J Antimicrob Chemother 2010; **65**: 2674–2684
doi:10.1093/jac/dkq356 Advance Access publication 18 October 2010

Journal of Antimicrobial Chemotherapy

Evaluation of e-Bug, an educational pack, teaching about prudent antibiotic use and hygiene, in the Czech Republic, France and England

Donna M. Lecky[1]*, Cliodna A. M. McNulty[1], Pia Touboul[2], Tereza Koprivova Herotova[3], Jiří Beneš[3], Pierre Dellamonica[2], Neville Q. Verlander[4], Patty Kostkova[5] and Julius Weinberg[5] on behalf of the e-Bug Working Group†

[1]Health Protection Agency Primary Care Unit, Microbiology Department, Gloucester Royal Hospital, Great Western Road, Gloucester GL1 3NN, UK; [2]Infectious and Public Health Departments Nice, University Hospital, Hopital l'Archet 1, France; [3]3rd Faculty of Medicine, Charles University, Prague, Czech Republic; [4]Statistics, Modelling and Bioinformatics Department, Health Protection Agency Centre for Infections, 61 Colindale Avenue, London NW9 5EQ, UK; [5]City University, Northampton Square, London EC1V 0HB, UK

*Corresponding author: Tel: +44-8454-225062; Fax:+44-1452-526197; Email: donna.lecky@hpa.org.uk
†Members of the e-Bug Working Group are listed in the Acknowledgements.

Received 17 February 2010; returned 4 May 2010; revised 27 July 2010; accepted 26 August 2010

Objectives: e-Bug, a junior and senior school educational programme to decrease the spread of infection and unnecessary antibiotic use, was developed and consisted of eight sections providing information on the spread, treatment and prevention of infection as well as basic information on microbes, both useful and harmful. Each section comprised teacher background information, lesson plans and an interactive student activity, and extension activities were also available for more able students. This study aimed to evaluate the effectiveness of the e-Bug pack in improving children's knowledge in these key areas, when used within the National Curriculum in England, France and the Czech Republic.

Methods: Junior (9–11 years) and senior (12–15 years) school classes were divided into either control or intervention groups for evaluation of the resource. Students were required to complete identical knowledge questionnaires at three timepoints (before, immediately after and 6 weeks after teaching), to assess knowledge change and retention. Teaching, using the e-Bug pack, was given by junior and senior school teachers.

Results: The junior e-Bug teaching pack demonstrated a significant improvement in student's knowledge in all sections and there was no significant decrease in student knowledge observed after a 6 week period. Knowledge improvement with the senior e-Bug pack varied between regions, although consistent improvement was observed for Gloucestershire (England) and Ostrava (Czech Republic).

Conclusions: Although a success, modifications are required in both packs to further improve student knowledge and make the packs more appealing.

Keywords: children, education, Europe, school

Introduction

As highlighted by the European Health Council in 2008, 'antimicrobial resistance is still a growing health problem which increases morbidity, mortality, and health costs'.[1] To reduce the spread of antibiotic-resistant organisms in the hospital setting, several European Union (EU) countries have introduced hygiene[2,3] and prudent antibiotic prescribing campaigns.[4,5]

Antibiotic resistance has been associated with inappropriate antibiotic use[6,7] and is now emerging as a problem in the community and, through inappropriate antibiotic use, the public contribute to its emergence and spread.[8] European questionnaire surveys indicate that the public still do not understand that antibiotics are usually not needed for coughs and colds. Moreover, there is high usage of antibiotics without consulting a health professional in Eastern and Southern Europe.[9–11] Several countries have undertaken public antibiotic awareness campaigns[12] and the EU annual European Antibiotic Awareness Day[13] advises the general public that taking antibiotics for the wrong reasons, such as against colds or flu, is of no benefit but may actually cause bacteria to become resistant to antibiotic treatments, kill their helpful bacteria and often results in side effects such as diarrhoea.[1,14]

In many European countries, antibiotic prescription rates are high in children and antibiotics are the most common medication prescribed.[15] Public campaigns thus far have targeted adults, who are the gatekeepers to antibiotic use, with little education of children, who are our future generation of antibiotic users and prescribers. Teaching children about the different types of microbes and the increasing problems of antibiotic resistance with unnecessary use of antibiotics, should not only raise awareness in our future generation of antibiotic users but also in the family environment, as these children take the messages home to their parents. Children are the main reservoir of common cold viruses.[16] Within schools, respiratory and gastrointestinal infections are a major cause of childhood illness, with poor respiratory and hand hygiene contributing to increased spread. Secondary cases in parents and school staff are common.[17,18] School hygiene campaigns have been shown to reduce rates of infection in schoolchildren, staff and their families, and this in turn may reduce antibiotic use.[19,20]

e-Bug is a European DG SANCO-sponsored project that has been developed to disseminate a school education resource across Europe (where DG SANCO stands for Directorate General for Health and Consumer Protection). It comprises a booklet of detailed lesson plans covering microbes, hygiene, antibiotics and vaccines, and a web site hosting complementary games, presentations and graphics. The project is led by the HPA Primary Care Unit in Gloucester and involves a consortium of 10 associate partner countries (Belgium, Czech Republic, Denmark, France, England, Greece, Italy, Poland, Portugal and Spain) and eight collaborating partner countries (Croatia, Finland, Hungary, Ireland, Latvia, Lithuania, Slovakia and Slovenia) accounting for 62% (334 million) of the European population.

The aim of this study is to evaluate student knowledge in England, France and the Czech Republic, before and after teaching, using a final draft version of the e-Bug educational pack compared with control groups and to assess whether this knowledge is retained 6 weeks post-teaching.

Methods

The e-Bug teaching pack

The initial core teaching programme has two interactive teacher resource packs to assist in educating children aged 9–11 years (junior) and 12–15 years (senior),[21] each comprising eight distinct lesson plans (Table 1). The resource was developed by microbiologists in collaboration with health and education professionals across the 18 EU partner countries. Each individual activity was piloted with schoolchildren who were not involved in the main study. Pack lesson plans aimed to cover Klob and Fry's four learning styles: observers; thinkers; deciders; and doers.[22]

The e-Bug resource links into a specific area of the school National Curriculum in each country. Guidance on the content and lesson plans is provided for the teacher. Each 45 min lesson has student handouts, worksheets and factsheets and involves a teacher-mediated introduction to the sub-section, an interactive activity and a follow-up plenary question-and-answer session. Each lesson also has an extension activity for homework or more able students.

