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Can a multifaceted educational intervention targeting both nurses and physicians change the prescribing of antibiotics to nursing home residents? A cluster randomized controlled trial

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Objectives: To assess the impact of a multifaceted educational intervention concerning treatment of infections in the nursing home setting.

Methods: We used a cluster randomized controlled trial. Fifty-eight nursing homes in Sweden were randomly assigned either to educational intervention or control. The intervention consisted of small educational group sessions with nurses and physicians, feedback on prescribing, presentation of guidelines and written materials. The primary outcome was the proportion of quinolones prescribed for lower urinary tract infection (UTI) in women. Secondary outcomes were for all infections: number of UTIs per resident, proportion of recorded infections treated with an antibiotic, proportion of infections handled by physicians as 'wait and see', and for lower UTI in women, proportion of nitrofurantoin.

Results: Of the 58 nursing homes, 46 completed the study. A total of 702 and 540 infections were recorded pre- and post-intervention. The proportion of quinolones decreased significantly in the intervention and control groups, by −0.196 (9/93 to 36/123) and −0.224 (4/66 to 31/109), respectively [95% confidence interval (CI) −0.338, −0.054 and −0.394, −0.054], but the difference between intervention and control groups was not significant, with an absolute risk reduction of 0.028 (95% CI −0.193, 0.249). The changes in proportion of infections treated with antibiotics and proportion of infections handled by physicians as 'wait and see' was significant in comparison with controls: −0.124 (95% CI −0.228, −0.019) and 0.143 (95% CI 0.047, 0.240). No intervention effect could be seen for the other outcomes.

Conclusions: The educational intervention had no effect on the primary outcome, but decreased the overall prescribing of antibiotics.

Keywords: Changing physician behaviour, urinary tract infections, long-term care facilities, institutionalized, elderly

Introduction

Inappropriate use of antibiotics is still a common problem in the nursing home setting and can lead to adverse events for the residents, development of resistance, increased mortality and also excessive costs for the care providers.[1–10] To address the problem of inappropriate prescribing, a multifaceted educational intervention was developed. The main focus was on antibiotic treatment for lower urinary tract infection (UTI) in women, as it is the main indication for antibiotic treatment in nursing homes.[3] Traditionally physicians have been the target group for interventions concerning prescribing practices for UTIs in outpatient care.[11–13] However, as it was known that 38% of antibiotic treatment in nursing homes is initiated without direct contact with the physician, we decided to include the nurses in the intervention as well, although they are not formally authorized to prescribe antibiotics for UTI.[1] This was also supported by Loeb *et al.*[14] Changing professional practice is difficult, and there is no universal recipe for success, but reviews suggest that multifaceted, active strategies have a higher likelihood of success than single interventions.[15,16]

The aim of this paper is to present the evaluation of a multifaceted educational intervention on change in a predetermined set of outcomes concerning infections in the nursing home setting.

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Material and methods

We have adopted the CONSORT statement for reporting randomized controlled trials.[17,18] Additional information required for cluster randomized trials has also been reported in accordance with the extension to the CONSORT statement 2001, expressed in Campbell *et al*. 2004.[19]

Design

This study is a cluster randomized controlled intervention study with two study arms, i.e. intervention and control (Figure 1). The nursing home was the unit of allocation and intervention, but in the analysis, individual resident data were used, allowing for clustering on the nursing home level.

Participants/setting

The research coordinator sent an invitation letter to all nurses charged with medical responsibility within local authority elderly care in Sweden enquiring about participation in the study (n=366 at the time of invitation). The inclusion criteria were nursing homes where residents have a common dining room and staff, and a self-assessed stable staff situation. Exclusion criteria were specialized nursing homes or wards (e.g. oncology wards). For a flow chart of the trial, see Figure 1. A pilot study including seven nursing homes preceded the trial. The aim of the pilot study was to optimize the instruments and educational intervention and to enable us to do a sample size calculation. Nursing homes from different parts of Sweden were included in the main trial. Data from the pilot study were not included in the analysis of the main trial.

