

BMJ Open Compliance with national guidelines for antibiotic prophylaxis in hip fracture patients: a quality assessment study of 13 329 patients in the Norwegian Hip Fracture Register

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ABSTRACT

Objective We assessed compliance with new guidelines for prophylactic antibiotics in hip fracture surgery in Norway introduced in 2013.

Design The data from the Norwegian Hip Fracture Register was used to assess the proportion of antibiotics given according to the national guidelines.

Setting All hospitals in Norway performing hip fracture surgery in the period from 2011 to 2016.

Participants We studied 13 329 hemiarthroplasties (HAs) for acute hip fracture.

Main outcome measure Type and timing between first and last dose of prophylactic antibiotics compared with the national guidelines.

Results Before the guidelines were introduced, the recommended drugs cephalotin or clindamycin was used in only 86.2% of all HAs. In 2016, one of the two recommended drugs was administered in 99.2% of HAs. However, hospitals' adaption of the recommended administration of the two drugs improved slowly, and by the end of the study period, only three out of five HAs were performed with the correct drug administered in the correct manner. We found major differences in compliance between hospitals.

Conclusions The change towards correct administration of antibiotic prophylaxis was varied both when investigating university and non-university hospitals. We suggest that both hospital leaders and the national Directorate of Health need to investigate routines for better dissemination of information and education to involved parties. Strong leadership concerning evidence-based guidelines on antibiotic prophylaxis in surgery may take away some autonomy from executing healthcare professionals, but will result in better patient care and antibiotic stewardship.

INTRODUCTION

Due to the complexity of modern medicine, guidelines and checklists have become a necessary part of treatment in all medical fields. For guidelines and checklists to have effect, it is imperative that they are used and

Strengths and limitations of this study

- The strengths of our study are the high coverage and completeness of the Norwegian Hip Fracture Register combined with the large number of patient forms we were able to investigate.
- Another strength is that the forms are filled out by the surgeon immediately after surgery, thereby ensuring correct information regarding prophylaxis.
- One limitation of our study is the lack of clear guidelines for clindamycin as a prophylactic drug.
- There may be a discrepancy between what was filled in on the form and the actual timing of the prophylaxis.
- The last clear limitation is the high number of excluded cases.

followed. Until 2013, there were no national guidelines for prophylactic antibiotics in orthopaedic surgery in Norway, and many different regimens were used. Engesaeter *et al.*¹ found the lowest risk of revision, for any reason, if four doses of antibiotics were administered systemically on the day of surgery in total hip arthroplasty. Extended prophylaxis of 2 or 3 days did not decrease the revision risk compared with four doses administered on the day of surgery according to that study.

Guidelines for prophylactic antibiotics in orthopaedic surgery was first introduced in Norway in 2013.² The guidelines were based on a thorough evaluation of available knowledge, using the Grades of Recommendation Assessment, Development and Evaluation (GRADE) system³ as a tool for giving the best possible recommendations and were published on the Norwegian Directorate of Health's website.² The guidelines state that cephalotin, a first-generation cephalosporin, should be the only drug of choice, except in



cases of penicillin allergy, where clindamycin should be used instead.

Cephalotin has a half-life of about 45 min, and should, therefore, be administered at short intervals (the guidelines state an interval of 90 min), to exceed minimal inhibitory concentrations (MIC). It is also recommended that the first dose should be administered 30–60 min before the incision is made.^{4–7} Studies have shown that this first dose probably is the most important one.^{6,8} For arthroplasty procedures, four doses were recommended. In cases of known penicillin allergy, four doses of clindamycin, administered every 6 hours, were recommended. When the guidelines were published, the aim was to improve administration of prophylactic antibiotics. From many different administration regimens, to a uniform regimen throughout Norway.

The aim of this study was to assess whether hospitals in Norway follow the new guidelines published by the Norwegian Directorate of Health, and if so, at what pace the guidelines were implemented.

