The Royal New Zealand College of General Practitioners
Te Whare Tohu Rata o Aotearoa

ORIGINAL RESEARCH PAPER

ORIGINAL RESEARCH: CLINICAL

Antibiotic prescribing patterns of general practice registrars for infective conjunctivitis: a cross-sectional analysis

Marcus D. Cherry;[1] Amanda Tapley BBiomedSc(Hons), MMedStat;[1,2] Debbie Quain BNursing;[1,2] Elizabeth G. Holliday BSc(Hons), MSc(Stats), PhD;[1] Jean Ball BMath, Grad Dip Med Stats;[3] Andrew Davey BSc, BE(Hons), DCH, BMed, MClinEpid, FRACGP;[1,2] Mieke L. van Driel MD, MSc, PhD, FRACGP;[4] Alison Fielding BND, PhD;[1,2] Neil Spike MBBS, FRACGP;[5,6] Kristen FitzGerald B Med Sci, MBBS (Hons), DRANZCOG, FRACGP, MPH & TM;[7] Parker Magin PhD, FRACGP[1,2,8]

[1] University of Newcastle, School of Medicine and Public Health, Faculty of Health and Medicine, Callaghan, New South Wales, Australia.
[2] GP Synergy, General Practice Regional Training Organisation, NSW and ACT Research and Evaluation Unit, Newcastle, New South Wales, Australia.
[3] Hunter Medical Research Institute, Clinical Research Design IT and Statistical Support Unit, New Castle, NSW, Australia
[4] The University of Queensland, Primary Care Clinical Unit, Faculty of Medicine, Brisbane, Queensland, Australia.
[5] Eastern Victoria General Practice Training, Melbourne, Victoria, Australia.
[6] Department of General Practice, University of Melbourne, Melbourne, Victoria, Australia.
[7] General Practice Training Tasmania, Hobart, Tasmania, Australia.
[8] Corresponding author. Email: parker.magin@newcastle.edu.au

J PRIM HEALTH CARE
2021;13(1):5–14.
doi:10.1071/HC20040
Received 29 April 2020
Accepted 14 January 2021
Published 8 March 2021

ABSTRACT

INTRODUCTION: Over-prescription of antibiotics for common infective conditions is an important health issue. Infective conjunctivitis represents one of the most common eye-related complaints in general practice. Despite its self-limiting nature, there is evidence of frequent general practitioner (GP) antibiotic prescribing for this condition, which is inconsistent with evidence-based guidelines.

AIM: To investigate the prevalence and associations of GP registrars' (trainees') prescription of antibiotics for infective conjunctivitis.

METHODS: We performed a cross-sectional analysis of the Registrar Encounters in Clinical Training (ReCEnT) ongoing prospective cohort study, which documents GP registrars' clinical consultations (involving collection of information from 60 consecutive consultations, at three points during registrar training). The outcome of the analyses was antibiotic prescription for a new diagnosis of conjunctivitis. Patient, registrar, practice and consultation variables were included in uni- and multivariable logistic regression analyses to test associations of these prescriptions.

RESULTS: In total, 2333 registrars participated in 18 data collection rounds from 2010 to 2018. There were 1580 new cases of infective conjunctivitis (0.31% of all problems). Antibiotics (mainly topical) were prescribed in 1170 (74%) of these cases. Variables associated with antibiotic prescription included patients' Aboriginal or Torres Strait Islander status, registrar organisation of a follow up (both registrar and other GP follow up), and earlier registrar training term (more junior status).

DISCUSSION: GP registrars, like established GPs, prescribe antibiotics for conjunctivitis in excess of guideline recommendations, but prescribing rates are lower in later training. These prescribing patterns have educational, social and economic consequences. Further educational strategies may enhance attenuation of registrars' prescribing during training.

KEYWORDS: Epidemiology; general practice; conjunctivitis; antibiotic stewardship; medical education

WHAT GAP THIS FILLS

What is already known: Judicious prescription of antibiotics in general practice has important social, economic and public health consequences. The continued prescription of antibiotics for common infective conditions in which they have minimal clinical benefit is an ongoing concern.

What this study adds: This study identifies the prevalence and associations of Australian GP registrars' antibiotic prescribing for conjunctivitis, and informs educational approaches to rational prescribing for GPs and registrars.