Table 1. e-Bug pack structure

Section and sub-sections
Introduction to Microbes
An Introduction
Good Microbes
Bad Microbes
Spread of Infection
Hand Hygiene
Respiratory Hygiene
Food Hygiene (junior schools only)
Sexually Transmitted Infections (senior schools only)
Treatment and Prevention of Infection
Antibiotic Use and Medicine
Vaccines

Evaluation

The study was a before-and-after evaluation of the e-Bug teaching pack using control and intervention groups. Packs were taught in specific sections of each country's National Curriculum, with intervention group teachers given full control of how and where they would use the resource. Effectiveness was measured by assessing student knowledge of the key learning outcomes at three intervals: baseline; post-intervention; and retention (Figure 1). The sections examined in both junior and senior schools were *Introduction to Microbes*, *Spread of Infection* and *Treatment and Prevention of Infection*.

Population

Evaluation was undertaken with classes of 9- to 11-year-old (junior) and 12- to 15-year-old (senior) students in state-maintained schools in two separate regions of England (Gloucestershire and London), France (Nice and Bordeaux) and the Czech Republic (Prague and Ostrava).

Sample size

The sample size was based on data from evaluation of the English *Bug Investigators* resource.[23] For an 80% power to detect, at the 0.05 level of significance, a useful difference in knowledge between the intervention and control groups of 15%, the required sample size was 151 students in each of the control and intervention groups at both baseline and post-intervention stage. Allowing for 30 children from each class, previous experience from the UK of recruitment of schools and dropout rates suggested that 30 junior (15 intervention and 15 controls; 900 children) and 30 senior (15 intervention and 15 controls; 900 children) school classes should be approached in each country in order to be sure of having 10 of each of the junior and senior intervention and control classes (40 classes and 1200 children in total). This number of classes allows for a further 30% of schools (400 children) to drop out and for a further 25% non-completion of questionnaires by 200 children, giving 151 students in each group. The 60 classes to be approached in each country are for the entire country, not in each region.

School selection

In a school, junior classes (9–11 years) and senior classes (12–15 years) were eligible to take part if they had not yet been taught that particular section of the National Curriculum. Across all three countries some schools included both intervention and control groups, although these were taught by different teachers.

England

Gloucestershire and London schools were selected at random from a list obtained from Local Education Authority (LEA) websites and schools were asked to participate in the study via e-mail, telephone and letter. Contact

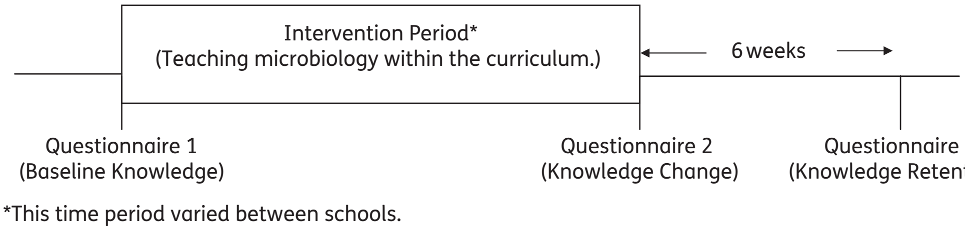

Figure 1. Questionnaire timeline.

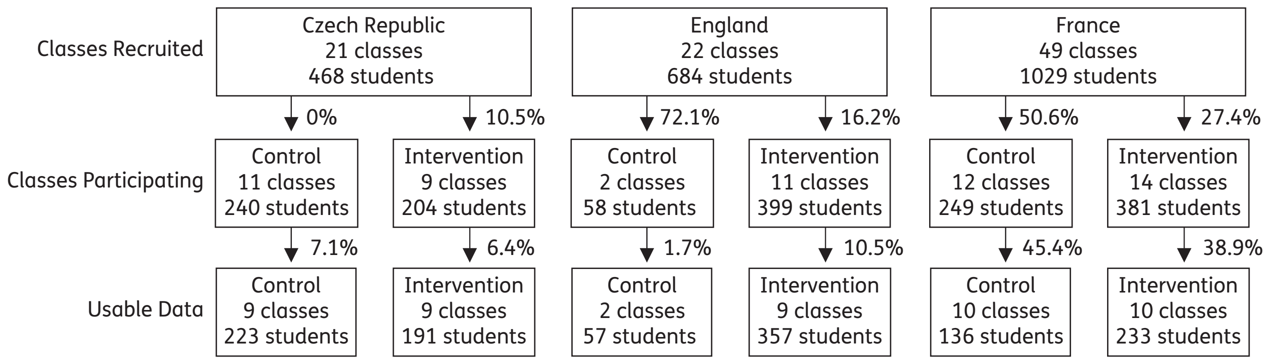

Figure 2. Recruitment of junior school classes and students to the evaluation, illustrating the percentage of student dropout between each phase.

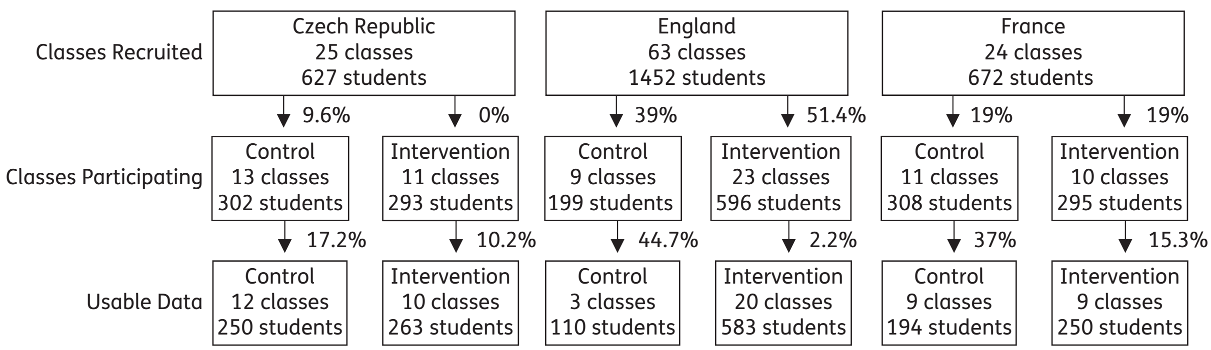

Figure 3. Recruitment of senior school classes and students to the evaluation, illustrating the percentage of student dropout between each phase.

teachers attended an evaluation briefing session prior to the introduction of the resources in the school. As some English schools already had their microbiology lessons planned for the following term, we took a pragmatic approach to allocation of intervention and control groups. Schools that already had their microbiology lessons planned for the following term were placed in the control group. Most schools who did not have their lesson plans in place requested to be in the intervention group rather than the control group and some stated they would not participate in the study if placed in the control group. This led to under-recruitment of control schools (Figures 2 and 3).