MATERIAL AND METHODS

The Norwegian Hip Fracture Register (NHFR) has collected data on all hip fracture procedures in Norway since 2005.⁹ The information about the patient, fracture and type of surgery, as well as type of antibiotic prophylaxis, number of doses and duration recorded as the time interval between the first and the last dose in hours is reported to the NHFR on a one-page questionnaire completed by the surgeon immediately after each surgery. The questionnaires are sent from each hospital to the NHFR database for registration. Both primary surgery and reoperations are registered. The completeness of reporting to the NHFR compared with the Norwegian Patient Registry has been found to be 94.5% for primary hemiarthroplasties (HAs).¹⁰

The data from 19 106 HAs due to femoral neck fracture registered in the NHFR from 1 January 2011 to 31 December 2016 were evaluated, spanning 2 years before and 4 years after publication of the new guidelines. In

this studied period, around 90% of femoral neck fracture patients in Norway were treated with HA.¹⁰ Of these, some HAs had incomplete information on the total number of antibiotic doses (2521), type of antibiotic drug (107) and duration of prophylaxis (2805), and were excluded. We also excluded HAs where patients received more than one drug for prophylaxis (344). This left 13 329 HAs eligible for analyses.

One large hospital had a high number of excluded patients (n=1128). From that specific hospital, only 323 cases had been correctly reported, representing an inclusion rate of only 22%. Therefore, this hospital was excluded from the analyses due to infrequent correct reporting. Excluding the remaining reported cases from that hospital did not change our findings. In comparison, 27 hospitals had an inclusion rate of more than 75% and only 9 had an inclusion rate of between 50% and 60%.

Analyses of number of doses and duration of cephalotin prophylaxis revealed four main groups: completion of four doses within 4.5, 6, 12 and 24 hours, respectively. The timing of the first dose is not recorded in the NHFR, meaning that verification of whether this dose was given before surgery or not was not possible. We could, however, verify that doses were given at intervals short enough to keep concentrations above MIC. Stipulating that both 4.5 and 6 hours could be interpreted as correct administration of four doses with intervals of 90 min, we decided to treat these as one group, leaving three groups for analyses: in the first group, completion of all doses was registered as administered during the first 6 hours postoperatively; in the second group, it was completed between 7 and 12 hours postoperatively and in the third group, between 13 and 24 hours postoperatively. Four doses of cephalotin administered during the first 6 hours postoperatively were defined as the correct administration according to the guidelines.

The first version of the guidelines did not contain recommendations on number of doses or dosage for clindamycin. Therefore, both three and four doses of

Table 1 Type of antibiotic prophylaxis used from 2011 to 2016

	2011	2012	2013	2014	2015	2016
Cephalotin total	1860 (82.6%)	1926 (90.0%)	1919 (93.1%)	2070 (95.0%)	2109 (95.2%)	2346 (94.8%)
Correct administration (%)			86 (4.5%)	406 (19.6%)	955 (45.3%)	1379 (58.8%)
Incorrect administration (%)			1833 (95.5%)	1664 (80.4%)	1154 (54.7%)	967 (41.2%)
Clindamycin total	82 (3.6%)	73 (3.4%)	86 (4.2%)	86 (3.9%)	97 (4.4%)	112 (4.5%)
Correct administration (%)			74 (86%)	72 (83.7%)	83 (85.6%)	100 (89.3%)
Incorrect administration (%)			12 (14%)	14 (16.3%)	14 (14.4%)	12 (10.7%)
Other drug	311 (13.8%)	142 (6.6%)	57 (2.7%)	24 (1.1%)	9 (0.4%)	16 (0.6%)
Total	2253	2141	2062	2180	2215	2474
Correct administration (%)			7.8%	21.9%	46.9%	59.8%