Introduction

In Australia, most antibiotics are prescribed in general practice.[1] There are several evidenced-based guidelines that may guide antibiotic prescribing decisions, notably the *Therapeutic Guidelines*.[2] Despite this, many general practitioners (GPs), including GP registrars (specialist GP vocational trainees), continue to prescribe outside of these guidelines.[3] For registrars, this includes antibiotic prescribing for common infective respiratory, otological and dermatological conditions for which there is no, or limited, indication.[4–8] Complex professional, personal and social expectations may influence these prescribing behaviours.[9]

Eye-related disease is a common presentation in general practice. Conjunctivitis, the inflammation of the ocular conjunctiva, is among the most common eye-related disorders encountered,[10] occurring in ~2% of all GP consultations.[11] Most conjunctivitis is infective. Viral conjunctivitis comprises most cases encountered in adults, and up to 80% of infections.[12] Bacterial conjunctivitis is less frequent, but is the most common aetiology in paediatric patients.[13] Generally, infective conjunctivitis is a mild, self-limiting disease with symptomatic and microbiological remission occurring within 5–7 days.

There remains an inappropriately high rate of antibiotic prescription for infective conjunctivitis in general practice, with ~900,000 and 3.4 million annual prescriptions for topical ocular antibiotics occurring in the Netherlands and the UK, respectively.[14] Such prescriptions may be inappropriate for several reasons. Most infective conjunctivitis is virally mediated, particularly in adults. Second, health-care providers, including GPs, are poor discriminators of infective aetiology, leading to empirical prescription of large amounts of antibiotics. Clinical differentiation of viral from bacterial infection is particularly difficult, with 'classical' signs and symptoms being poor predictors of infectious cause.[15] Around 90–95% of GPs prescribe antibiotics for conjunctivitis, even for cases they feel to be of viral origin.[8,16]

Antibiotics have only modest benefit in bacterial conjunctivitis, with marginal clinical and microbiological improvement associated with their use,[17] particularly in paediatric cases.[18] Additionally, most conjunctivitis cases resolve spontaneously without antibiotic interventions and with minimal complications.[11,17] Antibiotic use may also delay urgent ophthalmic care for more serious ocular conditions.[19]

Injudicious use of antibiotics may contribute to public misapprehension about conjunctivitis, drive social expectations for antibiotic prescription, and has economic consequence.[14,20] Thus, the evidence-based guidelines most used by Australian GPs recommends against prescription of topical antibiotics for viral conjunctivitis, and antibiotics for bacterial conjunctivitis only if marked symptoms or the patient is a neonate or young infant.[21] These guidelines are based on high-quality, expert evidence that suggests only modest clinical benefit in even marked infections.[17,22]

This study aims to establish the prevalence and associations of antibiotic prescribing by Australian GP registrars for infective conjunctivitis.

Methods

We conducted a cross-sectional analysis of Registrar Clinical Encounters in Training (ReCEnT) study data from 2010 to 2018.

The Registrar Encounters in Clinical Training (ReCEnT) study

ReCEnT is an Australian prospective cohort study that documents the consultations of GP registrars during their specialist training. ReCEnT is

conducted in three of Australia's nine Regional Training Organisations in three states and one territory, encompassing 43% of Australia's GP registrar population.[23] Prior to 2016, it was conducted in five of Australia's then 17 Regional Training Providers in five states. The methodology has been described in detail elsewhere.[24] Registrars complete paper-based case report forms for 60 consecutive consultations during each of three 6-month training terms, recording clinical and educational information. They are provided with feedback to promote reflection on their clinical practice and educational needs, and may give consent to have their data used for research purposes.[25]

Primary outcome measure

The primary outcome was whether an antibiotic was prescribed for a new diagnosis of conjunctivitis. Relevant antibiotics were defined as Anatomical Therapeutic Chemical (ATC) codes D06AX02, D09AA01, D10AF03, G01AA05, J01BA01, J01CA04, J01CE02, J01CF02, J01CF05, J01CR02, J01DB01, J01DC02, S01AA01, S01AA07, S01AA12, S01AX11, S01AX13, S02AA01, and S03AA08.

Independent variables

Patient variables included patient age-group, gender, Aboriginal or Torres Strait Islander status, non-English-speaking background status, and whether patients were known to the attending practice or registrar. Registrar variables included registrar age, gender, full-time or part-time status, present training term (Term 1–3), having previously worked in the practice and having obtained medical qualification in Australia or internationally. Practice variables included practice size (small = <5 doctors, large = ≥ 5 doctors), bulk-billing status (whether the practice routinely charges direct patient consultation fees), practice rurality (major city, inner regional or outer regional, remote, very remote), training region, and the Socio-Economic Indexes for Area Index of Relative Socioeconomic Disadvantage (SEIFA-IRSD) decile of the practice location. Consultation variables included consultation duration, number of clinical problems addressed, pathology testing ordered, follow-up organised (with the registrar or another doctor), referrals ordered, learning goals generated, and whether information or assistance was obtained during the consultation (from the registrar's supervising GP or another source). With the exception of consultation duration, registrar age, SEIFA-IRSD index, and number of problems addressed, consultation variables were classified in binary form (yes or no).

