous Australian study outlined major differences in the available resources and implementation of antimicrobial stewardship (AMS) programs between public and private hospitals.[8] Identifying common themes associated with inappropriate prescribing in different settings will help direct AMS efforts within each hospital sector. The 2014 National Antimicrobial Prescribing Survey (NAPS) data demonstrated that surgical prophylaxis was the most common indication for antimicrobial prescribing (13%) in participating Australian hospitals and that 40% of these prescriptions were in some way inappropriate.[9] However, it is unclear if antimicrobial-prescribing practices differed between the two types of hospitals and whether there were any specific targets for AMS intervention within each hospital sector.

Aims

The aims of this study were to use the 2014 NAPS data to:

1) describe current antimicrobial prescribing practices in public and private hospitals,
2) identify similarities and differences between the two hospital sectors in terms of indications for antimicrobial use (in particular surgical prophylaxis), compliance with guidelines and reasons for non-compliant therapy
3) provide specific recommendations to improve antimicrobial use in each hospital sector.

Methods

Antimicrobial prescribing data was obtained from the 2014 NAPS database. The NAPS is a voluntary, nation-wide survey conducted annually and is available to all Australian acute healthcare facilities. The

data collection tool is standardised and designed to assist auditing of antimicrobial prescribing practices and facilitate local quality improvement. The 2014 NAPS took place between August 2014 and February 2015. Hospitals conducted snapshot surveys as either a whole hospital PPS, whole hospital serial point prevalence surveys (sPPS) (ie conducted a PPS at regular intervals over a period of several weeks, recommended for smaller hospitals with fewer inpatients) or a one off sample of randomly selected patients (for hospitals with fewer available resources). A minimum data set of 30 prescriptions from each hospital was recommended.

Data collection was in accord with the previously reported standardised NAPS method[10], and included assessments of compliance with antimicrobial prescribing guidelines (see **Table 1** for compliance with guidelines assessment criteria).

Ethics

The study was approved by Melbourne Health Human Research Ethics Committee as a quality assurance/negligible risk research initiative (QA2013066).

Statistical analysis

Data were presented descriptively, with the categorical data presented as frequencies and percentages. Chi-squared tests were used to test for differences across groups for categorical data, with the Fishers Exact test employed when frequencies were small. All tests were two-tailed and a p-value of less than 0.05 was considered to indicate statistical significance. Statistical analysis was performed using Stata version 12.1 (StataCorp LP, Texas, USA).

Results

A total of 202 hospitals (166 public and 36 private) were included in the data analysis. In terms of hospital location, the surveyed private hospitals were representative of all Australian private hospitals as determined by a comparison of surveyed versus non-surveyed private sites based on Australian Institute of Health and Welfare (AIHW) classification (**Table 2**).[7] There was a statistically significant difference in the proportion of females (Public: 48.1%, Private: 52.4%, p=0.002) and age in the patients admitted to public (Median 66, Interquartile range (IQR): 45 – 80) and private hospitals (Median 68, IQR: 54 – 79) (p<0.001). Compared with the Australia-wide distribution of all public hospitals and based on AIHW classifications, major city hospitals contributed a greater proportion of surveyed hospitals (47.0% of surveyed public hospitals vs 25.4% of all Australian public hospitals) and a smaller proportion of remote hospitals (7.2% vs 20.6%, respectively).

In public hospitals the majority of surveyors were pharmacists (64%) followed by doctors (19%) and nurses (17%), whereas in private hospitals surveyors were split evenly between nurses (48%) and pharmacists (45%) [p<0.001]. Of note, there were no doctors involved as surveyors in the private hospitals.

A total of 10,882 patients were included in the study, with data collected from 17,175 prescriptions. Seven percent (1,208) of prescriptions were excluded from the analysis due to the indication for these prescriptions being classified as either 'unknown' or 'other' by surveyors. The remaining 15,967 prescriptions were included in the analysis. Overall, an indication was documented in 74.1% of antimicrobial prescriptions, with documentation substantially higher in public hospitals compared with private hospitals (77.2% vs 51.8%). This was particularly evident for certain surgical units including gynaecology (76.5% vs 16.2%, p<0.001), general surgery (74.6% vs 26.0%, p<0.001), ear nose and throat surgery (60.9% vs 15.9%, p<0.001) and plastic surgery (73.3% vs 43.7%, p<0.001).