France

General inspectors for junior schools and science inspectors for senior schools in each local school authority were asked to select two groups of comparable schools, taking into account school type (private/public), geographical location and socioeconomic environment, for the intervention and the control groups. The inspectors sent teachers a detailed information letter explaining the evaluation method but gave no training on how to the use the resources.

Czech Republic

Schools in Prague were selected at random, whereas schools in the Ostrava region were recommended by the Regional Public Health Authority. All schools were public schools with a non-selected student population. Prague and Ostrava regions represent two areas with different socioeconomic backgrounds. Both the director and the teachers in every school were instructed on how to use e-Bug packs and how to use evaluation questionnaires. Reminder follow-up instruction letters were also sent to junior schools prior to the start of the evaluation.

Intervention schools

In the 2008–09 academic year, teachers within the intervention group used the e-Bug resource to teach their class under normal classroom conditions.

Control schools

Control classes were taught the microbiology section of the school curriculum using their usual materials. Teachers were asked not to use e-Bug learning materials in the pack or the e-Bug web site.

Teacher and student questionnaires

Student knowledge

Change in knowledge was measured using a modified version of a validated questionnaire used in a previous study (Tables 2 and 3).[23,24] Students were asked to tick 'agree', 'disagree' or 'don't know' to a series of statements related to the learning outcomes of the e-Bug pack. The same questionnaires were used in each country. Control classes completed the questionnaires at the same timepoints as the intervention classes. Student names were collected so that the three questionnaires at baseline, post-intervention and retention could be matched. In France, this involved taking the first three letters of the first and family names in order to meet confidentiality data storage requirements. Questionnaires collected in England and the Czech Republic followed their institutional guidelines on the storage of data.

Confounding factors

To adjust for possible confounders, we collected information pertaining to school location, i.e. city, town or rural, number of students and year groups in the school, age groups of students in the school and in the participating class, number of students in the participating class and the number of students registered as having a learning disability in the school and in the participating class. Information collected on the teachers included teaching qualifications held, number of years of experience teaching science and teacher's knowledge of microbiology pertinent to this age group. The number of students on the learning disability register was not available for France.

Ethical considerations

Previous consultation with the South West Multicentre Research Ethics Committee (MREC) confirmed that consent need not be sought from an NHS Research Ethics Committee (NHS REC) for this type of study as it did not involve NHS patients, staff or facilities.[23] Provided anonymized results were published, no ethical review was needed as the study was educational and posed no potential harm for participants. At the end of the evaluation in England a small gift was given to each child participating in the evaluation and schools were given a certificate of participation. In France and the Czech Republic each participating school was given €80 to cover time and consumables.

Written consent was obtained from the head of science or head teacher in each participating school in England and the Czech Republic and the school inspectors in France.

Data analysis

Analysis was carried out centrally in the UK. The effectiveness of the pack was assessed by grouped statement data, i.e. baseline, post-intervention and retention questionnaires were matched by student name. The analysis was performed separately for junior and senior schools. Two types of outcome were analysed: question-specific, which was dichotomous and assumed to be normally distributed; and section-specific (the number of correct responses for each section), which was treated as continuous. When students did not respond to a question they were omitted from that question-specific question *and* section.

Confounding variables

Continuous confounding variables were categorized so that all fixed confounders were categorical. Those variables that are continuous (number of students and years of teacher experience) were categorized as follows. For junior schools the categories chosen were: 0–199, 200–299, 300–399 and 400 or more for number of students in the school; 0–14, 15–24 and 25 or more for number of students in the class; and 0, 1–4, 5–9, 10–19 and 20 or more for years of teacher experience. The corresponding categorizations chosen for senior schools were: 0–399, 400–499, 500–699 and 700 or more; 0–19, 20–29 and 30 or more; and 0–4, 5–9, 10–19, 20–29 and 30 or more. Number of year groups was treated as categorical. A preliminary analysis revealed that, while the magnitude of the estimated impact of the educational pack differed between the analyses that included or excluded the potential confounders, the qualitative conclusion of the pack's effectiveness did not. Thus, these confounders were not included in subsequent analysis. Subsequent analysis was performed in a single hierarchical model with a three-way interaction between region, intervention (intervention and

Table 2. Junior school knowledge questionnaire

Section/question	Correct response
Introduction to Microbes	
If you cannot see a microbe it is not there	false
All bacteria are harmful	false
Bacteria and viruses are the same	false
Fungi are microbes	true
Microbes are found:	
in boiling water	false
in our mouths	true
on our hands	true
on animals	true
All microbes are bad	false
People have microbes all over their body	true
We use some microbes to make yogurt	true
We use some microbes to make bread	true
Some microbes can make us ill	true
Spread of Infection	
Bad microbes can spread:	
when you touch someone's hands	true
from raw meat	true
from well cooked meat	false
People should wash their hands:	
before eating	true
after a bath	false
before helping make a meal	true
after touching pets	true
If people wash their hands they are less likely to get ill	true
Washing with soap *and* water removes more microbes than water alone	true
Microbes cannot spread by sneezing or coughing	false
Sneezing into a tissue stops more microbes than sneezing into a hand	true
Treatment and Prevention of Infection	
Antibiotics:	
kill bacteria	true
kill viruses	false
will cure any illness	false
kill our good bacteria	true
help when you have a cough	false
Most coughs and colds get better without antibiotics	true
Vaccines help protect people against some microbes	true