Statistical analysis

The analyses were conducted at the level of diagnosis. In ReCEnT, diagnoses are coded according to the International Classification of Primary Care (second edition) (ICPC-2) classification system. For this study, analyses were restricted to ICPC-2 F70, which included the diagnoses of 'conjunctivitis', 'bacterial conjunctivitis', 'viral conjunctivitis', or 'infectious conjunctivitis'. This study did not include codes for non-infective conjunctivitis (chemical, allergic, etc), gonococcal conjunctivitis, chlamydial conjunctivitis or trachoma.

Descriptive statistics included frequencies for categorical variables and mean with standard deviation (s.d.) for continuous variables. The frequencies of categorical variables were compared between outcome categories using Chi-square tests or Fisher's exact test, as appropriate. For continuous variables, means were compared using a *t*-test.

The initial analytic approach was to use a logistic regression within the generalised estimating equations framework to account for repeated-measures within registrars. An exchangeable working correlation structure was assumed. However, the low numbers of Aboriginal or Torres Strait Islander patients not being prescribed antibiotics caused collinearity in the final model, so other methods were tried.

First, we established that adjusting for clustering by registrar was not necessary for this model, based on no evidence for inflated standard errors of parameter estimates when independence was assumed. The final fitted model was a logistic regression model using Firth's penalised likelihood for estimation (as a method of addressing issues of separability and small sample sizes), which allowed the effect for Aboriginal or Torres Strait Islander status to be estimated.

Table 1. Demographics of participating GP registrars and their practices

Variable	Class	*n* (%)
Registrar variables (2333)		
Gender	Female	1467 (62.9)
Qualified as a doctor in Australia	Yes	1873 (80.7)
Registrar-term or practice-term variables (*n* = 5470)		
Registrar training term	Term 1	2191 (40.1)
	Term 2	1977 (36.1)
	Term 3	1302 (23.8)
Registrar age (years)	Mean (s.d.)	32 (6.3)
Registrar worked at practice previously	Yes	1204 (22.3)
Registrar does other regular medical work	Yes	942 (25.2)
Registrar works full-time	Yes	4104 (77.6)
Practice routinely bulk bills	Yes	1430 (26.4)
Number of GPs working at practice	≥5	3289 (62.3)
Rurality of practice	Major city	3279 (60.6)
	Inner regional	1406 (26)
	Outer regional	648 (12.0)
	Remote	61 (1.1)
	Very remote	16 (0.3)
Socioeconomic Index for Area (Decile) of practice	Mean (s.d.)	5.46 (2.81)

Table 2. Antibiotics most commonly prescribed for infective conjunctivitis

Antibiotic	Route of administration	Frequency (*n*)	Percentage (%)
Chloramphenicol	Topical	1186	95.8
Framycetin	Topical	24	1.9
Cefalexin	Oral	8	0.7
Tobramycin	Topical	6	0.5
Amoxicillin	Oral	4	0.3
Ciprofloxacin	Topical	3	0.2

In the final analyses, univariate analyses were conducted for each covariate. Covariates with a univariate P value <0.20 were considered for inclusion in the multiple regression model. Once the model with all significant covariates was fitted, model reduction was assessed. Covariates that were no longer significant (at $P < 0.2$) in the multivariable model were tested for removal from the model (with removal if this did not substantively change the resulting model).

The Hosmer–Lemeshow test was used to assess goodness-of-fit of the model. Results were presented as odds ratios (ORs) with 95% confidence intervals (CIs) and P values of <0.05 were considered statistically significant. The analyses were programmed using STATA 14.1 (StataCorp) and SAS V9.4 (SAS Institute Inc.).

Ethics approval

Ethics approval was obtained from the University of Newcastle Research Ethics Committee Reference H-2009–0323.

Results

A total of 2333 registrars recorded 325,058 consultations over 18 six-monthly data collection rounds from 2010 to 2018. The demographics of participating registrars and their practices are provided in Table 1.

Of these consultations, 2295 (0.45% [95% CI: 0.43–0.47]) involved a diagnosis of 'conjunctivitis'. Of these, 321 (14%) were diagnosed as allergic conjunctivitis and were excluded from analysis. There were 1974 (86%) diagnoses of 'non-allergic conjunctivitis'. Of these cases, 1580 (80%) were documented as a 'new problem'.