There were significant differences between public and private hospitals in terms of prescriptions indicated for treatment of infection (81.5% and 48.4% respectively), surgical prophylaxis (9.6% and 46.9% respectively) and medical prophylaxis (8.8% and 4.6% respectively) [p<0.001]. Public hospitals had a higher proportion of patients receiving antimicrobials for community-acquired pneumonia compared with private hospitals (13.0% vs 5.9%).

Overall, the most commonly prescribed antimicrobials were cephazolin (11.1%), ceftriaxone (9.1%), metronidazole (6.5%), piperacillin-tazobactam (6.1%) and amoxycillin-clavulanic acid (6.0%). For treatment indications, the three most common antimicrobials used in public hospitals were broad-spectrum agents (ceftriaxone, piperacillin-tazobactam and amoxycillin-clavulanic acid), whereas in private hospitals there were narrower spectrum agents that featured in the top three (cephazolin, cephalexin and metronidazole) (see **Figure 1**). For surgical prophylaxis, cephazolin comprised the vast majority of antimicrobial prescriptions across both public (61.3%) and private (58.8%) facilities. Compared with public hospitals, private hospitals had more frequent use of the oral antibiotic cephalexin (11.4% vs 5.9%, p<0.001).

There were no significant differences in the frequency of prescription of 'last line' treatment antibiotics such as meropenem, linezolid, daptomycin, colistin and tigecycline.

A small percentage of prescriptions were for topical antimicrobials (3.6%), however, this was higher in public hospitals compared with private hospitals (3.9% vs 1.1%). The most common indications for which topical antimicrobials were used were tinea, oral candidiasis and conjunctivitis. There was some

use in surgical prophylaxis (40 of 2246 prescriptions), with approximately half of these being for topical chloramphenicol.

Although there were no statistically significant differences in overall rates of compliance with prescribing guidelines, public hospitals had a higher percentage of antimicrobial prescriptions that were compliant with locally endorsed guidelines, rather that the TG:A[11,12], compared to private hospitals (**Table 3**). **Figure 2** shows the breakdown of compliance with guidelines between public and private hospitals for both the top five treatment and surgical prophylaxis prescriptions. Indications with higher overall rates of non-compliant prescribing were community-acquired pneumonia, urinary tract infections and surgical prophylaxis, particularly orthopaedic surgery. There was also greater non-compliance with guidelines for prophylaxis in public hospitals compared with private hospitals for the three most common surgical specialties: plastic surgery (73.4% vs 38.0%, p<0.001), general surgery (45.5% vs 18.2%, p<0.001) and orthopaedic surgery (45.0% vs 37.4%, p=0.039).

Reasons for non-compliance with guidelines are given in **Table 4**. For treatment prescriptions, the main reason for non-compliance in public hospitals was spectrum being too broad (31.2%) whilst the main reason in private hospitals was incorrect dose/frequency (28.5%). Specific examples of the antimicrobial spectrum being too broad included the use of ceftriaxone for surgical prophylaxis and the use of piperacillin-tazobactam for community-acquired pneumonia. Specific examples of incorrect dosing included the use of cephazolin 1g for surgical prophylaxis and the use of cephalexin 500mg 8-hourly for wound infections and urinary tract infections. Prophylaxis greater than 24 hours was the main reason for non-compliance of surgical prophylaxis prescriptions for both public (62.5%) and private hospitals (69.7%).

Discussion

This study represents the largest survey of antimicrobial prescribing in Australian hospitals to date. Based on the latest hospital demographic data,[7] the survey represents 23% and 13% of all acute care public and private hospitals in Australia respectively. There are notable differences between antimicrobial use in public and private hospitals in Australia based on the findings presented.