Table 3. Senior school knowledge questionnaire

Section/question	Correct response
Introduction to Microbes	
If you cannot see a microbe it is not there	false
There are more bad microbes than good microbes	false
Bacteria and viruses are the same size	false
Fungi can be used to make antibiotics	true
Microbes are found:	
in boiling water	false
on animals	true
all over our body	true
Bacteria that normally live in the skin and gut are good for your health	true
You are in good health if you don't have any microbes in your body	false
Viruses cannot reproduce by themselves	true
Bacteria can only survive in a host cell	false
We use dead bacteria to make yogurt through fermentation	false
Microbes are the cause of all illnesses	false
Microbes can cause food poisoning	true
Spread of Infection	
Bad microbes can spread:	
when you touch someone's hands	true
when you touch door handles	true
from only one sexual contact	true
through safe sex	false
People should wash their hands:	
before eating	true
after a bath	false
before helping to make a meal	true
after touching pets	true
Hygiene cannot prevent infections	false
Washing with soap *and* water removes more microbes than water alone	true
Microbes cannot spread by sneezing or coughing	false
Sneezing into a tissue or sleeve stops more microbes spreading than sneezing into a hand	true
Treatment and Prevention of Infection	
Antibiotics:	
kill bacteria	true
kill viruses	false
will cure any infection	false
work on most coughs and colds	false
You should only take prescribed antibiotics until you feel better	false
Vaccines help protect people against only viral infections	false
There is a vaccine for the common cold	true
Antibiotics do not kill our good bacteria	false
If taken often, and inappropriately, antibiotics are less likely to work in the future	true

control group) and knowledge phase (baseline, change and retention). Section-specific analysis was performed using normal linear regression and question-specific analysis was performed using logistic regression.

Only named data were analysed as these questionnaires could be matched. In France, some students either forgot or were wrongly instructed by their teacher and had not entered their name. Analysis of these unnamed, i.e. unmatched, data was performed separately to investigate any possible bias caused by omitting these data.

All analyses were performed in STATA, version 10, using xtmelogit and xtmixed for the logistic and normal hierarchical models, respectively, and xtlogit and xtreg, respectively, when analysing the dichotomous and continuous outcomes for the unnamed French junior school data.

Results

Response

Junior schools

Two thousand one hundred and eighty-one students were initially recruited into the study from the Czech Republic, England and France. However, school dropout rates were extremely high between recruitment and participation stages: Czech Republic (10.5% intervention); England (72.1% control and 16.2% intervention); and France (50.6% control and 27.4% intervention) (Figure 2). This resulted in 984 intervention group students (204 Czech Republic, 399 England and 381 France) and 547 control group students (240 Czech Republic, 58 England and 249 France) who actually participated in the evaluation (Figure 2). From the participation stage to usable data a number of questionnaires were not returned/valid due to either school dropout or incorrectly completed questionnaires in each country for both the intervention (6.4% Czech Republic, 10.5% England and 38.9% France) and control (7.1% Czech Republic, 1.7% England and 45.4% France) groups. Only data from students who filled in at least two of the three questionnaires were analysed. This resulted in a final usable dataset of 781 intervention group students (191 Czech Republic, 357 England and 233 France) and 416 control group students (223 Czech Republic, 57 England and 136 France).

Senior schools

Two thousand seven hundred and fifty-one students were initially recruited from the Czech Republic, England and France. However, school dropout rates were extremely high between recruitment and participation stages: Czech Republic (9.6% control); England (39% control and 51.4% intervention); and France (19% each for control and intervention groups) (Figure 3). This resulted in 1184 intervention group students (293 Czech Republic, 596 England and 295 France) and 809 control group students (302 Czech Republic, 199 England and 308 France) who participated in the evaluation (Figure 3). Again, high dropout rates were observed in both the intervention groups (10.2% Czech Republic, 2.2% England and 15.3% France) and the control groups (17.2% Czech Republic, 44.7% England and 37% France) between the participation stage and the final usable dataset. The final usable dataset for senior schools involved 1096 intervention group students (263 Czech Republic, 583 England and 250 France) and 554 control group students (250 Czech Republic, 110 England and 194 France).

Knowledge before use of education pack

Student knowledge across all three sections was extremely variable prior to teaching (Table 4). Correct responses for baseline knowledge was highest in the *Spread of Infection* section (73.1%–84% of junior children and 68.5%–78.1% of senior students) and poorest in the *Treatment and Prevention of Infection* section, which included prudent antibiotic use and vaccines (33.8%–53.7% of junior children and 28.6%–53.7% of senior students). Students in England demonstrated the lowest average baseline knowledge for the *Treatment and Prevention of Infection* section.

Table 4. Percentage of students with correct responses before teaching by section

Location	Introduction to Microbes	Spread of Infection	Treatment and Prevention of Infection
Junior schools			
Gloucestershire	51.7	78.3	33.8
London	—	—	—
Nice	59.2	74.8	46.8
Bordeaux	67.3	84.0	53.7
Prague	57.7	76.3	50.3
Ostrava	57.2	73.1	41.2
Senior schools			
Gloucestershire	49.3	68.5	28.6
London	60.0	77.6	33.3
Nice	63.5	77.5	52.5
Bordeaux	62.3	74.6	51.0
Prague	62.9	78.1	53.7
Ostrava	58.9	77.8	49.0

Knowledge after education

Junior school section-specific analysis

Within the intervention group, knowledge after teaching improved significantly across all three sections for each country (Table 5). This knowledge was retained 6 weeks after intervention teaching.

Control group students also demonstrated an increase in knowledge across all three areas of teaching. However, this improvement was not as marked as in the intervention groups (Table 5). There was little significant difference in knowledge change when comparing the intervention and control groups, with the exception of the Czech Republic, where the Ostrava region showed a significantly higher knowledge improvement when using the e-Bug pack in all three sections and Prague demonstrated a higher knowledge change for the *Introduction*

Table 5. Junior school student percentage knowledge change (95% confidence interval) over time for control and intervention groups

