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ORIGINAL ARTICLE

GPs' antibiotic prescription patterns for respiratory tract infections – still room for improvement

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Abstract
Objective. Inappropriate use of antibiotics is associated with increased antibiotic resistance in the community. About 90% of all antibiotic prescriptions in Norway are issued by general practitioners and in 60% issued for respiratory tract infections. The article describes and analyses antibiotic prescription patterns by general practitioners in Vestfold, Norway. *Design.* Prospective cohort study. *Subjects.* A total of 145 list-holding general practitioners in Vestfold, Norway in February to March 2003. *Methods.* Merging of two electronic administrative data sets: antibiotic prescriptions dispensed in pharmacies and general practitioners' electronic bills from the National Insurance Agency. *Main outcome measures.* Proportion and type of antibiotic prescribed for different respiratory tract infectious diagnoses. *Results.* We found large variations among general practitioners' antibiotic prescription habits. In 27% of consultations with RTI diagnoses, an antibiotic was prescribed; 37% were for Penicillin V and 28% for a macrolide. Quinolones and cephalosporins were only rarely prescribed. In a logistic regression analysis the following factors were independently associated with antibiotic prescription rate: type of infection, type of contact, being a general practitioner specialist, and years since medical exam. In another logistic regression analysis the following factors were independently associated with broad-spectrum antibiotic prescription: type of infection, age of patient, type of contact, being a specialist, length of list, and being a high prescriber of antibiotics. *Conclusion.* The variation in proportion of total antibiotic prescribing and broad-spectrum prescription for respiratory tract infections is high, and reveals potentials to change general practitioners' prescription behaviour, in order to maintain the positive situation in Norway as to antibiotic resistance.

Key Words: *Antibiotics, family practice, general practice, predictors, respiratory infection*

Inappropriate use of antibiotics is of great public health concern because of its association with increased antibiotic resistance in the community [1]. Bacterial strains that are increasingly resistant to antimicrobial agents pose a severe health threat, and of particular concern is community-acquired infections caused by multi-drug-resistant *Streptococcus pneumoniae* [2,3], macrolide-resistant *Streptococcus pyogenes* [4–6], and methicillin-resistant *Staphylococcus aureus* [7,8].

Low levels of antimicrobial resistance in Scandinavian countries are probably due to relatively conservative antimicrobial prescribing practice, compared with southern Europe and the USA [9]. In Norway, the vast majority of all antibiotic prescriptions (90%) are issued by general practitioners (GPs). About 60% of these are prescribed for common respiratory tract infections (RTIs) [10]. In a general practice survey from another Norwegian county [10], the authors found that antibiotics often were prescribed for probable viral infections, e.g. acute bronchitis. In a Dutch study Kuyvenhoven et al. found that antibiotic prescription for RTI was associated only with number of years in practice and doctor's general attitude towards prescribing [11]. An Italian study found that geographical location and number of patients under care was associated [12]. In the USA, Gonzales found that female patient gender and rural practice were associated with more antibiotic prescribing [5]. Another American study showed that type of specialty and

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Large variations were found in list-holding GPs' prescribing habits for respiratory tract infections, both for antibiotic prescribing rates and proportion of broad-spectrum antibiotics.

- In 27% of consultations with respiratory tract infections, an antibiotic was prescribed; 37% were Penicillin V and 28% were macrolides.
- The GPs with the highest prescription rate were also more likely to prescribe broad-spectrum antibiotics.

geography were both associated with prescription of broad-spectrum antibiotics [13].

In the national guidelines (2000) for antibiotic prescribing in Norwegian general practice [14], two main goals were pointed out: to reduce the overall antibiotic prescription by 30% to reach the Dutch level of utilization and to use relatively as many narrow-spectrum compounds as possible for RTIs to counteract development of resistance. To our knowledge no previous studies have been performed to analyse predictors for antibiotic prescription in Norway.

The purpose of this study was to

- describe and analyse antibiotic prescriptions in general practice by diagnosis, encounter and patient and physician characteristics;
- describe the variation in antibiotic prescribing among GPs in Vestfold;
- find predictors for total prescribing of antibiotics and for prescribing of broad-spectrum antibiotics for RTIs.