Reflective of the differences in casemix between the two hospital sectors,[7] it was somewhat predictable that antimicrobial prescriptions for the treatment of infections predominated in public hospitals, whereas surgical prophylaxis prescriptions accounted for nearly half of all antimicrobial use in private hospitals. These data were consistent with recent point prevalence surveys in Australian public and private hospitals.[1,2]

Although, as noted above, overall rates of compliance with prescribing guidelines were similar between public and private hospitals for both treatment and surgical prophylaxis, rates of compliance with locally endorsed guidelines, if different from TG:A[11,12], were significantly higher in public hospitals. It is unclear, however, whether these local guidelines were developed on the basis of direct disagreement with TG:A[11,12] recommendations, or simply derived from TG:A[11,12] but using locally based data such as antibiograms. The latter may be a viable approach in settings that require local susceptibility data to initiate adequate empirical antimicrobial therapy, such as tertiary referral intensive care units.[13]

The fact that no doctors were involved as auditors in private hospitals is reflective of previous data that noted differences between public and private hospital personnel dedicated to undertake AMS activities. A 2012 survey of Victorian hospitals indicated that approximately a third of surveyed metropolitan public hospitals had funding for pharmacists and/or medical staff available to conduct AMS activities such as regular auditing of antimicrobial prescribing.[8] In contrast, at the time there was no private hospital that reported having dedicated funding for pharmacists or medical staff to oversee AMS activities such as auditing antimicrobial prescriptions. In private hospitals, it would appear that nurses are being given primary roles in managing AMS programs including auditing.

Specific targets for AMS interventions

Use of excessively broad-spectrum therapy will be major area to target for public hospitals, particularly in the treatment of respiratory infections. Prescribing guidelines, such as TG:A[11,12], are a useful starting point to help address these issues, but there are concerns that these may not be able to take into account patient specific factors, and so may not be applicable when used in clinical practice.[14] Additional educational interventions, in the form of patient specific post-prescription advice via an antimicrobial management team or use of computerised decision support systems, if not already implemented, may be considerations for hospitals that report non-compliance due to overuse of broad-spectrum antimicrobials.

For private hospitals, improving antimicrobial dosing/frequency should be a priority, as this accounted for nearly a third of non-compliance among treatment prescriptions. These findings, together with previous qualitative work showing that private hospital specialists self-reported a deficiency in up-to-date antimicrobial knowledge,[15] suggest that ongoing educational support is imperative to improve the quality of antimicrobial prescribing practices in private hospitals. This may be achieved by having increased time for pharmacists to perform AMS duties within private hospitals.

Both hospital sectors will need to address the issue of overuse of antimicrobials for surgical prophylaxis. Not only are antimicrobials being used beyond the recommended cut-off of 24 hours post-operatively,[11] but there is a significant proportion of surgical prophylaxis prescriptions that may not be indicated. As previous Australian data also suggest there is room to improve timing of antimicrobial administration in relation to surgical incision,[6] there is strong argument for surgical prophylaxis to be viewed as a top priority area for quality improvement Australia wide.

Although this study provides the first detailed picture of antimicrobial prescribing in Australian hospitals, there are some limitations to consider. First, the representativeness of the results may be biased as participation in the survey was voluntary, hence participants may have likely been more interested in AMS. Second, although the data may be considered generalisable for most types of hospitals, major city hospitals were more strongly represented, whilst remote hospitals less so. As many of these major city hospitals are tertiary referral centres and often have more complex patients, this may have contributed to the higher broad-spectrum use observed in public hospitals. Third, surveyors from different professions performed the assessment of compliance, potentially affecting comparability of data between hospitals. The difference in assessor background was particularly evident between public and private hospitals, with the former having nursing surveyors as a minority, whilst the latter having these surveyors as the majority but no surveyors who were doctors. Recent Australian data investigating the reliability of assessments of antimicrobial concordance with TG:A[11] made by assessors from different clinical backgrounds confirms that further work is required to improve inter-rater reliability between this heterogeneous mix of surveyors.[16] Data comparability between hospitals could have been further affected given that assessments made earlier in the study period used the previous version of TG:A[11]. Fourth, certain surgical wound classifications (i.e. Class III and Class IV) often require greater than 24 hours of antimicrobial use, often as pre-emptive therapy. However, as the NAPS tool did not specifically capture wound classification, the broad recommendation of greater than 24-hours post-operatively was reported as a reason for non-compliance.