Table 2 Patient characteristics

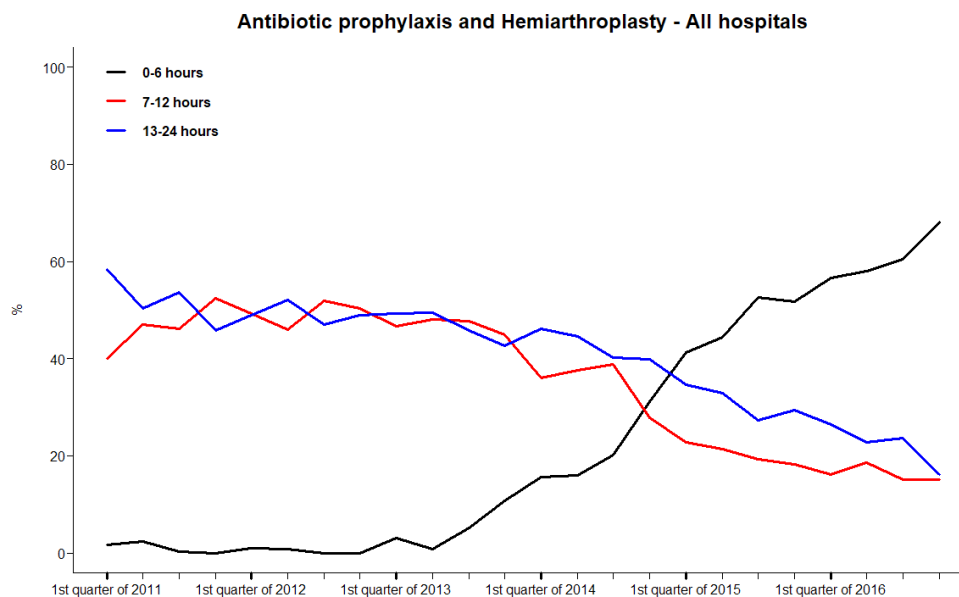
	Correct antibiotic and administration as stated in the guidelines of 2013	Incorrect antibiotic or administration as stated in the guidelines of 2013	All groups
Total number of HAs	3316	10013	13329
Age, mean	82.9	82.5	82.6
Gender, male (%)	1010 (30.5)	3020 (30.2)	4030 (30.2)
Dementia, no (%)	2047 (61.7)	6352 (63.4)	8399 (63)
Dementia, yes (%)	901 (27.2)	2564 (25.6)	3465 (26)
Dementia, uncertain (%)	306 (9.2)	908 (9.1)	1214 (9.1)
Dementia, missing (%)	62 (1.9)	189 (1.9)	251 (1.9)
ASA 1 (%)	29 (0.9)	122 (1.2)	151 (1.1)
ASA 2 (%)	997 (30.1)	3258 (32.5)	4255 (31.9)
ASA 3 (%)	1998 (60.3)	5872 (58.6)	7870 (59)
ASA 4 (%)	261 (7.9)	661 (6.6)	922 (6.9)
ASA 5 (%)	2 (0.1)	9 (0.1)	11 (0.1)
Missing ASA (%)	29 (0.9)	91 (0.9)	120 (1.0)
Anterolateral approach (%)	183 (5.5)	741 (7.4)	924 (6.9)
Direct lateral approach (%)	2466 (74.4)	8271 (82.6)	10737 (80.6)
Posterior approach (%)	634 (19.1)	811 (8.1)	1445 (10.6)
Other/missing approach (%)	33 (1)	190 (1.9)	223 (1.7)

clindamycin given over a period of 8–24 hours were defined as the correct administration according to the guidelines.

Treatments for all types of hip fractures are included in the NHFR. HAs account for approximately 34% of the total number of registered operations. More than 90% of the displaced femoral neck fractures in patients older than 70 years are treated with an HA, so the included operations make up the vast majority of the surgeries for these fractures. We did not include hip fractures treated

with any form of osteosynthesis, as the recommendations in the guidelines are prophylaxis during surgery, and not after as is the case with HAs. Most HAs are performed by junior registrars, whereas total hip arthroplasties are performed by consultants specialising in hip surgery. We, therefore, excluded hip fractures treated with total hip arthroplasty to remove bias from more experienced surgeons.