Material and methods

In Norway, general practice is organized as a list system implying that every citizen has one particular general practitioner (GP). Part of the GP's salary is paid for by the National Insurance Agency (NIA), based on bills from the GPs regarding all patient encounters. Furthermore, all antimicrobial agents are prescription drugs, and the pharmacies make an electronic record each time a prescription drug is dispensed.

Vestfold is located in the south-eastern part of Norway and has a total population of approximately 200 000. At the time of the study there were 152 list-holding GPs in the county. The study was based on electronically provided data from February and March 2003, where datasets from the National Insurance Administration (NIA) and the prescription database from the pharmacies were merged. From these two sources it is possible not only to analyse the total use of antibiotics in the county, but also to relate the dispensed antibiotics to the diagnoses set at preceding contacts with the general practitioners.

Merging pharmacies' dispensing data for prescription drugs with the contact data was done by using patient's date of birth (PID), doctor's identity (DID) code from the National Registry of Health Professionals (NRAH), and dates for encounters and dispensing. Each prescription with information on PID and DID was checked against corresponding contact records. A GP–patient contact with matching PID and DID occurring 0–7 days before antibiotic delivery was considered to be the contact leading to prescription. If two or more contacts within the period matched the criteria, the one closest in time was selected.

During the two months 11 400 antibiotic prescriptions were issued by the GPs in the county. About 3000 (26%) antibiotic prescriptions (pharmacy data) did not match preceding general practice encounters (NIA data). They represent prescriptions made by seven list-holding doctors who did not use electronic data handling plus prescriptions following patient encounters that took place in emergency rooms which were not included in our data file.

We included all R-code diagnoses in the International Classification of Primary Care (ICPC) except R96 (asthma) and R97 (allergic rhinitis) which we consider not to be relevant for antibiotic prescriptions. We included ICPC symptom codes R01–R29 in the URTI group in order to achieve the most relevant selection of patients. The diagnostic codes H01, H70–72, and H74 were included to reflect prescriptions for otitis media. One or two ICPC codes were available for each recorded contact. With two diagnoses, the code most relevant for antibiotic prescription was selected. Broad-spectrum antibiotics in this article are defined as antibiotics other then Penicillin V (phenoxymethyl penicillin).

SPSS was used for the descriptive analyses. To identify predictors for antibiotic prescription in RTIs, we performed two multilevel logistic regression modellings in STATA with antibiotic prescription and broad-spectrum prescribing respectively as the dependent variable. The level of statistical significance was set to 0.05. The study was approved by the regional ethical committee and the Norwegian Data Inspectorate.

Results

During the two months, the overall antibiotic prescription rate was 27 per 100 visits for RTIs or 32 per 100 patients with RTIs (Table I). A visit is defined

Table I. Antibiotic prescriptions and diagnoses from 145 Norwegian list-holding general practitioners in Vestfold country, February–March 2003.

Diagnoses	ICPC codes	Phenoxymethyl penicillin %	Broad spectrum penicillins %	Macrolides and lincosamides %	Tetracyclines %	Trimetoprim %	Cotrimoxazole %	Nitrofurantoin %	Other ATC J01 %	Total prescriptions on visits n	Patient visits n	Prescriptions per 100 visits	Prescriptions per 100 patients	Prescriptions indirect contacts n	Indirect patients' contact n	Prescriptions per 100 indirect contacts
Upper respiratory tract symptoms and infections	R01-29 + R74	37	8	37	15	1	1	0	1	845	5362	16	18	136	2418	6
Acute bronchitis	R78	21	8	30	39	0	1	0	1	584	1066	55	64	45	374	12
COPD/Chronic bronchitis	R91 + R95	5	13	17	48	6	4	1	6	137	895	15	20	37	645	6
Ear infections	H01/70-72/74	45	27	23	1	1	2	0	0	361	1165	31	37	20	200	10
Pneumonia	R81	24	13	26	34	0	0	0	3	410	929	44	58	69	473	15
Sinusitis	R75	36	16	30	18	1	0	0	0	581	915	63	70	104	453	23
Acute to nsillitis	R72/76	72	6	19	2	0	1	0	0	668	992	67	75	54	284	19
Other respiratory diagnoses	Other R diagnoses	22	15	31	27	2	1	0	3	385	3138	12	15	96	2220	4
Total respiratory diagnoses		37	12	28	20	1	1	0	1	3971	14462	27	32	561	7067	8
All other ICPC diagnose codes		15	20	21	12	21	2	3	6	2514	67818	4	5	813	57561	1

On–call prescriptions omitted.

as a consultation in the GP's office (based on the contact code), leading to a respiratory tract or ear diagnosis. The difference between the rates reflects that several patients had more than one visit during the study period. When antibiotics were issued for RTIs, penicillins were used in 49% (phenoxymethyl penicillin (pcV) 37%) and macrolides/lincosamides in 28% of cases.