Conclusion

Although overall rates of compliance with prescribing guidelines are similar between public and private hospitals, there are many other aspects of antimicrobial prescribing that vary between the two groups of hospitals. Importantly, findings from this study have provided priority areas for antimicrobial prescribing improvement for each hospital sector to consider. For public hospitals, improvement will have to include promoting, where appropriate, the use of narrower spectrum antimicrobial agents.

Private hospitals, on the other hand, have a significant burden of antibiotics being used for surgical prophylaxis, and given the rate of prolonged prophylaxis, it represents a critical area for improvement.

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Tables

Table 1. Compliance with guidelines assessment criteria

Compliance with guidelines	
Compliant with Therapeutic Guidelines (TG:A[11,12])	• The prescription complies with the current paper or online TG:A[11,12] including: ▪ *route, dose, frequency* AND ▪ *takes into account acceptable alterations due to the patient's age, weight, renal function (eGFR/CrCl), etc. or other prescribed medications*
Compliant with local guidelines	• The prescription complies with an officially endorsed local guidelines, including: ▪ *route, dose, frequency* AND ▪ *takes into account acceptable alterations due to the patient's age, weight, renal function (eGFR/CrCl), etc. or other prescribed medications* • Local guidelines must have executive or drug and therapeutic committee approval. • If the local guidelines are based exactly on the TG:A[11,12], then choose "Therapeutic Guidelines" preference
Non-compliant	• There is non-compliance with *both* Therapeutic Guidelines and any officially endorsed local guidelines. UNLESS ▪ *takes into account acceptable alterations due to the patient's age, weight, renal function (eGFR/CrCl), etc. or other prescribed medications*
Other	• There are no guidelines available for the documented or presumed indication. OR • The medical records are not comprehensive enough to determine a documented or presumed indication. OR • It is difficult to assess if there is compliance.

Table 2. Remoteness and survey methodology of participating hospitals

	Public n = 166	Private n = 36	**Combined n = 202**
Remoteness	n (%)	n (%)	n (%)
Major city	78 (47.0)	26 (72.2)	**104 (51.5)**
Inner or outer regional	76 (45.8)	10 (27.8)	**86 (42.6)**
Remote or very remote	12 (7.2)	N/A‡	**12 (5.9)**
Survey methodology	n (%)	n (%)	**n (%)**
PPS	88 (53.0)	17 (47.2)	**105 (52.0)**
sPPS	61 (36.8)	9 (25.0)	**70 (34.6)**
Random sample	17 (10.2)	10 (27.8)	**27 (13.4)**

‡ note: there are no remote or very remote private hospitals in Australia

PPS – whole facility point prevalence survey

sPPS – whole facility serial point prevalence survey

Table 3. Compliance with prescribing guidelines for treatment, medical and surgical prophylaxis prescriptions

	Public n (%)	Private n (%)	**Combined** n (%)
Treatment	**11,459 (81.5)**	**927 (48.4)**	**12,386 (77.6)**
Compliant with prescribing guidelines	6,486 (56.6)	557 (60.1)	**7,043 (56.9)**
Therapeutic Guidelines: Antibiotic	*5,356 (46.7)*	*540 (58.3)*	***5,896 (47.6)***
Locally endorsed guidelines	*1,130 (9.9)**	*17 (1.8)**	***1,147 (9.3)***
Non-compliant with guidelines	2,658 (23.2)	144 (15.5)	**2,802 (22.6)**
Other	2,315 (20.2)	226 (24.4)	**2,541 (20.5)**
Surgical prophylaxis	**1,348 (9.6)**	**898 (46.9)**	**2,246 (14.1)**
Compliant with prescribing guidelines	637 (47.3)	525 (58.5)	**1,162 (51.7)**
Therapeutic Guidelines: Antibiotic	*401 (29.8)*	*464 (51.7)*	***865 (38.5)***
Locally endorsed guidelines	*236 (17.5)**	*61 (6.8)**	***297 (13.2)***
Non-compliant with guidelines	627 (46.5)	340 (37.9)	**967 (43.1)**
Other	84 (6.2)	33 (3.6)	**117 (5.2)**
Medical prophylaxis	**1,246 (8.8)**	**89 (4.6)**	**1,335 (8.4)**
Compliant with prescribing guidelines	1,031 (82.7)	70 (78.7)	**1,101 (82.5)**
Therapeutic Guidelines: Antibiotic	*262 (21.0)*	*54 (60.7)*	***316 (23.3)***
Locally endorsed guidelines	*769 (61.7)**	*16 (18.0)**	***785 (58.8)***
Non-compliant with guidelines	67 (5.4)	10 (11.2)	**77 (7.0)**
Other	148 (11.9)	9 (10.1)	**157 (14.3)**
Total	**14,053**	**1,914**	**15,967**