Sample size calculation

The number of clusters needed was calculated as 25 in each arm to have 90% power to detect a 20% relative difference in prescribing of quinolones (α=0.05), assuming a baseline rate of 4.5% quinolone users based on the pilot study and literature, average cluster size of 60 residents, and an intracluster correlation coefficient (ICC) taken from the literature of 0.05.[20–22]

Data collection and outcomes

During 3 months from 15 September to 15 December 2003 we collected baseline data. The parts of the trial relevant to this paper were a diagnosis-prescribing survey (DPS) (Figure S1) and a nursing home questionnaire (NHQ) Figure S2 (Figures S1 and S2 are available as Supplementary data at *JAC* Online). For the DPS, the nurse responsible was requested to fill in a form for all patients with infectious symptoms requiring a physician's opinion. Recorded information included patient age, sex, indwelling urinary catheter (IUC), if physician was present at the nursing home, the main infection, antibiotic treatment if prescribed, type of antibiotic, treatment length and factors influencing the choice of treatment or referral of the patient. If a resident had several diagnoses on one occasion, one form for each infection was recorded. As the purpose was not to assess the risk for infections in nursing homes, but to present changes in the prescribing pattern, recurrent infections were included. We focused on a predetermined set of outcome variables as indicators for a possible change. The proportion of quinolones for lower UTI in women was the primary outcome. Secondary outcomes were the number of UTIs per resident; and for all infections, the proportion of infections treated with antibiotics and the proportion of infections handled by physicians as 'wait and see'; and for lower UTI in women, the proportion of nitrofurantoin. The proportion of admissions to hospital was presented as an indicator for the adverse events of the intervention. The NHQ was used to collect information on the nursing homes, as specified in Table 1. Intervention was conducted from 25 October 2004 to 21 January 2005. From 14 February to 16 May 2005 we collected post-intervention data by using the same instruments as for baseline data collection. The DPS and NHQ were repeated for the nursing homes and the results were compared with the baseline results.

Random assignment

In 2004, after the baseline DPS, the nursing homes were stratified into three equal-sized groups based on the number of UTIs per resident for each nursing home at baseline. To get a geographic spread of the intervention and control, the nursing homes were also divided into three geographical areas. The nursing homes within each of the nine final strata were randomly assigned to either intervention or control. E. P. performed a randomization by computer where 50% in each stratum were randomly selected to comprise the intervention group.

Educational intervention

The description of the intervention was influenced by the framework for describing the key features of a quality improvement intervention published by Hulscher *et al*. 2003 (see Figure 2).[23] The development of the intervention began with project group meetings, focus group discussions with physicians, nurses and nursing assistants working in nursing homes, and eventually evaluation of the intervention in the pilot study and revision before the main trial. In addition to feedback and references to available guidelines, structural, organizational and social barriers to change were discussed. Material for presentation was developed in the study group. To make the intervention more context-specific, the participating physician and hygiene nurse were local, and we also referred to guidelines from the local drug therapeutic committees. Recommended treatments for UTI in women were at the time of the trial, pivmecillinam or nitrofurantoin for 5–7 days and trimethoprim for 3–5 days (note: national guidelines were changed in 2007). For patients with IUC, quinolones for 10 days was the recommended treatment.

Statistical analysis

The nursing homes were analysed according to intention to treat (ITT) with respect to allocation. However, a full application of ITT analysis was not possible, as complete outcome data were not available for all randomized nursing homes.[24] What separates the analysis from a true ITT is that the evaluation of the intervention has been done for the 46 nursing homes remaining at follow-up, i.e. an available case analysis. All questionnaires were sent to the coordinator for entering and analysis of data using SPSS 17.0 (at the beginning we used SPSS 10.0) software. For precision of measurement, the 95% confidence interval (CI) is presented both for baseline characteristics and the main outcome variables. After baseline, the actual ICC for each variable was calculated in SPSS according to the mixed effect model. For the primary outcome, the calculated ICC was 0.03. All figures describing the intervention effect are adjusted for the design effect (D_{eff}), which was calculated for each outcome variable: $D_{eff}=1+(n-1)\rho$, where ρ is the ICC.[25] A multivariable linear regression was performed in SPSS 17.0 to explore potential confounders: residents' age; availability of physicians, nurses and nursing assistants; IUC; volume of disinfection alcohol consumed and special needs of the residents. Special needs of the residents were calculated as $1/7\times Hyg_{prop}+1/7\times Cloth_{prop}+1/7\times Mov_{prop}+1/7\times Toi_{prop}+1/7\times Eat_{prop}+1/7\times Press_{prop}+1/7\times Leg_{Prop}$, where Hyg_{prop} is the proportion of residents not managing personal hygiene; $Cloth_{prop}$ is the proportion of residents not managing clothing; Mov_{prop} is the proportion of residents not managing moving around; Toi_{prop} is the proportion of residents not managing visits to the toilet; Eat_{prop} is the proportion of residents not managing eating; $Press_{prop}$ is the proportion of residents at the nursing home with pressure wounds; and Leg_{Prop} is the proportion of residents at the nursing home with leg

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ulcerations. The choice of items was influenced by the Katz ADL score, but dichotomized to independent or dependent. Two additional items, pressure wounds and leg ulcerations, were added.[26] We chose to give an equal weight to each of these variables in the calculation.