Upper respiratory tract infections (URTIs) had an antibiotic prescription rate of 18 per 100 patients, and pcV and macrolides/lincosamides were equally prescribed (37% each). Acute tonsillitis had the highest antibiotic prescription rate (75 per 100 patients) of all the RTI diagnoses; pcV was issued in 72% of these. In sinusitis the overall prescription rate was 70 per 100 patients, with a pcV fraction of 36% and a macrolide/lincosamide fraction of 30%. In pneumonia the prescription rate was 58 per 100 patients with a pcV fraction of 24%. The rate for acute bronchitis was 64 per 100 patients with a pcV fraction of 21%.

We also recorded prescriptions per indirect contacts (telephones or visits at the counter). Sinusitis dominated with a rate of 23 per 100 indirect contacts, followed by tonsillitis with a rate of 19 per 100.

Gender information was missing in 5.2% of the prescriptions. Of the remaining, 62.2% were issued to female patients and 37.8% to male patients.

A considerable variation in antibiotic prescription patterns for RTIs was seen among individual GPs (Figure 1). Those assigned to the highest quintile of prescribers prescribed antibiotics three times more frequently than those in the lowest quintile (32% vs 11%).

Figure 2 demonstrates the proportion of broad-spectrum antibiotics by total antibiotic prescription for each doctor. The doctors in the highest quintile had an average of 88% prescriptions of broad-spectrum antibiotics, as compared with the lowest quintile who prescribed 32% broad-spectrum antibiotics for respiratory tract infections.

The multiple logistic regression analysis revealed the following independent predictors for antibiotic prescribing (Table II): type of infection (tonsillitis and sinusitis had the highest odds ratio followed by acute bronchitis, pneumonia, and ear diagnoses), type of contact (higher prescription rate at consultations), being a specialist (lower prescription rate). We also found that doctors who had their medical exams in the period 1981–1990 had the lowest prescription rate.

Table III demonstrates the logistic regression analysis to find predictors for broad-spectrum antibiotic prescription. The following factors were found to be independently associated with high broad-spectrum prescription: type of infection (higher for lower respiratory tract infections including pneumonia, chronic obstructive pulmonary disease COPD, and acute bronchitis), age of patient (higher proportion for older patients), type of contact (higher proportion for simple encounters and telephone contact), being a specialist (gave a near significant lower proportion), length of list (shortest lists gave low proportion) and being a high prescriber of antibiotics (the two highest quintiles had a significantly higher proportion of broad-spectrum prescribing than the lowest quintile).

Discussion

The use of new broad-spectrum antibiotics such as quinolones and cephalosporines accounted only for 1% (Other ATC J01, see Table I) while penicillins accounted for 49% of the GPs' prescriptions for RTIs. This corresponds well with national figures for the same time period [15], and may be one important contributing factor for the low level of antibiotic resistance in Norway. The 28% share made up by macrolides and lincosamides probably reflects more frequent use of these compounds as compared with the 16% reported from Norwegian general practice back in 1989 [10]. This development is not in according with the guidelines distributed to all Norwegian GPs in 2000, highlighting first-hand use of macrolides only for atypical lower respiratory tract infections and allergy to penicillins. Of all patients treated with antimicrobial drugs in general practice, only 1% will develop skin reactions to the drug [16]. Penicillin allergy should therefore not account for the majority of the macrolide prescriptions. We have, however, no data in our study that can substantiate this topic. An increase in macrolide prescription in outpatient care of 33% from 1999 to 2005 has been registered nationally along with a rise in proportion of pneumococci with lowered sensitivity or resistance to macrolides seen in blood cultures in hospitals [15]. As RTIs are one of the main indications for prescribing macrolides it is even more important to focus on correct use of this group of antibiotics [12,17].