* *p<0.001*

Table 4. Reasons for non-compliance with prescribing guidelines for treatment and surgical prophylaxis prescriptions

	Public n (%)	Private n (%)	**Combined** n (%)
Treatment	**2,423**	**117**	**2,540**
Incorrect route	140 (5.3)	5 (3.5)	**145 (5.2)**
Incorrect dose/frequency	520 (19.6)	41 (28.5)	**561 (20.0)**
Incorrect duration*	211 (7.9)	16 (11.1)	**227 (8.1)**
Spectrum too narrow	164 (6.2)	10 (6.9)	**174 (6.2)**
Spectrum too broad	828 (31.2)	28 (19.4)	**856 (30.5)**
Antimicrobial not indicated	560 (21.1)	17 (11.8)	**577 (20.6)**
Surgical prophylaxis	**783**	**394**	**1,177**
Incorrect route	13 (2.1)	23 (6.8)	**36 (3.7)**
Incorrect dose/frequency	151 (24.1)	38 (11.2)	**189 (19.5)**
Surgical prophylaxis >24hours‡	392 (62.5)	237 (69.7)	**629 (65.0)**
Spectrum too narrow	22 (3.5)	3 (0.9)	**25 (2.6)**
Spectrum too broad	41 (6.5)	26 (7.6)	**67 (6.9)**
Antimicrobial not indicated	164 (26.2)	67 (19.7)	**231 (23.9)**

*Only for treatment prescriptions

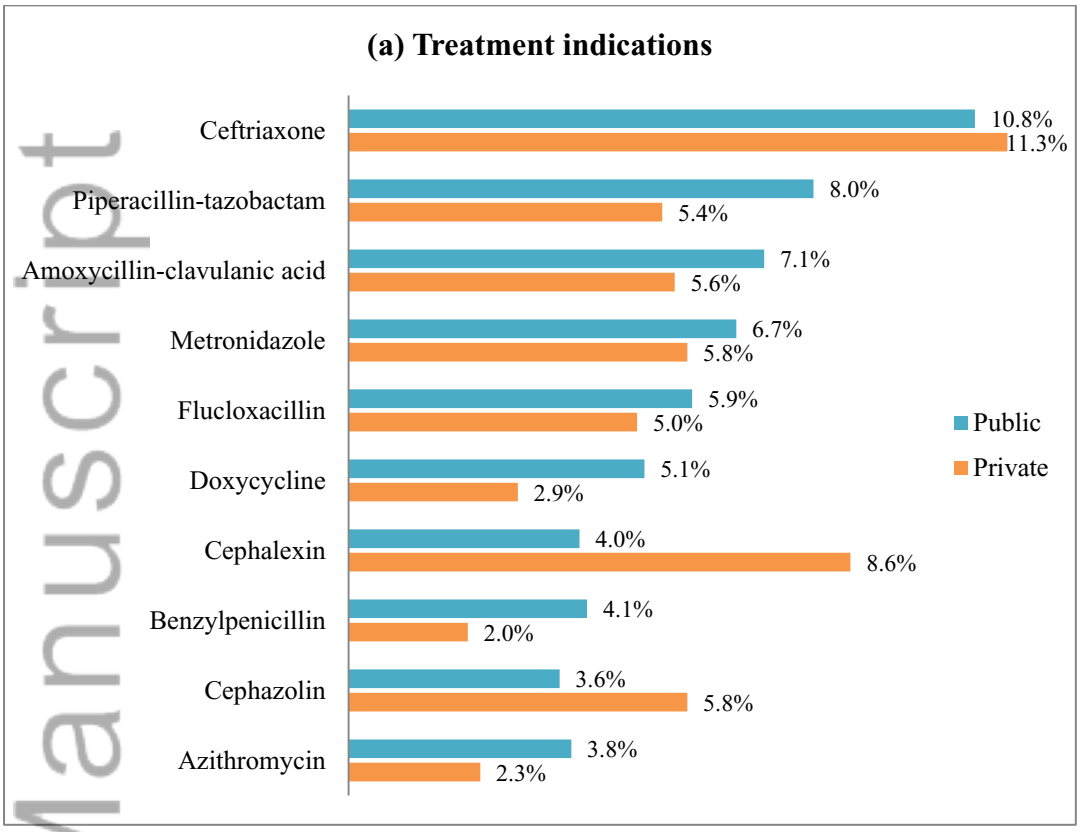
‡Only for surgical prophylaxis prescriptions