Ethics

The research was conducted in accordance with the Declaration of Helsinki. The study was approved by the Regional Ethics Committee in

Table 1. Characteristics of intervention versus control nursing homes included in the analysis of the intervention effect, at baseline

	Control nursing homes	Intervention nursing homes
Number of included nursing homes	20	26
Number of residents	1143	1394
Mean number of residents/nursing home	57.2 (37.1–77.3)	53.6 (37.2–70.1)
Mean age (years)	83.7 (82.6–84.9)	83.9 (82.0–85.8)
Proportion of females	0.67 (0.64–0.71)	0.69 (0.64–0.74)
Proportion of UTIs/resident	0.15 (0.13–0.17)	0.14 (0.12–0.16)
Antibiotic courses/resident and year, mean	1.11 (0.13–2.10)	0.97 (0.14–1.79)
Proportion of residents with indwelling urinary catheters	0.08 (0.05–0.11)	0.07 (0.04–0.10)
Proportion of residents immunized against influenza	0.73 (0.61–0.85)	0.65 (0.51–0.78)
Use of disinfection alcohol, litre/resident and month	0.19 (0.09–0.28)	0.13 (0.08–0.18)
Number of staff/resident		
physicians (h/week/resident)	0.08 (0.06–0.10)	0.05 (0.03–0.07)
registered nurses	0.08 (0.05–0.11)	0.08 (0.04–0.11)
nursing assistants	0.77 (0.56–0.98)	0.67 (0.54–0.79)

Values in parentheses are 95% CIs.