The variation in proportion of total antibiotic prescribing and broad-spectrum prescription is high, as the quintile of doctors with high prescription prescribes almost three times as frequent as the lowest quintile. This variation reveals potentials to change GPs prescription behaviour, in order to maintain the positive situation in Norway regarding antibiotic resistance [15]. A number of Nordic studies have highlighted this topic during the last years [18–21].

Among doctor factors in the logistic regression analysis, being a specialist gave lower prescription rate (odds ratio 0.66, $p < 0.01$). We also found that doctors whose medical exam was in the period 1981–1990 (i.e. 12–22 years of practice) had the lowest prescription rates. This is in line with the Dutch

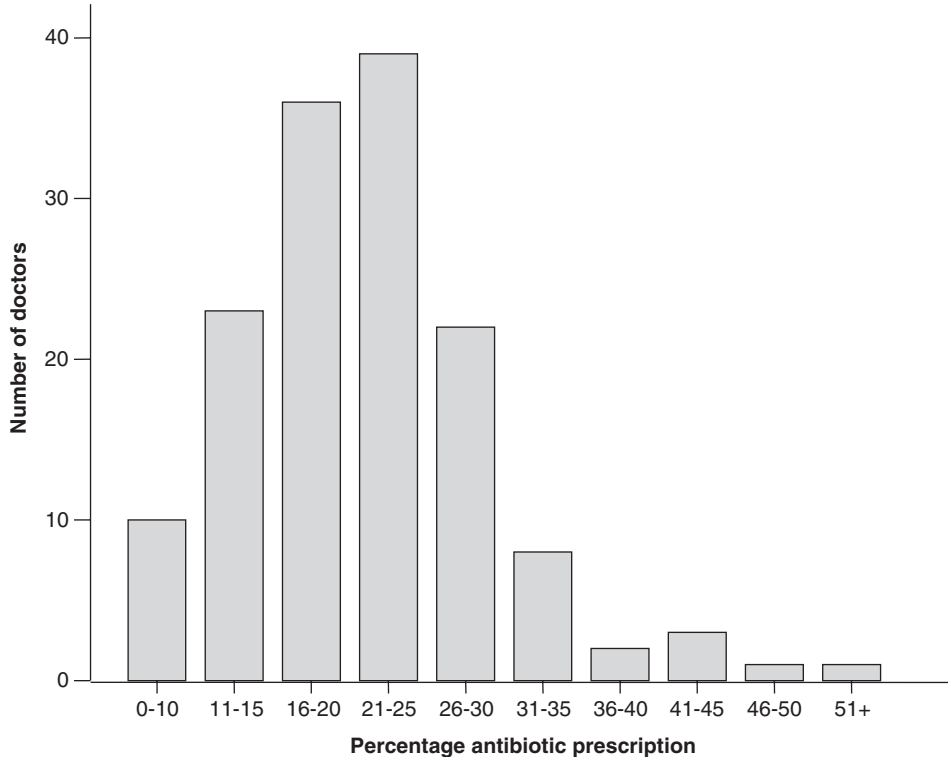

Figure 1. Proportion of antibiotic prescription on visits for respiratory tract infections, winter 2003, among listholding GPs in Vestfold county, given as percentages.

study [11], and may reflect that experienced GPs are best at avoiding unnecessary antibiotic prescribing. This benefit, however, seemed in our data to diminish with further increase in years of practice.

We found a number of factors to be independently associated with prescribing of broad-spectrum antibiotics. We find it interesting that a high total prescribing of antibiotics was a significant predictor for