All surveyors were required to indicate whether surgical prophylaxis prescriptions was >24hrs, however, all other reasons for non-compliance were optional and more than one reason could be selected per prescription

Medical prophylaxis prescriptions were not included as there was a high rate of compliance with guidelines for this indication

Figures

Figure 1: Most common antimicrobials for treatment (a) and surgical prophylaxis (b) indications, by public and private



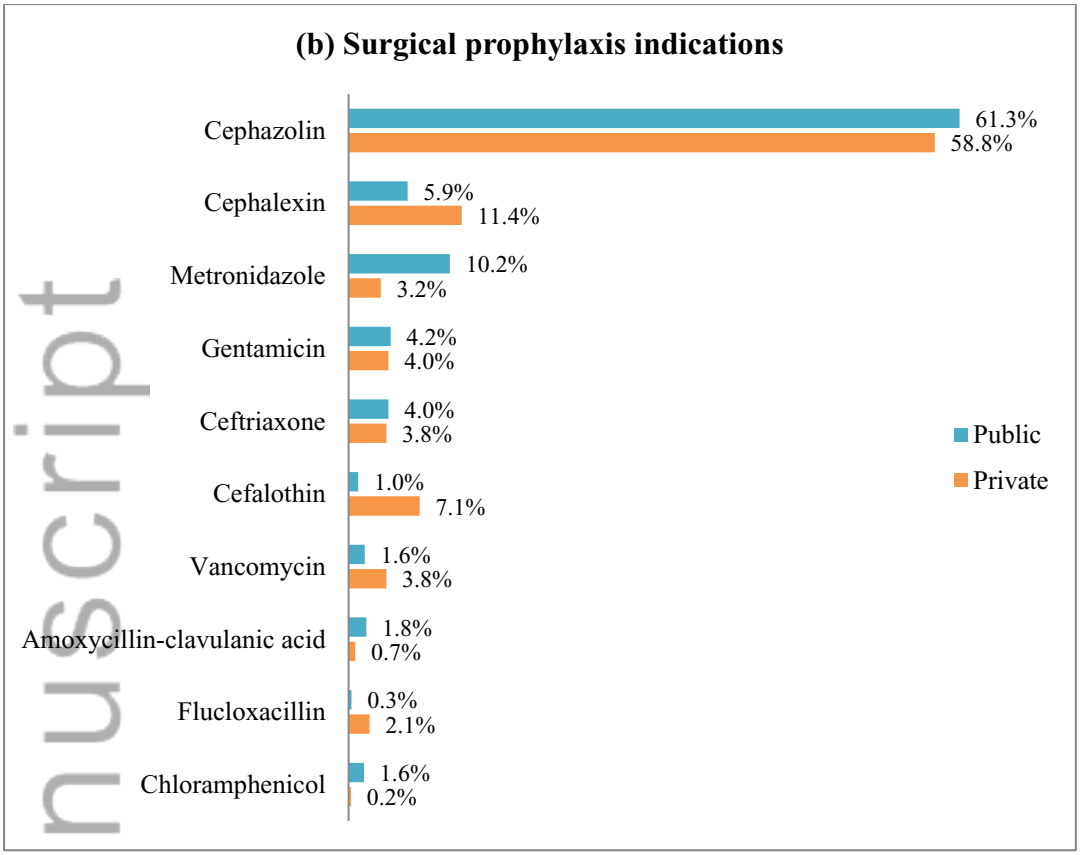
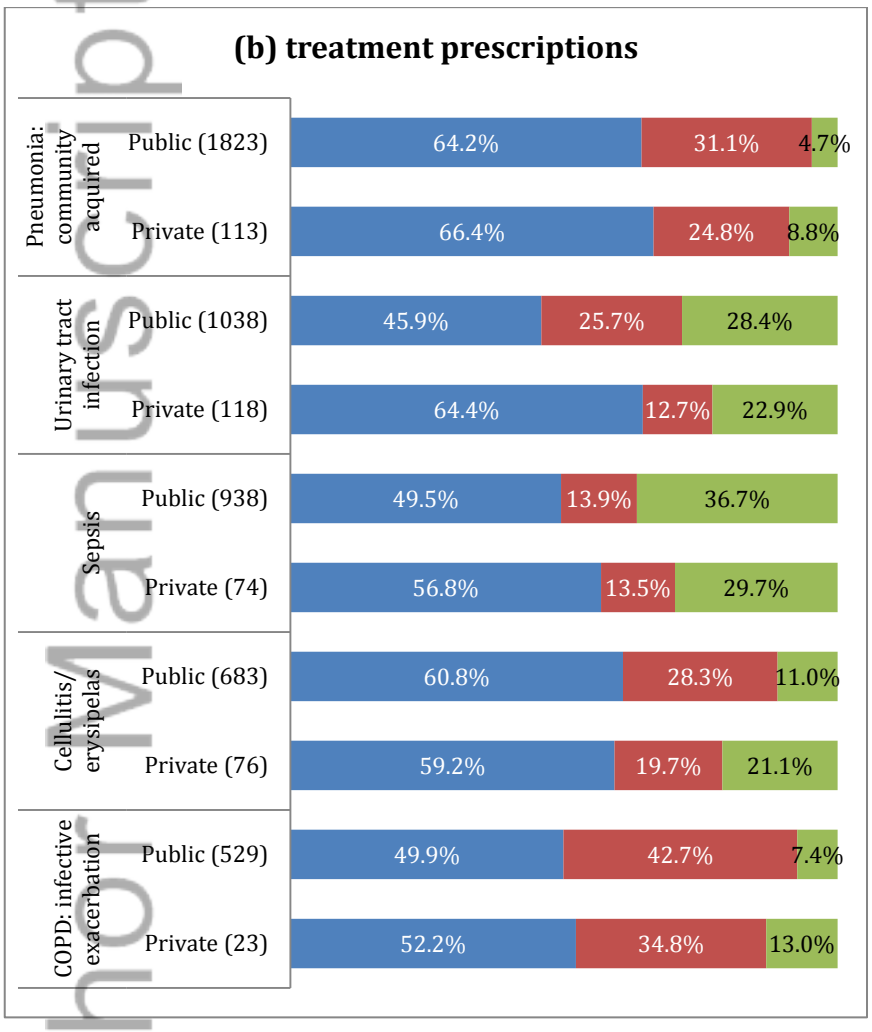
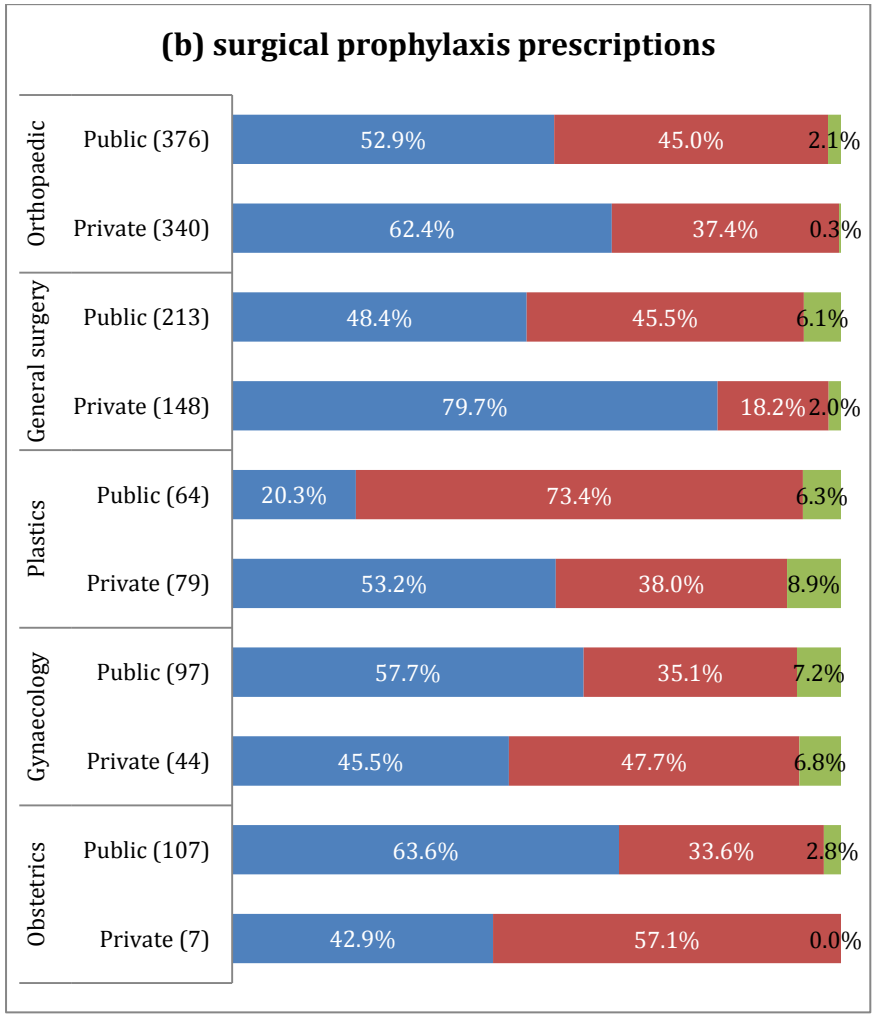
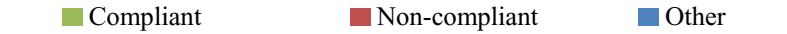