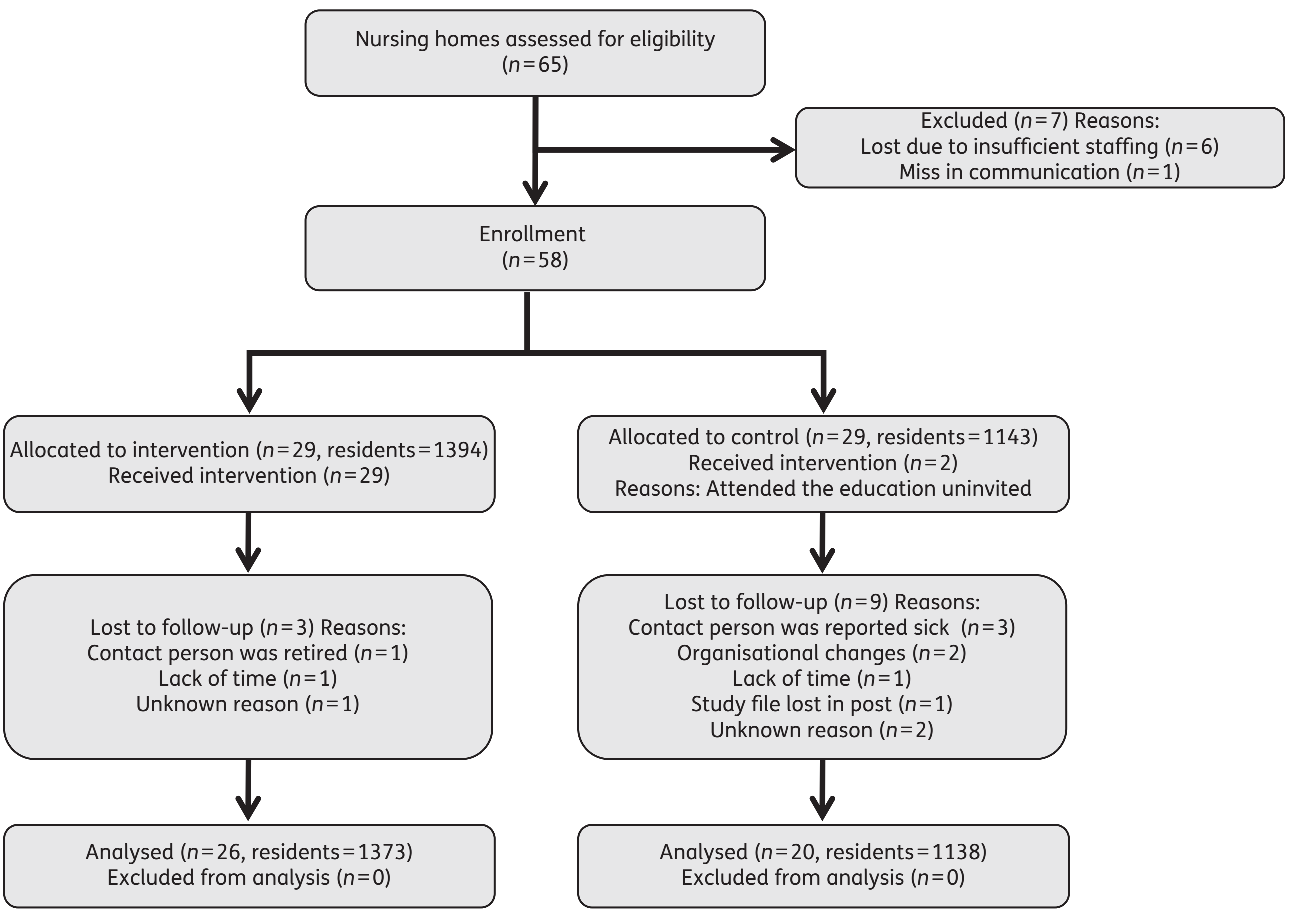

Figure 1. Flow chart of the trial.

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Stockholm (dnr 03-070). The heads of all units involved in the project, as well as physicians and nurses, were asked to give their written informed consent. The participation was voluntary, i.e. only nursing homes where the staff agreed to participate were included. After the end of the trial the control nursing homes were invited to a similar educational session as that provided for the intervention homes. The trial registration number is NCT01054677 at http://www.clinicaltrials.gov/.

Results

Baseline characteristics were similar for the intervention and control nursing homes (Table 1). Antibiotic courses per resident and year, the immunization rate, the number of residents per nursing home, the use of disinfection alcohol and the availability of physicians and nursing assistants seemed a little bit higher in the control group, but all 95% CIs overlap. Of the original 58 nursing homes, 46, with a total of 2511 residents, remained at follow-up (Figure 1). These nursing homes had 2537 residents at baseline. Efforts were made to get details on the dropouts, but for three of them it was not possible. During the 3 months of data collection there were 702 infectious episodes recorded pre-intervention, compared with 540 post-intervention. According to the attendance lists, 164 people attended the educational intervention, of which 13 were general practitioners. A total of 165 nurses and 41 physicians at the nursing homes gave their written informed consent to participate in the trial.

For changes in the main outcome variables, see Table 2. Proportions are presented with their 95% CIs. Discrepancies between the denominator for each proportion and the respective number presented for all infections and lower UTI in women are explained by missing values. The proportion of the primary outcome, quinolones for lower UTI in women, decreased significantly in both the intervention and control group, by −0.196 and −0.224, respectively (95% CI −0.338, −0.054 and −0.394, −0.054). The difference in change between the intervention and control group was not significant at 0.028 (95% CI −0.193, 0.249). The number of UTIs per resident decreased significantly in both the intervention and control groups −0.031 and −0.070, respectively, but the change of 0.038 was not significant (95% CI −0.013, 0.089). The proportion of infections treated with an antibiotic decreased significantly, by −0.124 (95% CI −0.228, −0.019) in comparison with the control group. The proportion of infections handled by physicians as 'wait and see' increased significantly in the intervention group compared with the control group, by 0.143 (95% CI 0.047, 0.240). The proportion of nitrofurantoin prescribed remained the same in both groups before and after the intervention.

Parameter estimates for relevant explanatory variables in the multivariable regression on the primary outcome—proportion of quinolones for lower UTI in women—were intervention, 0.163 (95% CI 0.026, 0.301); physician-hours per week, 2.178 (95% CI 0.357, 3.998); and special needs, 0.115 (95% CI 0.036, 0.194).