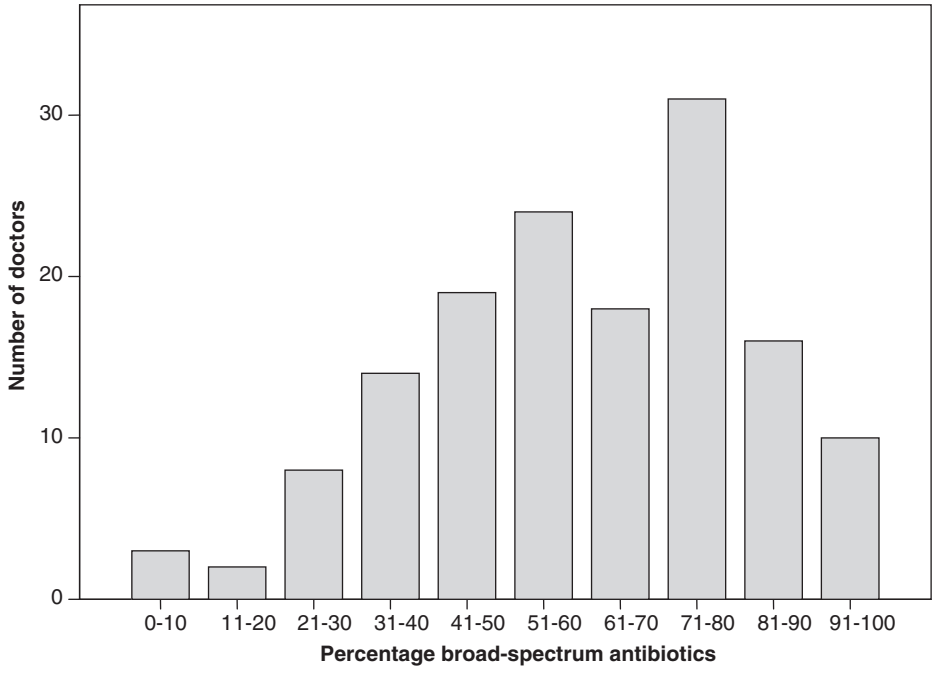

Figure 2. Proportion of broad-spectrum antibiotic prescription on visits for respiratory tract infections, winter 2003, among listholding GPs in Vestfold county, given as percentages.

Table II. Logistic regression analysis with factors independently associated with prescription of antibiotics for respiratory tract infections among list-holding doctors, during two winter months in Vestfold county, winter 2003.

Factor	Bivariate analysis OR (95% CI) p-value	Multivariate analysis OR (95% CI) p-value
Patient factors:		
Type of respiratory tract infections (RTI)		
URTI + URT symptoms (REF)	1.00	1.00
Acute bronchitis	5.43 (4.36–6.76) < 0.01	5.75 (4.62–7.15) < 0.01
COPD/chronic bronchitis	0.88 (0.72–1.07) 0.21	1.00 (0.80–1.24) 1.00
Acute otitis media + ear pain	2.70 (2.21–3.30) < 0.01	2.62 (2.08–3.31) < 0.01
Pneumonia	3.61 (2.96–4.36) < 0.01	4.39 (3.52–5.47) < 0.01
Acute sinusitis	6.94 (5.65–8.53) < 0.01	8.69 (6.86–11.0) < 0.01
Acute tonsillitis	9.14 (7.10–11.78) < 0.01	10.27 (7.66–13.8) < 0.01
Other airway diagnoses	0.69 (0.55–0.86) < 0.01	0.77 (0.62–0.95) 0.01
Age		
51+ (REF)	1.00	1.00
33–50	1.33 (1.22–1.46) < 0.01	1.07 (0.97–1.18) 0.16
0–32	1.21 (1.07–1.36) < 0.01	0.94 (0.83–1.07) 0.38
Gender of patient		
Female (ref)	1.00	1.00
Male	0.98 (0.92–1.06) 0.66	1.05 (0.97–1.13) 0.25
Contact type		
Telephone		
+ simple encounter (REF)	1.00	1.00
Consultations + home visits	4.41 (3.82–5.09) < 0.01	4.63 (3.94–5.45) < 0.01
Doctor factors:		
Gender of doctor		
Female (REF)	1.00	1.00
Male	1.09 (0.93–1.29) 0.30	1.18 (0.98–1.41) 0.08
Specialist		
Non-specialist (REF)	1.00	1.00
Specialist GP	0.97 (0.80–1.17) 0.76	0.66 (0.50–0.88) < 0.01
Length of list		
1001–1500 (REF)	1.00	1.00
1501–2000	1.09 (0.91–1.30) 0.36	0.89 (0.69–1.15) 0.37
2001+	1.37 (1.13–1.67) < 0.01	0.95 (0.74–1.23) 0.71
0–1000	1.09 (0.81–1.48) 0.56	1.08 (0.83–1.39) 0.57
Year of medical exam		
1958–1970 (REF)	1.00	1.00
1971–1980	1.02 (0.84–1.24) 0.83	0.90 (0.74–1.11) 0.33
1981–1990	0.91 (0.73–1.15) 0.43	0.62 (0.45–0.86) < 0.01
1991 +	0.93 (0.69–1.26) 0.63	0.90 (0.64–1.28) 0.57