Prevalence of antibiotic prescription for infective conjunctivitis

A total of 1337 prescriptions occurred for 1580 new diagnoses of infective conjunctivitis, with multiple medications prescribed in several cases. Of these, 1170 (74% [95% CI:72–76]) were prescribed an antibiotic, with a total of 1238 antibiotic prescriptions (Table 2).

The most commonly prescribed topical antibiotic was chloramphenicol (95.8%), followed by framycetin (1.9%). A low number of oral antibiotics were also prescribed for non-allergic conjunctivitis ($n = 17$, 1.4%), with cephalexin being the most common ($n = 8$, 0.7%), followed by amoxicillin ($n = 4$, 0.3%). Additionally, 23 anti-allergy medications (oral cromoglicic acid, oral and topical antihistamines) were prescribed, including 10 patients for whom both an anti-allergy and antibiotic were prescribed.

Associations of antibiotic prescription for non-allergic conjunctivitis

Univariate analysis of characteristics associated with antibiotic prescription for newly diagnosed conjunctivitis are shown in Table 3. Univariate and multiple regression models with outcome 'antibiotic prescribed' are presented in Table 4.

Antibiotic prescription was strongly associated with the patient being of Aboriginal or Torres Strait Islander status (OR = 17.6, $P = 0.046$). Registrars being in a later (more senior) term was associated with reduced odds of antibiotic prescribing (OR = 0.68, $P = 0.025$ and 0.47, $P < 0.001$ respectively for Terms 2 and 3, compared to Term 1). There was considerable variability within regions in antibiotic prescribing, with one region having an OR of 0.36 for prescribing compared to the referent region ($P = 0.001$). There was some evidence for an association of antibiotic prescribing with the practice being a fully bulk-billing practice, although this was not statistically significant (OR 1.38, $P = 0.075$). Antibiotic prescription was also associated with a follow-up appointment with the registrar (OR 1.42, $P = 0.019$) or another GP in the practice (OR 5.15, $P = 0.016$). A shorter consultation length was significantly associated with antibiotic prescription, but the effect size was small (OR 0.98, $P = 0.021$).

Discussion

We could find no other research internationally into the frequency and associations of antibiotic prescribing by GP trainees for conjunctivitis. Patients presenting with new infective conjunctivitis were prescribed topical or systemic antibiotics or both in 74% of instances. This includes the prescription of multiple antibiotics in 5.8% of cases. Notable associations of antibiotic prescribing were patient Aboriginal or Torres Strait Islander status, organisation of patient follow up, earlier training term, and training location.

Our antibiotic prescribing rate of Australian GP registrars for infective conjunctivitis is in keeping with other international studies in general practices. A large Dutch study found that topical antibiotics were prescribed in 80% of cases of infective conjunctivitis[26] and US research discovered that nearly 60% of patients diagnosed with infective conjunctivitis filled an antibiotic prescription for it.[27] Similarly, a British questionnaire found that 95% of GPs regularly prescribe topical antibiotics for infective conjunctivitis.[16]

The most commonly prescribed antibiotic by GP registrars was chloramphenicol (95.8%), this being consistent with antibiotic recommendations in the Australian *Therapeutic Guidelines*.[21] Although not consistent with established evidence or guidelines, systemic agents represented a minority of total prescriptions (1.4%). The co-prescription of anti-allergy medications and antibiotics in a small proportion of diagnoses may reflect difficulty in distinguishing aetiology in some conjunctivitis cases.

Aboriginal or Torres Strait Islander patients were more likely to receive antibiotics than non-Indigenous patients. Although gonococcal and trachoma-related eye disease is prevalent in Aboriginal or Torres Strait Islander communities[28] and Aboriginal or Torres Strait Islander individuals have an increased burden of serious infectious disease,[29] we could find no research evidence to support increased antibiotic prescription for non-gonococcal, non-trachoma conjunctivitis in this population. It may be that registrars are cautiously prescribing for this high-risk population group.

Reassuringly, proportions of conjunctivitis presentations with antibiotic prescription were lower in later GP training terms. GP antibiotic prescribing practices, once established, may remain stable over time,[30] hence making registrars in the early phases of GP training important targets for developing rational antibiotic prescribing behaviours.