Section/location	Control			Intervention		
	baseline	post-intervention	retention	baseline	post-intervention	retention
Introduction to Microbes						
Gloucestershire	6.8 (−4.4, 18.0)	**33.5** (22.3, 44.7)	33.7[b] (22.6, 44.9)	0	**32.5** (30.3, 34.7)	29.8 (27.0, 32.6)
London[a]	–	–	–	–	–	–
Nice	8.1 (−0.7, 16.9)	**24.3** (14.5, 34.1)	26.5 (15.5, 37.4)	7.0 (−0.8, 14.7)	**30.0** (22.3, 37.8)	32.5 (24.3, 40.6)
Bordeaux	9.3 (−0.6, 19.1)	**29.1** (18.8, 39.4)	31.5 (21.3, 41.8)	13.2 (2.2, 24.2)	**36.4** (24.2, 48.5)	36.2 (23.8, 48.6)
Prague	3.5 (−4.7, 11.7)	**14.1** (5.3, 22.9)	13.4 (4.7, 22.0)	6.0 (−2.4, 14.4)	**26.4**[b] (18.0, 34.8)	28.4[b] (19.9, 36.9)
Ostrava	−0.7 (−8.7, 7.3)	2.1 (−6.2, 10.4)	**11.6** (3.6, 19.6)	4.7 (−3.5, 12.8)	**30.8**[b] (22.7, 39.0)	29.1[b] (21.0, 37.3)
Spread of Infection						
Gloucestershire	5.7 (−3.5, 14.9)	10.5 (1.3, 19.8)	12.2 (3.0, 21.4)	0	**10.6** (8.6, 12.6)	12.2 (9.6, 14.8)
London[a]	–	–	–	–	–	–
Nice	2.8 (−4.7, 10.3)	**−7.7** (−16.2, 0.8)	−2.1 (−11.7, 7.5)	−3.0 (−9.5, 3.4)	**6.2**[b] (−0.3, 12.6)	8.1[b] (1.2, 14.9)
Bordeaux	1.8 (−6.3, 9.9)	**11.5** (3.0, 20.1)	12.4 (3.9, 21.0)	5.0 (−4.0, 14.0)	**15.5** (5.3, 25.7)	11.9 (1.5, 22.3)
Prague	3.3 (−3.5, 10.1)	3.4 (−4.1, 10.9)	2.1 (−5.2, 9.4)	−3.8 (−10.9, 3.3)	**9.4** (2.4, 16.5)	6.9 (−0.2, 14.1)
Ostrava	−4.4 (−11.1, 2.2)	−5.3 (−12.3, 1.7)	−4.3 (−11.0, 2.4)	−2.7 (−9.5, 4.1)	**8.6**[b] (1.8, 15.4)	10.7[b] (3.9, 17.5)
Treatment and Prevention of Infection						
Gloucestershire	2.8 (−8.4, 14.1)	**16.8** (5.5, 28.1)	14.7 (3.5, 25.9)	0	**15.4** (12.6, 18.1)	14.6 (11.1, 18.1)
London[a]	–	–	–	–	–	–
Nice	15.9 (6.7, 25.0)	24.1 (13.6, 34.6)	12.1 (0.0, 24.3)	13.3 (5.5, 21.1)	**22.5** (14.6, 30.3)	27.4[b] (19.0, 35.9)
Bordeaux	19.0 (9.1, 28.9)	26.9 (16.4, 37.5)	32.2 (21.6, 42.7)	18.7 (7.8, 29.7)	**30.8** (18.1, 43.5)	22.3 (9.3, 35.3)
Prague	14.0 (5.7, 22.3)	19.8 (10.5, 29.2)	24.4 (15.4, 33.4)	16.9 (8.2, 25.5)	**29.8**[b] (21.2, 38.4)	26.0 (17.3, 34.7)
Ostrava	12.4 (4.3, 20.5)	10.1 (1.4, 18.7)	10.3 (2.1, 18.5)	9.5 (1.2, 17.8)	**28.3**[b] (19.9, 36.6)	20.0[b] (11.7, 28.3)

Values in bold type are significantly different from the previous phase.
[a]No schools were available.
[b]Knowledge in this group (control or intervention) was significantly higher when compared with the other.

Table 6. Senior school student percentage knowledge change (95% confidence interval) over time for control and intervention groups

Section/location	Control baseline	Control post-intervention	Control retention	Intervention baseline	Intervention post-intervention	Intervention retention
Introduction to Microbes						
Gloucestershire	−3.5 (−9.7, 2.7)	**12.3** (7.3, 17.4)	7.8 (0.7, 14.9)	0	**18.9**[b] (17.1, 20.7)	19.1[b] (17.2, 20.9)
London[a]	–	–	–	9.3 (−1.7, 20.2)	14.9 (3.9, 25.9)	14.7 (3.2, 26.1)
Nice	11.0 (2.9, 19.0)	**19.1** (11.0, 27.2)	16.6 (8.4, 24.8)	11.5 (4.2, 18.7)	**20.3** (12.9, 27.8)	20.2 (12.3, 28.0)
Bordeaux	8.3 (1.9, 14.7)	**20.3** (13.9, 26.6)	23.3(16.9, 29.7)	10.3 (3.5, 17.0)	**22.2** (15.4, 28.9)	24.5 (17.7, 31.2)
Prague	11.6 (5.2, 18.0)	14.8 (8.2, 21.5)	10.1 (3.5, 16.8)	13.4 (7.1, 19.8)	13.8 (7.2, 20.4)	18.6[b] (12.1, 25.2)
Ostrava	4.3 (−1.9, 10.6)	0.8 (−5.9, 7.6)	4.7 (−1.5, 10.9)	8.9 (2.6, 15.3)	**24.0**[b] (17.6, 30.3)	20.1[b] (13.7, 26.5)
Spread of Infection						
Gloucestershire	−3.6 (−9.9, 2.7)	**7.0** (2.0, 12.0)	−**1.6** (−8.9, 5.8)	0	**15.0**[b] (13.0, 17.0)	13.9[b] (11.8, 15.9)
London[a]	–	–	–	7.8 (−2.3, 17.8)	13.2 (3.1, 23.4)	11.8 (1.0, 22.5)
Nice	7.8 (0.1, 15.4)	10.8 (3.1, 18.4)	7.6 (−0.3, 15.4)	7.2 (0.3, 14.0)	**14.0** (6.9, 21.1)	12.2 (4.6, 19.9)
Bordeaux	4.2 (−1.9, 10.2)	**12.1** (6.1, 18.1)	13.6 (7.6, 19.7)	4.5 (−1.9, 10.9)	**14.9** (8.5, 21.3)	12.7 (6.3, 19.2)
Prague	7.9 (1.8, 14.0)	7.0 (0.5, 13.4)	4.9 (−1.4, 11.3)	9.1 (3.1, 15.2)	14.2[b] (7.9, 20.6)	14.2[b] (8.0, 20.5)
Ostrava	4.8 (−1.2, 10.7)	2.2 (−4.3, 8.8)	3.6 (−2.3, 9.5)	8.8 (2.8, 14.8)	**16.5**[b] (10.5, 22.6)	14.5[b] (8.4, 20.6)
Treatment and Prevention of Infection						
Gloucestershire	−5.2 (−13.1, 2.8)	**14.3** (8.0, 20.6)	**3.0** (−6.0, 12.0)	0	**24.4**[b] (22.2, 26.7)	24.7[b] (22.4, 27.1)
London[a]	–	–	–	4.5 (−14.7, 23.7)	16.2 (−3.1, 35.4)	22.0 (2.3, 41.6)
Nice	17.3 (4.0, 30.5)	28.1 (14.9, 41.4)	22.4 (9.0, 35.8)	21.1 (10.0, 32.2)	**33.1** (21.9, 44.2)	34.5 (23.2, 45.8)
Bordeaux	20.2 (9.9, 30.6)	**34.3** (24.0, 44.6)	31.7 (21.3, 42.0)	17.3 (6.6, 28.0)	26.1 (15.4, 36.8)	32.4 (21.7, 43.1)
Prague	31.0 (20.5, 41.5)	30.5 (19.8, 41.2)	28.8 (18.2, 39.5)	27.7 (17.3, 38.1)	33.2 (22.6, 43.9)	34.4 (23.8, 44.9)
Ostrava	14.6 (4.3, 24.9)	14.1 (3.3, 24.9)	20.2 (9.9, 30.5)	21.2 (10.9, 31.6)	**43.4**[b] (33.0, 53.8)	**32.6**[b] (22.1, 43.0)