Note: Analysis was done with multilevel modelling in STATA (n = 21 529).

broad-spectrum antibiotic prescribing, although this was most obvious for highest prescribers. This is in line with a previous Danish study [22]. Steinman et al. in the US found that being a specialist (other than GP specialist) vs a GP was a strong predictor for broad-spectrum prescribing [13]. Samore et al. have demonstrated a clear relation between the use of broad-spectrum antibiotics and resistance versus penicillins of pneumococci in a study of children with carriage of resistant pneumococci [23]. The use of cephalosporins more than doubled the risk of being carrier while the use of penicillins reduced the chance with an odds ratio of 0.20 [23]. Arason et al. analysed the relation between prevalence of multiresistant pneumococci among Icelandic children and found that use of broad-spectrum antibiotics was significantly associated with high prevalence of resistance [24].

The prescription rate for acute bronchitis is among the highest (64 per 100 patients) in this study. Macrolides are frequently used (30% of the prescriptions) to treat acute bronchitis, a condition that according to a Cochrane review [25] has limited beneficial effects from antibiotic treatment. This may reflect one of the most controversial usages of antibiotics in the study.

Pneumonia has a surprisingly low prescription rate of 44 per 100 visits (58 per 100 patients). This may be due to the fact that these patients more often are admitted to hospital or treated in the emergency room. However, many of them visit their GP for follow-up after recovery from their illness. We have, unfortunately, no means of telling which visits are

Table III. Logistic regression analysis with factors independently associated with prescription of broad-spectrum antibiotics for respiratory tract infections among list-holding doctors, during two winter months in Vestfold county, winter 2003.

Factor	Bivariate analysis OR (95% CI) p–value	Multivariate analysis OR (95% CI) p–value
Patient factors:		
Type of respiratory tract infections (RTI)		
URTI + URT symptoms (REF)	1.00	1.00
Acute bronchitis	2.08 (1.52–2.84) < 0.01	1.61 (1.15–2.26) < 0.01
COPD/chronic bronchitis	4.65 (2.44–8.87) < 0.01	2.53 (1.31–4.88) < 0.01
Acute otitis media + ear pain	0.69 (0.50–0.96) 0.03	0.75 (0.53–1.06) 0.11
Pneumonia	1.75 (1.22–2.50) < 0.01	1.38 (0.94–2.01) 0.10
Acute sinusitis	1.06 (0.78–1.46) 0.71	0.94 (0.69–1.29) 0.70
Acute tonsillitis	0.24 (0.18–0.31) < 0.01	0.23 (0.17–0.30) < 0.01
Other airway diagnoses	2.04 (1.45–2.86) < 0.01	1.82 (1.26–2.62) < 0.01
Age		
51+ (REF)	1.00	1.00
33–50	0.47 (0.39–0.58) < 0.01	0.75 (0.61–0.92) < 0.01
0–32	0.37 (0.30–0.45) < 0.01	0.64 (0.50–0.82) < 0.01
Gender of patient		
Female (ref)	1.00	1.00
Male	0.99 (0.87–1.13) < 0.01	1.05 (0.89–1.24) 0.59
Contact type		
Telephone		
+ simple encounter (REF)	1.00	1.00
Consultations + home visits	0.48 (0.39–0.60) < 0.01	0.52 (0.40–0.68) < 0.01
Doctor factors:		
Gender of doctor		
Female (REF)	1.00	1.00
Male	1.17 (0.82–1.68) 0.38	1.20 (0.79–1.84) 0.39
Specialist		
Non-specialist GP (REF)	1.00	1.00
Specialist GP	0.89 (0.62–1.29) 0.55	0.64 (0.40–1.03) 0.07
Length of list		
1001–1500 (REF)	1.00	1.00
1501–2000	1.25 (0.89–1.76) 0.21	1.05 (0.74–1.51) 0.77
2001+	1.58 (1.02–2.47) 0.04	1.55 (0.83–2.88) 0.17
0–1000	0.56 (0.43–0.78) < 0.01	0.55 (0.39–0.76) < 0.01
Year of medical exam		
1958–1970 (REF)	1.00	1.00
1971–1980	1.06 (0.72–1.54) 0.78	1.15 (0.80–1.64) 0.45
1981–1990	0.63 (0.39–1.02) 0.06	0.67 (0.38–1.18) 0.17
1991 +	0.72 (0.43–1.19) 0.20	0.93 (0.57–1.53) 0.79
Rate of total antibiotic prescribing in quintiles		
Q1: 6.0–16.8% (ref)	1.00	1.00
Q2: 16.9–21.2%	1.14 (0.76–1.71) 0.53	1.16 (0.74–1.81) 0.52
Q3: 21.3–25.4%	1.01 (0.67–1.52) 0.96	1.09 (0.73–1.64) 0.68
Q4: 25.5–29.3%	1.78 (1.19–2.66) < 0.01	1.73 (1.04–2.90) 0.04
Q5: 29.4–54.0%	1.31 (0.85–2.01) 0.22	1.64 (1.05–2.56) 0.03