Implications for clinical and educational practice

Over-prescription of antibiotics is discouraged due to antimicrobial resistance concerns.[31] However, long-term analyses of topical antibiotics have shown stable patterns of antibiotic resistance among ocular and conjunctival isolates[32,33] including in primary health locations that, similarly to Australia, use chloramphenicol as a first-line antibiotic for conjunctivitis management.[34] However, although bacterial resistance may not be

Table 3. Characteristics associated with an antibiotic prescription for newly diagnosed conjunctivitis

			Antibiotic prescribed for Conjunctivitis		
Factor group	**Variable**	**Class**	**No**	**Yes**	**P**
Patient factors	Patient age group (years)	<1	50 (12)	116 (10)	0.35
		1–5	107 (26)	296 (26)	
		6–13	36 (9)	84 (7)	
		14–18	9 (2)	21 (2)	
		>18	202 (50)	639 (55)	
	Patient gender	Male	174 (43)	536 (47)	0.16
		Female	230 (57)	602 (53)	
	Aboriginal or Torres Strait Islander	No	390 (99.5)	1031 (97)	0.012
		Yes	2 (0.5)	33 (3)	
	NESB	No	362 (92)	978 (91)	0.41
		Yes	30 (8)	97 (9)	
	Patient practice status	Existing patient	85 (21)	263 (23)	0.68
		New to registrar	270 (67)	751 (65)	
		New to practice	51 (13)	134 (12)	
Registrar factors	Registrar gender	Male	164 (40)	484 (41)	0.63
		Female	246 (60)	686 (59)	
	Registrar full-time or part-time	Part-time	88 (22)	232 (20)	0.51
		Full-time	313 (78)	906 (80)	
	Term	Term 1	125 (30)	439 (38)	0.006
		Term 2	185 (45)	519 (44)	
		Term 3	100 (24)	212 (18)	
	Worked at practice previously	No	320 (79)	873 (76)	0.17
		Yes	85 (21)	281 (24)	
	Qualified as doctor in Australia	No	67 (16)	240 (21)	0.064
		Yes	342 (84)	924 (79)	
	Registrar age	Mean (s.d.)	32 (6)	33 (6)	0.070
Practice factors	Practice size	Small	145 (36)	392 (34)	0.57
		Large	258 (64)	747 (66)	
	Practice routinely bulk bills	No	319 (79)	817 (71)	0.002
		Yes	84 (21)	330 (29)	
	Rurality	Major city	270 (66)	736 (64)	0.12
		Inner regional	102 (25)	272 (24)	
		Outer regional remote	36 (9)	146 (13)	
	Region	Region 1	80 (20)	253 (22)	0.001
		Region 2	17 (4)	97 (8)	
		Region 3	33 (8)	131 (11)	
		Region 4	173 (42)	399 (34)	
		Region 5	10 (2)	28 (2)	
		Region 6	64 (16)	207 (18)	
		Region 7	33 (8)	55 (5)	

(Continued)

Table 3. (Continued)

			Antibiotic prescribed for Conjunctivitis		
Factor group	**Variable**	**Class**	**No**	**Yes**	**P**
	SEIFA-IRSD (Decile) of practice	Mean (s.d.)	6 (3)	6 (3)	<0.001
Consultation factors	Sought help any source	None	325 (79)	892 (76)	0.44
		Supervisor	29 (7)	91 (8)	
		Other sources	56 (14)	187 (16)	
	Consultation duration	mean (s.d.)	16 (8)	16 (7)	0.13
	Number of problems	mean (s.d.)	2 (1)	2 (1)	0.13
	Pathology ordered	No	387 (94)	1082 (92)	0.19
		Yes	23 (6)	88 (8)	
	Learning goals generated	No	323 (84)	928 (83)	0.92
		Yes	63 (16)	184 (17)	
	Follow-up ordered	None	297 (72)	721 (62)	<0.001
		With registrar	111 (27)	413 (35)	
		With another GP in the practice	2 (0.5)	36 (3)	
	Referral ordered	No	395 (96)	1138 (97)	0.35
		Yes	15 (4)	32 (3)	

Data are presented as *n* (%).
NESB, non-English speaking background; SEIFA-IRSD, Socioeconomic Index for Areas Index of Socioeconomic Disadvantage.

significant at this time, excessive prescription of these agents may have other ramifications.

Overprescribing antibiotics has important social and economic repercussions. High rates of antibiotic prescribing for minor infective illnesses, including conjunctivitis, contributes to public misapprehension about the disease and reinforces a belief in the need for antibiotics in all cases. One qualitative study identified most patients with acute conjunctivitis, despite perceiving it as a minor illness, believed their illness would not clear up without treatment and that serious complications may occur without treatment.[35] Additionally, high rates of topical antibiotics generate large and unnecessary costs,[11,14] so rationalising prescribing for the condition may have economic benefits. Reducing antibiotic prescribing is essential for decreasing public misinformation about infective conditions and reducing unnecessary health-care expenditure.