Values in bold type are significantly different from the previous phase.
[a]No control schools were available.
[b]Knowledge in the intervention group was significantly higher when compared with the control group.

to Microbes and *Treatment and Prevention of Infection* sections. Nice also showed a higher knowledge improvement when using e-Bug for the *Spread of Infection* section. With the exception of Prague in the *Treatment and Prevention of Infection* section, these regions also demonstrated significantly higher knowledge retention than the control groups.

Senior school section-specific analysis

Senior intervention group Student knowledge after teaching improved over all three sections in three of the six regions (Table 6); knowledge remained unchanged for only the *Treatment and Prevention of Infection* section in Bordeaux but remained unchanged for all three sections in London and Prague. Six weeks after teaching, only the Ostrava region of the Czech Republic showed significant deterioration in student knowledge, and this was for *Treatment and Prevention of Infection*.

Senior control group Data were not available for London senior school students. In both regions of the Czech Republic (Ostrava and Prague) there was no increase in knowledge for any section. In two regions (Gloucestershire and Bordeaux), knowledge improved in all sections. However, 6 weeks after teaching this knowledge decreased in Gloucestershire schools for *Spread of Infection* and *Treatment and Prevention of Infection*. The Nice region of France also demonstrated an improvement in student knowledge for the *Introduction to Microbes* section.

Senior intervention group compared with control

Knowledge improvement was significantly higher in Gloucestershire and Ostrava schools for all three pack sections, and for schools in Prague in the *Spread of Infection* section, after teaching with e-Bug when compared with the control group. Knowledge retention in these regions was also significantly higher than that of the control group.

Unnamed data

Paired data analysis was not possible for 428 French questionnaires where the junior children's names were omitted. Analysis of the unnamed junior data suggests that there may have been some improvement in the Nice intervention junior schools for the *Introduction to Microbes* and *Treatment and Prevention of Infection* sections, although there was a significant decrease at the retention phase, indicating that any possible benefit was only temporary for schools in Nice. Bias in junior results appeared to be limited (data not shown, but available from authors).

Question-specific analysis

As the main aim of the e-Bug teaching resource was to increase student knowledge of the treatment of infection and prudent antibiotic use, we examined knowledge improvement in questions specific to this section more closely.

Junior school question-specific analysis Within junior intervention schools, student knowledge was seen to improve for the question 'Most coughs and colds get better without antibiotics' in three of the six regions (Prague, Ostrava and Gloucestershire), whereas only one of the six regions (Gloucestershire) demonstrated knowledge improvement within the control group.

Senior school question-specific analysis Four questions were examined in more detail for the senior schools:

(1) Antibiotics work on most coughs and colds
(2) You should only take prescribed antibiotics until you feel better
(3) Antibiotics do not kill our good bacteria
(4) If taken often, and inappropriately, antibiotics are less likely to work in the future.

Teaching with e-Bug demonstrated a knowledge improvement for all questions in the *Treatment and Prevention of Infection* section in Gloucestershire and Ostrava. Knowledge increase was also observed for Question 3 in Bordeaux and Question 4 in Nice after e-Bug teaching. In the control groups, knowledge improvement was observed in the Gloucestershire region only and this was for Questions 1 and 2; no improvement in knowledge for the four questions was observed for control students in any other region.

Discussion

The junior e-Bug teaching pack demonstrated a significant improvement in students' knowledge in all sections, and this knowledge was retained 6 weeks later. Knowledge improvement, measured by the questionnaire, was similar in control schools in England and France, which used usual teaching resources. In the Czech Republic, knowledge gain was significantly greater in the intervention than control schools for all activities. Comparison of the intervention with the control group highlighted that in areas where knowledge change was greater when using e-Bug, more of this knowledge was retained than in the control group.

In senior schools, student knowledge improvement varied between region and section, with Gloucestershire in England and Ostrava in the Czech Republic showing consistent, significant improvement in all sections. The *Spread of Infection* section showed the least improvement in knowledge; however, this section also had very high percentage baseline correct responses in all countries, suggesting that limited improvements could be achieved. Although there was little difference in knowledge change between control and intervention schools, it is possible that completion of the questionnaire by students at three time-points may in itself have increased knowledge in the control group; similar findings were observed by Hemalainen and Keinanen-Kiukaanniemis.[25] A further consideration of note is that contamination within schools may have occurred where some senior schools had both intervention and control classes. As in junior schools, comparison of the intervention with the control group highlighted that in areas where knowledge change was higher when using e-Bug, more of this knowledge was retained than in the control group.

During preliminary focus groups,[26] teachers highlighted that the resource must have strong links with the National Curriculum as schools have limited or no time to plan activities outside of this remit. As such, the pack has been designed to link to various sections of the National Curriculum in each partner country and pack evaluation has been shown to increase student knowledge in these sections of the National Curriculum in each evaluating country. The evaluated e-Bug pack should be viewed as a draft version and changes have been implemented in areas where an improvement in knowledge was not observed and where qualitative feedback was less favourable.[26] Improvements have included simplifying contents or activities where necessary, providing alternative activities for less able students, redesigning entire activities and providing a supporting web site for teachers. Future improvements will include the creation of a complementary student web site providing revision sheets, factsheets, games and quizzes.