Figure 2: level of compliance for common treatment (a) and surgical prophylaxis (b) prescriptions for public and private facilities*







** The numbers of prescriptions are shown next to each hospital category*

Abstract

Background: Identifying themes associated with inappropriate prescribing in Australian public and private hospitals will help target future antimicrobial stewardship initiatives.

Aims: To describe current antimicrobial prescribing practices, identify similarities and differences between hospital sectors and provide target areas for improvement specific to each hospital sector.

Methods: All hospitals included in the study were part of the 2014 national antimicrobial prescribing survey and conducted one of the following: a whole hospital point prevalence survey, serial point prevalence surveys or a sample of randomly selected patients. Data on the types of antibiotics used, their indications for use, and the quality of prescription based on compliance with national and local prescribing guidelines were collected.

Results: Two-hundred and two hospitals (166 public and 36 private) comprising 10,882 patients and 15,967 antimicrobial prescriptions were included. Public hospitals had higher proportions of prescriptions for treatment (81.5% vs 48.4%) and medical prophylaxis (8.8% and 4.6%), whilst private hospitals had significantly higher surgical prophylaxis use (9.6% vs 46.9%) [$p<0.001$]. In public hospitals, the main reasons for non-compliance of treatment prescriptions was spectrum being too broad (30.5%) while in private it was incorrect dosing. Prolonged duration was the main reason for non-compliance among surgical prophylaxis prescriptions in both types of hospitals.

Conclusions: Australian hospitals need to target specific areas to improve antimicrobial use. Specifically, unnecessarily broad-spectrum therapy should be a priority area in public hospitals, whilst emphasis on curtailing antimicrobial overuse in surgical prophylaxis needs to be urgently addressed across in the private hospital sector.

Keywords: antimicrobial stewardship, hospitals, prescribing, guidelines

What are the similarities and differences in antimicrobial prescribing between Australian public and private hospitals?

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