Main components of the intervention		
	-2 sessions of voluntary continuing medical education 1.5 h each	-2 to 3 external facilitators presented the guidelines and stimulated interactions between the participants: one pharmacist, one physician, and when possible a hygiene nurse. At least one of them was active in Strama-work.
	-Educational materials	-Leaflet on hygiene -Handouts during the sessions -Short written guideline for antibiotic prescribing
	-Feedback on performance	-Baseline results both written and verbal -Verbal summary at the end of the sessions
Main content of the intervention		
	-Feedback on baseline results -Guidelines on antibiotic prescribing for the most commonly encountered infections in the nursing home setting -Local pattern of antibiotic resistance	-The content of the intervention was presented both verbally and in writing.
Target group of the intervention		
	-Nurses and physicians at the included nursing homes. Ranged from 2–13 participants during the different sessions	-The nursing home was the cluster and unit of allocation and intervention
Main outcome measures, proportions		
	1. quinolones for lower urinary tract infections, UTI, in women 2. UTI per resident 3. antibiotic prescriptions for all infections 4. physicians' "wait and see" for all infections 5. nitrofurantoin for lower UTI in women	
Evaluation of the intervention		
	- Differences before and after intervention for the main outcome measures	-A written evaluation of the training was also completed after the sessions

Figure 2. Description of the educational intervention.

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Table 2. Results for the main outcome variables. The 95% CIs were adjusted for the intracluster correlation coefficient (ICC)

Outcome, total number of observations	Intervention proportion *f*/*n*		Difference in intervention group[a] proportion (95% CI)	Control proportion *f*/*n*		Difference in Control group[b] proportion (95% CI)	The effect of the intervention[c] (95% CI)
	2003	2005		2003	2005		
All residents (intervention and control group) 2003: *n*=2537, 2005: *n*=2511	1394	1373		1143	1138		
UTIs per resident	0.141 (197/1394)	0.110 (151/1373)	−0.031 (−0.056, −0.007)	0.152 (174/1143)	0.083 (94/1138)	−0.070 (−0.096, −0.043)	0.038 (−0.013, 0.089)
All infections, *n*=1242	368	330		334	210		
antibiotics	0.895 (325/363)	0.819 (258/315)	−0.076 (−0.129, −0.024)	0.884 (289/327)	0.931 (190/204)	0.048 (−0.004, 0.100)	−0.124 (−0.228, −0.019)
physician ‘wait and see’	0.085 (30/355)	0.177 (53/299)	0.093 (0.042, 0.144)	0.090 (28/311)	0.039 (8/203)	−0.051 (−0.096, −0.005)	0.143 (0.047, 0.240)
Lower UTI in women, *n*=434	136	113		119	66		
quinolones	0.293 (36/123)	0.097 (9/93)	−0.196 (−0.338, −0.054)	0.284 (31/109)	0.061 (4/66)	−0.224 (−0.394, −0.054)	0.028 (−0.193, 0.249)
nitrofurantoin	0.089 (11/123)	0.075 (7/93)	−0.014 (−0.089, 0.060)	0.073 (8/109)	0.136 (9/66)	0.063 (−0.028, 0.155)	−0.077 (−0.242, 0.088)

f/*n*, frequency of outcome/number of observations.
[a]Difference in intervention group is $d^I = p^I_{2005} - p^I_{2003}$ (p=proportion).
[b]Difference in control group is $d^C = p^C_{2005} - p^C_{2003}$.
[c]The effect of the intervention is $e = d^I - d^C$.

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Adverse events

There was no increase in admissions to hospital in the intervention group. The number of admissions in 2003 was 15/311 for the control group and 15/355 for the intervention group. In 2005 it was 5/203 for the control group and 20/299 for the intervention group. The change in the control group was −0.024 (95% CI −0.056, 0.008) and the change in the intervention group was 0.025 (95% CI −0.011, 0.060).

Discussion

The educational intervention significantly changed the proportion in courses of antibiotics prescribed and also influenced the proportion of infections handled by physicians as ‘wait and see’. However, no intervention effect could be seen for the other outcomes, including the primary outcome, the proportion of quinolones prescribed for lower UTI in women.

The significant and clinically relevant change in the prescribing of quinolones, the primary outcome variable, cannot be attributed to the intervention. Multivariable linear regression showed that the intervention influenced the prescribing of quinolones, but the availability of physicians and special needs were potential confounders. Concerning the quinolones, there has been rigorous work by the drug therapeutic committees and Strama, the Swedish strategic programme against antibiotic resistance, to reduce prescribing where it is not indicated. As an example, between 2003 and 2005 quinolones decreased from 173 to 149 prescriptions/1000/day in the age group ≥80 years.[27]

The modest effect of the intervention may have several explanations, including (i) low exposure to the intervention or staff from two control homes also participated in the intervention, and (ii) a secular trend in the outcome variables.