Strengths

As it was designed to be a pan-European educational resource, e-Bug has been evaluated in countries with a range of antibiotic use in East, South and West Europe.[27] Students were asked to write their names on the questionnaires, allowing paired rather than clustered analysis to be conducted. Knowledge was assessed in both control and intervention schools teaching a particular section of the National Curriculum, thereby allowing comparisons of e-Bug with other teaching materials in the field. In order to obtain a realistic view of how e-Bug would function in the classroom environment, teachers were given scope to teach the e-Bug resource however they saw suitable in their teaching environment. The main strength of the evaluation, however, is that it reflects three different countries' teaching conditions, which is important in ensuring that e-Bug is a pan-European resource.

The overall strengths of the e-Bug resource are the collaborations formed during its development, the input received from each child and school involved in the design and testing of the resource, and input from experts in health and education sectors from 18 European countries. Various pack sections encouraged teacher-led classroom/group discussion addressing misconceived ideas about antibiotic use, thereby providing students with a forum to voice their opinions and rectify their misconceptions. It has been reported that this form of active learning helps students retain material, motivates for further study and develops thinking skills.[28]

Limitations

Although initial response rates were high, there was a large decrease in the percentage of usable data collected, particularly for England (60.5% junior and 47.7% senior) and France (35.8% junior and 66% senior). Unfortunately, many of these schools did not notify us that they were withdrawing from the evaluation and therefore no other schools were recruited in time to replace them. We could have recruited more schools in the next academic year, but this was not possible due to time and budget constraints. In some cases teachers transferred to a different school at the end of the academic year and failed to hand in the questionnaires or teachers had difficulty finding the time to ensure students completed the questionnaires. Resource evaluation studies carried out in schools by McNulty *et al.*[23] and Hewitt *et al.*[29] observed similar low response rates. McNulty *et al.*[23] attributed this to teachers finding it difficult to add resources to their teaching plan if the resources are not linked to the National Curriculum; however, e-Bug has strong National Curriculum links. If possible, future studies should aim to recruit one class per school in order to minimize the number of students who drop out of the study, attempt to collect all questionnaires before the last few weeks of term and introduce teachers to the resource at least one term prior to evaluation to allow teachers time to familiarize themselves with the resource and implement it into their lesson plans. Because schools in some regions self-selected, teachers in both the control and intervention groups may have been more enthusiastic than teachers in schools that did not participate or were self-selected to be in the control group.

Our study shows that the students exposed to the pack had improved knowledge as assessed by the true/false questions. It does not address levels of understanding, or the ability of the participants to make more informed assessments about antibiotics and hygiene. However, there is evidence in the literature that knowledge is associated with behavioural change.[30–32] This would be a valuable follow-up study.

Our study may underestimate the effect of the e-Bug resources. In English and French junior schools we did not detect a significant difference in knowledge between intervention and controls immediately after teaching, as was seen in the Czech schools; this may have been because we did not reach the required control sample size. Future studies should allow for an even greater class dropout and non-completion of questionnaires. Our highest percentage dropout was 66% in French senior schools.

A high number of students in France, particularly within junior schools, failed to enter their name on the questionnaires, either because the schools preferred student anonymity or because of a misunderstanding of the evaluation procedure. As paired analysis could not be performed, these 428 students were eliminated from the main analysis. Inclusion of these would have improved knowledge outcomes but would not have made a difference to the relevance of the results.

This study focused mainly on student knowledge change with no attitude or behaviour assessment. If practical, future studies should assess these other outcomes.

Other work in this area

Numerous studies have been carried out assessing students' knowledge of medicine and antibiotic use within these age groups, and have found a similarity not only in students' knowledge of this topic but also in student desire for more information.[30,33–35] A recent study by Cebotarenco and Bush[30] found that reported antibiotic-related beliefs and behaviours were related, in that knowledge about what causes a cold or flu relates to whether or not an antibiotic is taken. Education may empower children to make the right choices regarding antibiotic use, but previous studies have shown that health education is confusing for teachers and that the teachers may also need supplementary education.[31,32] e-Bug aims to close this gap in knowledge by providing background information for teachers on each of the sections as well as detailed lesson plans that can be adapted to suit class needs.

e-Bug provides students with knowledge on hand and respiratory hygiene; however, the provision of adequate hand washing facilities, running water and soap to all children is essential in preventing the spread of infection. A study by Curtis and Cairncross[36] found that washing hands with soap can reduce the risk of diarrhoea by 42%–47%, whilst Luby *et al.*[37] demonstrated that, in households receiving plain soap and hand washing promotion, children aged <5 years had a 50% lower incidence of pneumonia than controls and children aged <15 years had a 53% lower incidence of diarrhoea and a 34% lower incidence of impetigo.

The study by Curtis and Cairncross[36] also indicated that hand washing is important in the prevention of acute respiratory infections. The use of tissues to prevent the spread of respiratory illnesses is essential and the CDC recommended 'Cover your nose and mouth with a tissue when you cough or sneeze' and 'Throw the tissue in the trash after you use it' to prevent contracting the recent H1N1 influenza.[38] A recent survey carried out by the East of England Strategic Health Authority (SHA) found that only 21% of people in the East of England always carry a tissue, and only 52% throw away tissues after using them once.[39] The survey also showed that 10% of people questioned never wash their hands after covering their mouth or nose to sneeze.[39]

Implications

As the children of today are the antibiotic consumers and prescribers of tomorrow, education about microbes and the transmission, treatment and prevention of infection will hopefully make them more aware about their own health and be more prudent users of antibiotics in the future. The main benefit of having this pan-European educational resource is that we can provide a united European education message on prudent antibiotic use and hygiene, which reinforces, sustains and is consistent with other health and educational campaigns in each country. It is recommended that for health education interventions to succeed they must be supported by strategies in the school and community environments.[40] Goossens *et al.*[27] suggested that national public campaigns should be sustained in countries with high antibiotic use and high seasonal variation. The use of e-Bug in schools complements these campaigns by introducing key messages about prudent antibiotic use to the younger generation.