We analysed 6 university hospitals and 44 non-university hospitals in Norway reporting to the NHFR. When


Figure 1 Antibiotic prophylaxis and hemiarthroplasty—all hospitals.

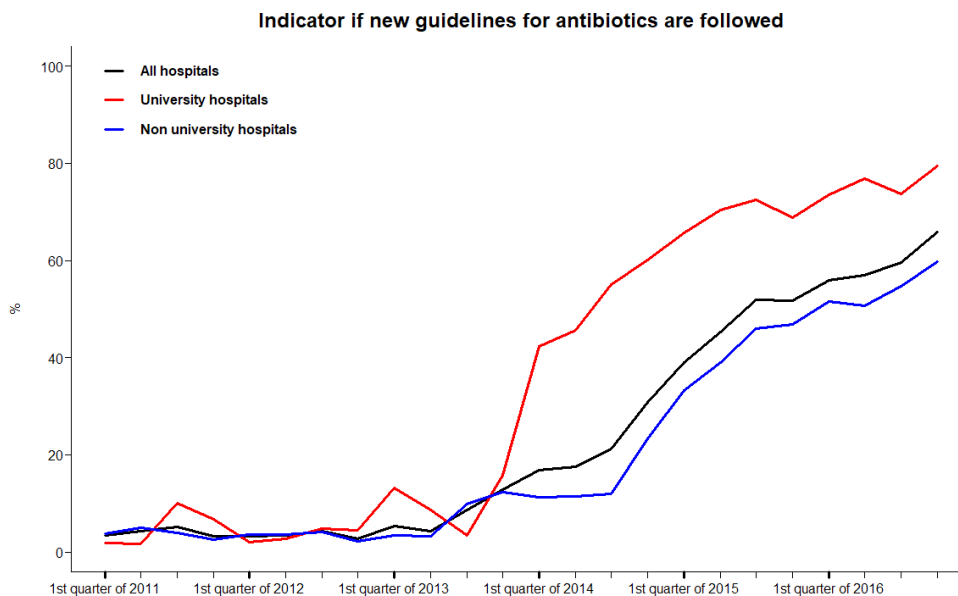


Figure 2 Indicator if new guidelines for antibiotics are followed—all hospitals.

cephalotin or clindamycin was used, we recorded whether it was administered correctly, and if there were any changes in their use from 2011 to 2016. We also assessed compliance, defined as 100% correct administration as described in the guidelines.

Descriptive statistics

The quarterly compliance with the national guidelines during 2011–2016 was calculated both for university hospitals and non-university hospitals. One university hospital submitted a high number of incomplete forms to the NHFR during the whole study period, and was consequently excluded from the comparisons of university hospitals. Analyses were performed using IBM SPSS, V.24.0 (IBM Corp.) and the statistical package R V.3.4.0 (<http://www.R-project.org>).

Patients and public involvement

This research was conducted without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

The NHFR has permission from the Norwegian Data Protection Authority to collect and store data on hip fracture treatment (permission granted on 3 January 2005: reference number 2004/1658–2 SVE/–). The patients have signed a written, informed consent, and in case they were not able to sign, their next of kin could sign the consent form on their behalf. This study only used data registered in the NHFR and no interventions were