We cannot be certain that the participants in the intervention were the same as the evaluated group, as we did not collect information on the identities of the prescribers. For feasibility reasons, the nursing homes did not receive the intervention at the same point in time, and it was >1 year between the pre- and the post-intervention data collection. During this time there were changes in the nursing homes’ staffs and residents, and factors outside the trial had time to influence the outcomes. The Hawthorne effect could also have affected the results if prescribing behaviour changed only because of the fact that the participants knew that they were being studied and not because of the intervention. For the quinolones, this might have had an additive effect on the secular trends described earlier. Seasonal changes in the use of antibiotics were not likely to have an influence on the results in this trial, since monthly sales statistics for ATC code J01 between 2002 and 2004 for elderly >80 years range from 39.1 to 43.3 DDD/1000 inhabitants.

There was a wide geographic spread of nursing homes, which was desirable for high external validity, although this probably contributed to a higher dropout rate in our study. There were more dropouts in the control nursing homes, as only 20 nursing homes remained for analysis, which raises the question of attrition bias. Experiences from the pilot study, where there were no dropouts, indicate that this difference could be explained by the absence of a coordinator in the control homes rather than that participants became weary of the study. An exploratory analysis at baseline showed that the outcomes in dropout nursing homes did not differ substantially from those of homes remaining during the whole trial (data not shown). Thus the dropouts probably had little influence on the intervention effect.

The antibiotic prescription rate at baseline in the nursing homes in this trial was a little bit lower compared with earlier studies (1.0 per resident and year compared with 1.1–1.9).[1] This could be an indication of selection bias, in that the nursing homes included in this study might be more interested in the area of infectious diseases and thus perhaps more restrictive in antibiotic treatment to begin with.

The study was undertaken at a reasonable cost and effort to the participants. The development of the intervention required the joint effort of the project group and the implementation of a network already established through the local Strama groups. One of the limitations with our study was that the intervention was a single-point measure to change antibiotic prescribing. To follow trends and to achieve desirable sustained effects in antibiotic prescribing requires multiple measurements and continuous efforts.

Sweden is a low-prescribing country with respect to antibiotics.[28] It was thus expected that this study might influence the pattern of prescribing towards the guidelines but not reduce the total use of antibiotics, although this is what eventually occurred. A review in 2006 of educational interventions targeting antibiotic prescribing behaviour (mainly for respiratory tract infections) showed a median absolute effect of −8.9% [interquartile range (IQR) −12.4% to −6.7%)]. When targeting the selection of antibiotics, the included interventions were considered effective with a median absolute improvement in prescribing of recommended antibiotics of 10.6% (IQR 3.4–18.2%).[29] The results are of a similar magnitude for total antibiotic prescribing (−12%) and ‘wait and see’ (14%), but the results for these secondary outcomes should be interpreted cautiously because there is a risk of type I error, as we set the same significance level, 0.05, for both the primary and secondary outcomes for ease of interpretation and comparison with other studies. In clinical practice the reduction in antibiotic prescribing in this context would mean a decrease of approximately six courses of antibiotics over 1 year in a nursing home with 50 residents.

In conclusion, the intervention had a modest effect. The primary outcome, proportion of quinolones, decreased significantly, but it cannot be attributed to the intervention. It was possible to decrease the proportion of infections treated with an antibiotic and to increase the proportion of infections handled by physicians using ‘wait and see’ through a multifaceted educational intervention targeting both nurses and physicians. One of the questions raised, which is essential for future educational interventions, is whether it is the nurse or the physician who has the most influence on antibiotic prescribing in the nursing home setting.

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Transparency declarations

E. P. is employed by Apoteket AB, The National Corporation of Swedish Pharmacies. All other authors: none to declare.

Contributions

E. P. was corresponding author and was involved in all parts of the study (conception, design, collection, analysis and interpretation of data, drafting the article and final approval of the version to be published. Å. V., S. M. and C. S. L. were involved in the conception, design, analysis and interpretation of data, revising the paper critically for important intellectual content and final approval of the version to be published. All authors had full access to all of the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Data sharing: additional data are available from the corresponding author.

Supplementary data

Figures S1 and S2 are available as Supplementary data at *JAC* Online (http://jac.oxfordjournals.org/).

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