The high prevalence of antibiotic prescribing has additional educational implications for GP training. There are several reasons why GP trainees may prescribe antibiotics inappropriately for infective conjunctivitis. Patients' expectations and preference for antibiotics may be important factors, particularly given the perceived infectivity of conjunctivitis in leading to work and school exclusion, despite a lack of evidence for these exclusionary policies.[36] Additionally, GP trainees may find management of ophthalmological problems particularly challenging.[10] A lack of clinical confidence in managing the condition, including lack of diagnostic confidence, fear of possible complications and perceived patient dissatisfaction with lack of prescribing, may also be important factors in registrars' prescribing for conjunctivitis, as they are for respiratory infections.[4–7] Consideration of our current findings, together with these contextual factors, may inform GP registrar training around clinical decision-making for conjunctivitis, and patient engagement in this process.

Strengths and limitations

The size of the ReCEnT study of GP vocational training is an important strength. This, and the high response rate, which is unusual in GP studies,[37] produce good generalisability to Australian GP vocational training, and is likely to be similar to

Table 4. Associations of antibiotic prescription for newly diagnosed conjunctivitis by multiple regression analysis

			Univariate		Adjusted	
Factor group	**Variable**	**Class**	**OR (95% CI)**	**P**	**OR (95% CI)**	**P**
Patient factors	Patient gender	Female	0.85 (0.68, 1.07)	0.1642	0.80 (0.62, 1.04)	0.098
	Aboriginal or Torres Strait Islander	Yes	5.07 (1.37, 18.7)	0.0150	17.6 (1.05, 295)	0.046
Registrar factors	Term (Comparator = Term 1)	Term 2	0.80 (0.62, 1.04)	0.092	0.68 (0.48, 0.95)	0.025
		Term 3	0.60 (0.44, 0.82)	0.0014	0.47 (0.32, 0.68)	<0.001
	Worked at practice previously	Yes	1.21 (0.92, 1.59)	0.18	1.23 (0.85, 1.77)	0.28
	Qualified as doctor in Australia	Yes	0.76 (0.56, 1.02)	0.067	0.99 (0.65, 1.50)	0.96
	Registrar age		1.02 (1.00, 1.04)	0.074	1.01 (0.98, 1.04)	0.42
Practice factors	Practice routinely bulk bills	Yes	1.53 (1.16, 2.01)	0.002	1.38 (0.97, 1.98)	0.075
	Rurality (Comparator = Major City)	Inner regional	0.98 (0.75, 1.27)	0.86	0.85 (0.55, 1.31)	0.46
		Outer regional remote	1.47 (1.00, 2.18)	0.051	0.90 (0.48, 1.66)	0.73
	Region (Comparator = Region 1)	Region 2	1.77 (1.00, 3.13)	0.050	1.67 (0.83, 3.35)	0.15
		Region 3	1.25 (0.79, 1.97)	0.34	0.97 (0.56, 1.68)	0.90
		Region 4	0.73 (0.54, 0.99)	0.046	0.68 (0.45, 1.02)	0.064
		Region 5	0.86 (0.40, 1.84)	0.70	0.74 (0.28, 1.97)	0.55
		Region 6	1.02 (0.70, 1.49)	0.91	0.70 (0.41, 1.20)	0.20
		Region 7	0.53 (0.32, 0.87)	0.012	0.36 (0.19, 0.66)	0.001
	SEIFA-IRSD (Decile) of practice		0.92 (0.88, 0.96)	<0.001	0.97 (0.92, 1.02)	0.19
Consultation factors	Follow-up ordered (Comparator = No follow up)	With registrar	1.53 (1.19, 1.96)	<0.001	1.42 (1.06, 1.90)	0.019
		With another GP	6.02 (1.63, 22.2)	0.007	5.15 (1.35, 19.6)	0.016
	Consultation duration		0.99 (0.97, 1.00)	0.12	0.98 (0.96, 1.00)	0.021

CI, confidence interval; SEIFA-IRSD, Socioeconomic Index for Area-Index of Socioeconomic Disadvantage.

apprenticeship-model-like GP vocational training internationally.

A limitation is that our methodology does not elicit appropriateness of prescribing for individual patient cases, and we are unable to appreciate the complex social and medical comorbidities that influence individual prescription decisions. We cannot assess if prescriptions were filled by patients, nor do we have complete data for delayed prescriptions. Additionally, ascertainment of conjunctivitis may have led to inappropriate inclusion of allergic conjunctivitis in our analysis. This, however, would have biased our findings to lower prevalence of antibiotic prescribing. Our cross-sectional analysis cannot establish that the lower antibiotic prescribing in more senior registrars represents a longitudinal decrease in individual registrars' prescribing during training.