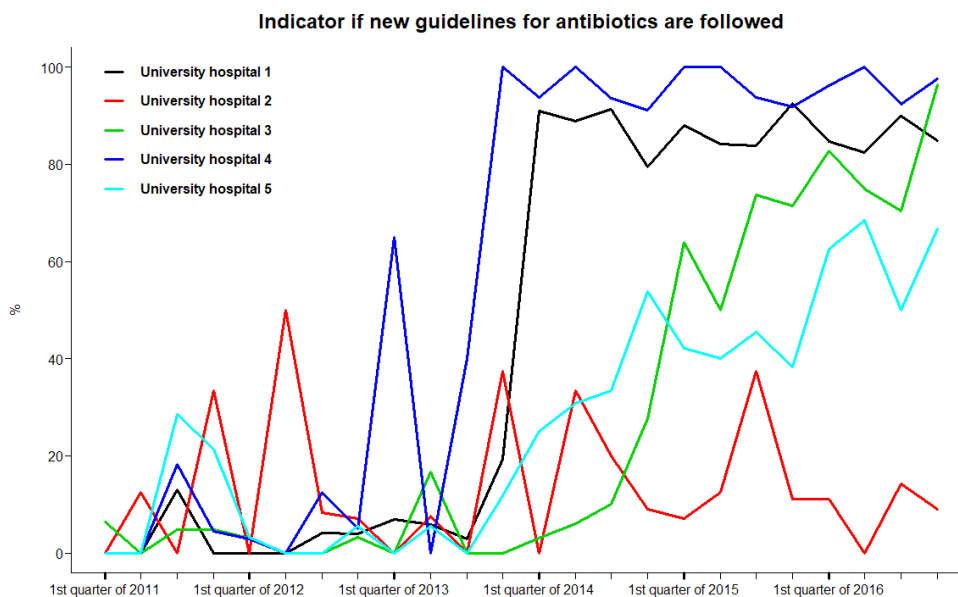


Figure 3 Indicator if new guidelines for antibiotics are followed—university hospitals.

done. The study was, therefore, performed in accordance with the regulations from the Norwegian Data Protection Authority and no ethics approval was necessary.

RESULTS

Types of antibiotics used 2011–2016

In 2011, 99.6%¹¹ of HAs received intravenous antibiotic prophylaxis, but cephalotin or clindamycin was used in only 86.2% of all HAs. This number rose steadily throughout the study period: in 2016, one of the two recommended drugs was administered in 99.2% of HAs. There was a small increase in the use of clindamycin during the period, whereas other antibiotics were gradually abandoned (table 1).

Compliance with the national guidelines

Table 2 shows baseline data for the 13 329 HAs included in the compliance analyses, dividing antibiotic prophylaxis according to the guidelines and other regimens. The groups were similar in age, gender, American Society of Anesthesiologists (ASA) class and cognitive function. HAs performed with a posterior approach were more often performed with the correct prophylactic regime compared with other surgical approaches. 10.8% of HAs in the study period were performed using a posterior approach. In 2011, only 4% of the HAs were performed with antibiotic prophylaxis as later recommended in the guidelines of 2013. We found a small but marked change towards administration of all four doses of cephalotin within 6 hours during 2014 (figure 1). However, for clindamycin, no such trend was found. Although better than cephalotin, erroneous administration remained at 10%–15% for the whole study period. This meant that only 21.9% of HAs received antibiotic prophylaxis in concordance with the guidelines in 2014.

The proportion of patients receiving correct administration of cephalotin increased steadily after 2014 and towards the end of the study period. In 2016, almost 60% of all registered HAs were performed with prophylaxis as recommended in the guidelines (figure 2). There were major differences between hospitals. Some hospitals showed a rapid change of practice shortly after the guidelines had been published, whereas others had yet to comply with the guidelines by the end of 2016. Two of the five university hospitals changed their routines according to the guidelines during the first months after they were published, two gradually became compliant and one did not comply at all (figure 3). University hospitals adapted to the new guidelines faster than non-university hospitals. There was, however, a similar rise in correct administration in both hospital categories (figure 2).

DISCUSSION

The change towards correct administration of antibiotic prophylaxis in HAs for hip fracture was slow after introduction of the national guidelines. At the end of the study

period, only three out of five HAs were performed with the correct drug administered in the correct manner. Most university hospitals adapted to the new guidelines faster than non-university hospital, but one university hospital did not comply with the guidelines at all.