Note: Analysis was done with multilevel modelling in STATA (n = 3661).

primary and which are follow-ups for the diagnoses in our data. Tetracyclines (34%) are used almost as often as penicillins (37%). This is not in accordance with the guidelines [14]. The reason may be suspected atypical pneumonia or possibly a concurrent COPD diagnosis. It may also reflect a prolonged prescription for pneumonia, possibly initiated in hospital.

Ear infections account for 37 prescriptions per 100 patients, although studies show a limited effect of antibiotic treatment [26,27]. There are, however, exceptions to the rule [14]. To analyse this further, data would have to be separated into different age groups.

Generally, the high proportion of macrolides and tetracyclines is not justified by the diagnoses. The prescription rates for, in particular, acute bronchitis, acute sinusitis, and URTI and upper respiratory tract (URT) symptoms are still too high, as a large proportion of these conditions are caused by viruses.

The internal validity of our data is accounted for by the completeness of the data included. Another rea-

son why these findings probably reflect daily practice is that all data were gathered from electronic data records without the GPs' knowledge.

The study has two important limitations. The data cover only what happens in the GPs' daily practice in their surgeries and say nothing about what goes on in emergency rooms. Some studies suggest that antibiotic prescribing may be more liberal in an emergency room setting than in daily practice [28]. The other limitation is the diagnostic precision for the recorded diagnoses. This depends on the GP's personal interpretation and use of the diagnostic criteria and may therefore explain some of the variations seen between individual GPs.

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References

[1] Goossens H, Ferech M, Vander Stichele R, Elseviers M. Outpatient antibiotic use in Europe and association with resistance: a cross-national database study. Lancet 2005; 365:579–87.

[2] Gonzales R, Steiner JF, Sande MA. Antibiotic prescribing for adults with colds, upper respiratory tract infections, and bronchitis by ambulatory care physicians. Jama 1997;278:901–4.

[3] Gonzales R, Maselli J, Sande MA. Trends in antimicrobial treatment of acute respiratory tract infections by United States primary care physicians 1994–1999. J Gen Intern Med 2001;16:196–7.

[4] Gonzales R, Malone D, Sande MA. Estimating the amount and cost of ideal and excess antibiotic use for acute respiratory tract infections in the United States. Clin Infect Dis 2001;33:757–62.

[5] Gonzales R, Steiner JF, Lum A, Barrett PH, Jr. Decreasing antibiotic use in ambulatory practice: Impact of a multidimensional intervention on the treatment of uncomplicated acute bronchitis in adults. JAMA 1999;281:1512–19.

[6] Finkelstein JA, Davis RL, Dowell SF, Metlay JP, Soumerai SB, Rifas-Shiman SL, et al. Reducing antibiotic use in children: A randomized trial in 12 practices. Pediatrics 2001;108:1–7.

[7] Poses RM, Smith WR, McClish DK, Anthony M. Controlling for confounding by indication for treatment: Are administrative data equivalent to clinical data? Med Care 1995;33: AS36–46.

[8] Mainous AG, 3rd, Hueston WJ, Love MM, Evans ME, Finger R. An evaluation of statewide strategies to reduce antibiotic overuse. Fam Med 2000;32:22–9.