Conclusion

GP registrars prescribe antibiotics for conjunctivitis more than is justified by national evidence-based guidelines. Although there is no current Australian or international benchmark recommendation for topical antibiotic prescription for infective conjunctivitis, a prescribing rate of 74% can be considered excessive. This overprescribing is consistent with that of established GPs internationally.

Although more senior registrars prescribe less than their junior colleagues, there is still considerable scope for improvement. The associations of antibiotic prescribing we have established should inform educational approaches to reduce antibiotic prescribing for conjunctivitis and further shape GP registrar teaching.

Competing interests

The authors declare no competing interests.

References

1. Del Mar CB, Scott AM, Glasziou PP, et al. Reducing antibiotic prescribing in Australian general practice: time for a national strategy. Med J Aust. 2017;207(9):401–6. doi:10.5694/mja17.00574
2. eTG complete (digital). Melbourne: Therapeutic Guidelines Ltd; 2019. Available from: www.tg.org.au
3. van Driel ML, Morgan S, Tapley A, et al. Changing the Antibiotic Prescribing of general practice registrars: the ChAP study protocol for a prospective controlled study of a multimodal educational intervention. BMC Fam Pract. 2016;17:67. doi:10.1186/s12875-016-0470-7
4. Dallas A, Magin P, Morgan S, et al. Antibiotic prescribing for respiratory infections: a cross-sectional analysis of the ReCEnT study exploring the habits of early-career doctors in primary care. Fam Pract. 2015;32(1):49–55. doi:10.1093/fampra/cmu069
5. Dallas A, van Driel M, Morgan S, et al. Antibiotic prescribing for acute otitis media and acute sinusitis: a cross-sectional analysis of the ReCEnT study exploring the habits of early career doctors in family practice. Fam Pract. 2017;34(2):180–7. doi:10.1093/fampra/cmw144
6. Dallas A, van Driel M, Morgan S, et al. Antibiotic prescribing for sore throat: a cross-sectional analysis of the ReCEnT study exploring the habits of early-career doctors in family practice. Fam Pract. 2016;33(3):302–8. doi:10.1093/fampra/cmw014
7. Magin PJ, Morgan S, Tapley A, et al. Changes in early-career family physicians' antibiotic prescribing for upper respiratory tract infection and acute bronchitis: a longitudinal study. Fam Pract. 2016;33(4):360–7. doi:10.1093/fampra/cmw025
8. Heal C, van Driel M, Gorges H, et al. Antibiotic stewardship in skin infections: a cross-sectional analysis of early-career GPs' management of impetigo. BMJ Open. 2019;9(10):e031527. doi:10.1136/bmjopen-2019-031527
9. Dallas A, van Driel M, de Mortel T, et al. Antibiotic prescribing for the future: exploring the attitudes of trainees in general practice. Br J Gen Pract. 2014;64(626):e561–7. doi:10.3399/bjgp14X681373
10. Morgan S, Tapley A, Henderson K, et al. Australian general practice trainees' exposure to ophthalmic problems and implications for training: a cross-sectional analysis. J Prim Health Care. 2016;8(4):295–302. doi:10.1071/HC16024
11. Schneider J, Scheibling C, Segall D, et al. Epidemiology and economic burden of conjunctivitis: a managed care perspective. J Manag Care Med. 2014;17(1):78–83.
12. Azari AA, Barney NP. Conjunctivitis: a systematic review of diagnosis and treatment. JAMA. 2013;310(16):1721–9. doi:10.1001/jama.2013.280318
13. Buznach N, Dagan R, Greenberg D. Clinical and bacterial characteristics of acute bacterial conjunctivitis in children in the antibiotic resistance era. Pediatr Infect Dis J. 2005;24(9):823–8. doi:10.1097/01.inf.0000178066.24569.98
14. Smith AF, Waycaster C. Estimate of the direct and indirect annual cost of bacterial conjunctivitis in the United States. BMC Ophthalmol. 2009;9:13. doi:10.1186/1471-2415-9-13
15. Marinos E, Cabrera-Aguas M, Watson SL. Viral conjunctivitis: a retrospective study in an Australian hospital. Cont Lens Anterior Eye. 2019;42(6):679–84. doi:10.1016/j.clae.2019.07.001
16. Everitt H, Little P. How do GPs diagnose and manage acute infective conjunctivitis? A GP survey. Fam Pract. 2002;19(6):658–60. doi:10.1093/fampra/19.6.658
17. Sheikh A, Hurwitz B. Topical antibiotics for acute bacterial conjunctivitis: Cochrane systematic review and meta-analysis update. Br J Gen Pract. 2005;55:962–4.
18. Rose PW, Ziebland S, Harnden A, et al. Why do General Practitioners prescribe antibiotics for acute infective conjunctivitis in children? Qualitative interviews with GPs and a questionnaire survey of parents and teachers. Fam Pract. 2006;23(2):226–32. doi:10.1093/fampra/cmi101
19. Royal Australian and New Zealand College of Ophthalmologists. Chloramphenicol use in ophthalmic practice: RANZCO Position Statement. Sydney (AU): The Royal Australian and New Zealand College of Ophthalmologists; 2018. 5 p.
20. Keen M, Thompson M. Treatment of acute conjunctivitis in the United States and evidence of antibiotic overuse: isolated issue or a systematic problem? Ophthalmology. 2017;124(8):1096–8. doi:10.1016/j.ophtha.2017.05.029
21. Conjunctivitis (2019). eTG complete [digital]. Melbourne: Therapeutic Guidelines Limited; 2020. Available from: www.tg.org.au
22. Jefferis J, Perera R, Everitt H, et al. Acute infective conjunctivitis in primary care: who needs antibiotics? An individual patient data meta-analysis. Br J Gen Pract. 2011;61(590):e542–8. doi:10.3399/bjgp11X593811
23. Taylor R, Randloff A, Edwards D, et al. Australian General Practice Training Program National Report on the 2017 National Registrar Survey. Canberra, ACT: Australian Government Department of Health; 2018. Available from: https://research.acer.edu.au/higher_education/57
24. Morgan S, Magin P, Henderson K, et al. Study protocol: the registrar clinical encounters in training (ReCEnT) study. BMC Fam Pract. 2012;13:50. doi:10.1186/1471-2296-13-50
25. Magin P, Morgan S, Henderson K, et al. The Registrars' Clinical Encounters in Training (ReCEnT) project: educational and research aspects of documenting general practice trainees' clinical experience. Aust Fam Physician. 2015;44(9):681–4.
26. Rietveld RP, ter Riet G, Bindels PJE, et al. Do general practitioners adhere to the guideline on infectious conjunctivitis? Results of the Second Dutch National Survey of General Practice. BMC Fam Pract. 2007;8:54. doi:10.1186/1471-2296-8-54
27. Shekhawat NS, Shtein R, Blachley T, et al. Antibiotic prescription fills for acute conjunctivitis among enrollees in a large United States managed care network. Ophthalmology. 2017;124(8):1099–107. doi:10.1016/j.ophtha.2017.04.034
28. Australian Institute of Health and Welfare. Indigenous eye health measures 2018. Canberra: Australian Institute of Health and Welfare; 2019. 147 p.
29. Bowen AC, Daveson K, Anderson L, Tong SYC. An urgent need for antimicrobial stewardship in Indigenous rural and remote primary health care. Med J Aust. 2019;211(1):9–11.e1. doi:10.5694/mja2.50216
30. Björnsdóttir I, Kristinsson K, Hansen E. Diagnosing infections: a qualitative view on prescription decisions in general practice over time. Pharm World Sci. 2010;32(6):805–14. doi:10.1007/s11096-010-9441-6