From a quality control perspective, any contemplated changes to a process must be thoroughly evaluated to fully assess their impact. This is a part of Shewhart's four-part cycle of *Plan, Do, Study and Act*,¹² and an essential part in improving the quality of any process. When the new guidelines were published, it was after an extensive evaluation (*Plan*). The introduction was performed by distributing the new guidelines by email and with lectures held around the country and publication on the National Directorate of Health webpage (*Do*). We now need to evaluate whether hospitals follow the new guidelines, and whether following the guidelines has any effect on infection rates (*Study*). If Norwegian hospitals do not follow the guidelines, we need to understand why, and if there are differences in antibiotic regimes that lead to differences in infection rates, we then need to act (*Act*).

Prophylactic antibiotics are known to have a major impact on infection risk.⁸ It is the single most important prophylactic measure against surgical site infections.^{13–16} We found a gradual increase in adherence to the Norwegian guidelines published in 2013. Recommendations on time between doses were slowly implemented, and at the end of the study period, still less than 60% of the HAs were performed with antibiotic prophylaxis according to the guidelines. University hospitals were faster at adapting the new guidelines than non-university hospitals.

Several studies have reported on adherence to guidelines with regards to surgical antibiotic prophylaxis,^{17–21} with varying results. A Dutch study²² showed that guidelines can be effective in improving the process of care, but that there are large differences in the impact of each guideline. When evaluating the influence of a guideline, the first and most important factor to examine is whether the guidelines actually are being followed. If guidelines are not being followed, we need to understand why. Grimshaw and Russell²³ suggested a classification for probability of success when implementing new guidelines, where local education of clinicians was the most important factor. He also advocated rigorous evaluation of existing guidelines. Cabana *et al*.²⁴ gave seven reasons for why clinicians do not follow practical guidelines. All these barriers can, in our opinion, be overcome by strong leadership and education of the health practitioners.

There is clear evidence that checklists may have a positive impact on results.^{25–28} A study from 2011 concluded that leaders are a key factor in the implementation and further utilisation of checklists.²⁹ Another tool that is available is a statistical process control (SPC).³⁰ This has been used for monitoring processes in real time in the process industry for many years and is gradually becoming a part of research into quality of healthcare.



Type of drug

Cephalotin is not the most potent antibiotic against post-operative infections. But, when considering antibiotic stewardship and common bacteria causing postoperative infections, it has been considered the best choice for antibiotic prophylaxis in HAs in Norway. A more broad-spectrum antibiotic prophylaxis will probably yield fewer postoperative infections, but would at the same time be ecologically unwanted.

In our study population, cephalotin and clindamycin were already the two most commonly used prophylactic antibiotics in HA surgery before the guidelines were published. There was an increase in use of these antibiotics during the study period, reaching almost complete adherence in choice of drug with the guidelines. There may always be indications for using other antibiotics, such as concomitant medical conditions. We, therefore, conclude that, when it comes to the type of antibiotic, Norwegian orthopaedic surgeons are adherent to today's guidelines.

Timing

Correct timing of antibiotics, defined as the recorded time interval in hours between first and last doses, should ensure that the concentration of antibiotics in the tissue stays above MIC at all times. With the short half-life of cephalotin, this can only be achieved by short intervals between doses.

In our study, two out of five HAs were performed with cephalotin prophylaxis using intervals exceeding 90 min, 4 years after the introduction of the guidelines. Given today's guidelines, and understanding of how prophylactic antibiotics work, deviance from them is unrecommendable. Less than 60% adherence to the national guidelines 4 years after the introduction of new guidelines may necessitate an intervention by local hospital leaders as well as the Norwegian Directorate of Health.