[9] Lindbaek M, Berild D, Straand J, Hjortdahl P. Influence of prescription patterns in general practice on anti-microbial resistance in Norway. Br J Gen Pract 1999;49:436–40.

[10] Straand J, Rokstad KS, Sandvik H. Prescribing systemic antibiotics in general practice. A report from the More & Romsdal Prescription Study. Scand J Prim Health Care 1998;16:121–7.

[11] Kuyvenhoven M, de Melker R, van der Velden K. Prescription of antibiotics and prescribers; characteristics: A study into prescription of antibiotics in upper respiratory tract infections in general practice. Fam Pract 1993;10:366–70.

[12] Mazzaglia G, Caputi AP, Rossi A, Bettoncelli G, Stefanini G, Ventriglia G, et al. Exploring patient- and doctor-related variables associated with antibiotic prescribing for respiratory infections in primary care. Eur J Clin Pharmacol 2003;59:651–7.

[13] Steinman MA, Landefeld CS, Gonzales R. Predictors of broad-spectrum antibiotic prescribing for acute respiratory tract infections in adult primary care. JAMA 2003;289:719–25.

[14] Berild D. Smittevernloven – håndbok. Antibiotika i allmennpraksis. Oslo: Statens helsetilsyn; 2000.

[15] NORM. NORM/NORM-VET report 2005. Consumption of antimicrobial agents and occurrence of antimicrobial resistance in Norway: University Hospital of Northern Norway; 2005.

[16] Linden PDvd, Lei Jvd, Vlug AE, Stricker BHC. Skin reactions to antibacterial agents in general practice. J Clin Epidemiol 1998;51:703–8.

[17] Brubakk O, Bruun JN. [When should macrolides be used in upper respiratory tract infections?]. Tidsskr Nor Laegeforen 2004;124:495–6.

[18] Hedin K, Andre M, Molstad S, Rodhe N, Petersson C. Infections in families with small children: Use of social insurance and healthcare. Scand J Prim Health Care 2006;24: 98–103.

[19] Jacobsen K. Re: GPs' reasons for "non-pharmacological" prescribing of antibiotics. Scand J Prim Health Care 2006; 24:191.

[20] Jansen AG, Sanders EA, Schilder AG, Hoes AW, de Jong VF, Hak E. Primary care management of respiratory tract infections in Dutch preschool children. Scand J Prim Health Care 2006;24:231–6.

[21] Strandberg EL, Ovhed I, Troein M, Hakansson A. Influence of self-registration on audit participants and their non-participating colleagues: A retrospective study of medical records concerning prescription patterns. Scand J Prim Health Care 2005;23:42–6.

[22] Steffensen FH, Schonheyder HC, Sorensen HT. High prescribers of antibiotics among general practitioners: Relation to prescribing habits of other drugs and use of microbiological diagnostics. Scand J Infect Dis 1997;29:409–13.

[23] Samore MH, Lipsitch M, Alder SC, Haddadin B, Stoddard G, Williamson J, et al. Mechanisms by which antibiotics promote dissemination of resistant pneumococci in human populations. Am J Epidemiol 2006;163:160–70.

[24] Arason VA, Kristinsson KG, Sigurdsson JA, Stefansdottir G, Molstad S, Gudmundsson S. Do antimicrobials increase the carriage rate of penicillin resistant pneumococci in children? Cross sectional prevalence study. BMJ 1996;313:387–91.

[25] Smucny J, Flynn C, Becker L, Glazier R. Beta2-agonists for acute bronchitis. Cochrane Database Syst Rev 2004(1): CD001726.

[26] Neumark T, Mölstad S, Rosén C, Persson L-G, Törngren A, Brudin L, et al. Evaluation of phenoxymethylpenicillin treatment of acute otitis media in children aged 2–16. Scand J Prim Health Care 2007;25:166–71.

[27] Glasziou PP, Del Mar CB, Sanders SL, Hayem M. Antibiotics for acute otitis media in children. Cochrane Database Syst Rev 2004(1):CD000219.

[28] Smabrekke L, Berild D, Giaever A, Myrbakk T, Fuskevag A, Ericson JU, et al. Educational intervention for parents and healthcare providers leads to reduced antibiotic use in acute otitis media. Scand J Infect Dis 2002;34:657–9.