31. Australian Commission on Safety and Quality in Health Care (ACSQHC). AURA 2019: third Australian report on antimicrobial use and resistance in human health. Report No. 3. Sydney: Australian Commission on Safety and Quality in Health Care; 2019. p. 274.
32. Asbell PA, Colby K, Deng S, et al. Ocular TRUST: nationwide antimicrobial susceptibility patterns in ocular isolates. Am J Ophthalmol. 2008;145(6):951–8.e1. doi:10.1016/j.ajo.2008.01.025
33. Asbell PA, Sanfilippo CM, Pillar CM, et al. Antibiotic resistance among ocular pathogens in the United States: five-year results from the Antibiotic Resistance Monitoring in Ocular Microorganisms (ARMOR) Surveillance Study. JAMA Ophthalmol. 2015;133(12):1445–54. doi:10.1001/jamaophthalmol.2015.3888
34. Silvester A, Neal T, Czanner G, et al. Adult bacterial conjunctivitis: resistance patterns over 12 years in patients attending a large primary eye care centre in the UK. BMJ Open Ophthalmol. 2016;1(1):.
35. Everitt H, Kumar S, Little P. A qualitative study of patients' perceptions of acute infective conjunctivitis. Br J Gen Pract. 2003;53:36–41.
36. Finnikin S, Jolly K. Nursery sickness policies and their influence on prescribing for conjunctivitis: audit and questionnaire survey. Br J Gen Pract. 2016;66(650):e674–9. doi:10.3399/bjgp16X686125
37. Bonevski B, Magin P, Horton G. Response rates in GP surveys: trialling two recruitment strategies. Aust Fam Physician. 2011;40(6):427–30.