Differences between hospitals

University hospitals should be at the forefront of change, and up to date on current knowledge. It is problematic that one university hospital did not comply with the obligation of reporting to the quality register (NHFR). This ought to be corrected (*Act*). It is also noticeable that one of the six university hospitals did not comply with the guidelines. In our opinion, there is no excuse for such oversight, and it should be remedied. Again, local leaders need to be involved, if not the National Directorate of Health may have to intervene. In Norway, each hospital generally uses one surgical approach and one standard prophylaxis for HAs. It is rare, if not non-existent, to find one hospital using several different approaches or allowing the administration of different antibiotic prophylaxis on a surgeon-by-surgeon basis. This may explain the difference we found when comparing surgical approaches. One of the few hospitals using the posterior approach was almost 100% adherent to the guidelines, thus giving this difference.

Strengths/weaknesses

The high number of procedures included and that nationwide results are presented are both strengths in the present study. When studying a large population using register-based data, there are some inherent weaknesses.³¹ Most are connected to the questionnaire and the completeness of the registry. The coverage in the NHFR is 100% and the completeness is 94.5% for HAs.¹⁰ This high completeness in the NHFR yields a low selection bias and a high external validity of our results. Our data are limited by the questions and registrations on the operation form filled in by the surgeons. There is a possibility that the antibiotic prophylaxis actually given may be different from what the surgeon records. For example, Stefánsdóttir *et al*³² showed in 2009 that although recommendations for timing of the preoperative antibiotic infusion were known, only 51% of the patients received it correctly. However, we have no reason to expect a systematically incorrect reporting from the surgeons. The timing of the first dose of antibiotic prophylaxis is not reported to the NHFR. This information would have strengthened our study on adherence to the national guidelines, but would have been even more important in a study investigating the benefit of correct antibiotic. The lack of clear guidelines for clindamycin when the guidelines were published is problematic when interpreting the results. However, we argue that allowing for the use of either two sets of guidelines available in the period removes some of the problem. That being said, we recognise this as problematic.

A high number of cases were excluded due to incomplete information on the operation forms. The excluded cases demonstrated similar baseline characteristics as the included patients (for all variables presented in table 2). They were excluded during the whole period we investigated (between 13% and 18% each year). Furthermore, except for one hospital, the excluded cases had been reported fairly evenly from all hospitals. A more complete registration would have increased the number of cases investigated, and accordingly strengthened our results. We do not know for sure whether the excluded cases represent a systematic reporting of incomplete data, or represent a random selection of cases which probably have had antibiotic prophylaxis according to the hospital's routine at the time of operation. However, we do know that this incomplete reporting comes from most of the reporting hospitals during the whole period investigated. There is, therefore, a reason to believe that most excluded patients had received either correct or wrong antibiotic prophylaxis. We, therefore, believe that the included cases make up a representative selection and can still be used to investigate compliance with guidelines at Norwegian hospitals, but we also acknowledge that the missing cases represent a weakness of our study.

CONCLUSION

The national guidelines have gradually become implemented at Norwegian hospitals. A rapid increase in

correct use of antibiotic immediately after the introduction of the guidelines was only found in a few hospitals. Throughout the country, hospitals still fail to comply with the guidelines. This must be addressed, both when evaluating existing guidelines as well as when planning new guidelines. As long as guidelines are based in evidence, there are few, if any, reasons not to follow them.

By using checklists and combining them with the SPC data, it should be possible to follow processes and intervene when they are not stable. No single hospital in our study showed 100% adherence to the guidelines. This shows that there still exist individual surgeons not adherent to hospital policy and the national guidelines. Early identification of non-compliance needs be brought to the attention of local leaders. If this does not lead to change, the National Directorate of Health and the public should be notified.

Modern medicine is complex and dependent on compliance to evidence-based guidelines. Eminence-based medicine may still be warranted in some areas, but in fields where there are evidence-based guidelines it has no place. To conclude, we advocate more guidelines in complex and well-studied fields in medicine and strong adherence to existing ones.

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Data availability statement Data are available upon reasonable request. The data that support the findings of this study are available from the corresponding author, [TL], upon reasonable request.

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