The future of e-Bug

There have been many changes made to the junior and senior school packs based on the evaluation feedback. The e-Bug resource was launched in September 2009 for associate partner countries, with collaborating partner country implementation due in January 2011. By September 2011, it is planned that e-Bug will be translated and implemented in the remaining

15 European Union/European Economic Area (EU/EEA) and associate EU countries.

Antibiotic prescribing and consumption rates differ throughout Europe,[41] as do the means of obtaining antibiotics. e-Bug provides a consistent health education message across Europe, which, when combined with education campaigns such as European Antibiotic Awareness Day (EAAD), may encourage cultural changes.

The resource was successfully used by many countries as part of their EAAD campaign in 2008 and has been viewed favourably by the European Centre for Disease Prevention and Control (ECDC). A further four countries, outside the initial e-Bug partnership, asked to use the resource in their 2009 EAAD campaign.

Acknowledgements

We thank all the schools, teachers and students who participated in the evaluation. Our thanks are also extended to Brigitte Dunais and Alice Gabrielova for quality control and data entry and to the ministries of education and local education authorities for their assistance in school recruitment.

Members of the e-Bug Working Group include Herman Goossens, Niels Adriaenssens, Stijn De Corte, Jette Holt, Marianne Noer, Patty Kostkova, David Farrell, Jenny Kremastinou, Koula Merakou, Dimitri Gennimata, Guiseppe Cornaglia, Raffaella Koncan, Pawel Grzesiowski, Anna Olczak-Pienkowska, Antonio Brito Avo and José Campos.

Funding

This work was supported by DG-SANCO of the European Commission (2005211).

Transparency declarations

None to declare.

References

1 Antimicrobial resistance: adoption of Council conclusion. *Council of the European Union*. 2008. Document 9637/08: Annex DG1. http://www.consilium.europa.eu/uedocs/cms_Data/docs/pressdata/en/lsa/101035.pdf (16 April 2010, date last accessed).

2 Magiorakos AP, Suetens C, Boyd L *et al*. National hand hygiene campaigns in Europe, 2000–2009. *Euro Surveill* 2009; **14**: pii=19190.

3 National Patient Safety Agency. cleanyourhands campaign 2007. http://www.npsa.nhs.uk/cleanyourhands/ (16 February 2010, date last accessed).

4 Kristinsson KG. Modification of prescriber's behaviour: the Icelandic approach. *Clin Microbiol Infect* 1999; **5**: 4S43–7.

5 Blanc V, Bruno-Bazureault P, Malicki A *et al*. 'Antibiotics only when necessary' campaign in the Alpes-Maritimes district: no negative impact on invasive infections in children in the community 1998–2003. *Presse Med* 2000; **37**: 1739–45.

6 Finch R. Bacterial resistance: the clinical challenge. *Clin Microbiol Infect* 2002; **8**: 21–32.

7 House of Lords Select Committee on Science & Technology. Resistance to antibiotics and other antimicrobial agents. Report No. HL Paper 81-I. London: House of Lords, 1997.

8 Davey PG, Pagliari C, Hayes A. The patient's role in the spread and control of bacterial resistance to antibiotics. *Clin Microbiol Infect* 2002; **8**: 43–68.

9 McNulty CAM, Boyle P, Nichols T *et al*. The public's attitudes to and compliance with antibiotics. *J Antimicrob Chemother* 2007; **60** Suppl 1: i63–8.

10 Grigoryan L, Burgerhof JG, Haaijer-Ruskamp FM *et al*. on behalf of the SAR group. Is self-medication with antibiotics in Europe driven by prescribed use? *J Antimicrob Chemother* 2007; **59**: 152–6.

11 Eurobarometer 55.2: Europeans, Science & Technology, May–June 2001. http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/03341 (16 February 2010, date last accessed).

12 Huttner B, Goossens H, Verheij T *et al*. Characteristics and outcomes of public campaigns aimed at improving the use of antibiotics in outpatients in high-income countries. *Lancet Infect Dis* 2010; **10**: 17–31.

13 Earnshaw S, Monnet DL, Duncan B *et al*. European Antibiotic Awareness Day, 2008—the first Europe-wide public information campaign on prudent antibiotic use: methods and survey of activities in participating countries. *Euro Surveill* 2009; **14**: pii=19280.

14 Finch RG, Metlay JP, Davey PG *et al*. Educational interventions to improve antibiotic use in the community: report from the International Forum on Antibiotic Resistance (IFAR) colloquium, 2002. *Lancet Infect Dis* 2004; **4**: 44–53.

15 Spyridis N, Sharland M. The European Union Antibiotic Awareness Day: the paediatric perspective. *Arch Dis Child* 2008; **96**: 909–11.

16 Goldmann DA. Transmission of viral respiratory infections in the home. *Pediatr Infect Dis J* 2000; **19** Suppl 10: S97–102.

17 Bowers T, McIver M. Ill health retirement and absenteeism amongst teachers. Department for education and employment. Research report 235. Norwich: HMSO, 2000.

18 HPA national influenza season summary 2005/2006. www.hpa.org.ik/infections/topics_az/influenza/seasonal/flureports0506.htm#summary (16 February 2010, date last accessed).

19 Lennell A, Fredlund H. Use of hand disinfection reduces absenteeism from day care centers. *Euro Surveill* 2008; **13**: pii=19006.

20 Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: a randomized, controlled trial of an infection-control intervention. *Pediatrics* 2008; **121**: 1555–62.

21 The e-Bug project—a European wide, DG SANCO funded, antibiotic and hygiene teaching resource for junior and senior school children. http://www.e-bug.eu/ebug.nsf/Home?OpenPage (16 February 2010, date last accessed).

22 Klob DA, Fry R. Toward an applied theory of experimental learning. In: Cooper C, ed. *Theories of Group Process*. London: John Wiley, 1975.

23 McNulty CAM, Bowen J, Gelb D *et al*. The Bug Investigator: assessment of a school teaching resource to improve hygiene and prudent use of antibiotics. *Health Educ* 2007; **1**: 10–26.

24 Milandri M. Children's views of microbes: current beliefs about bacteria in Italian grade school children. *Pediatr Infect Dis* 2004; **24**: 1077–80.

25 Hemalainen S, Keinanen-Kiukaanniemis S. A controlled study of the effect of one lesson on knowledge and attitudes of school children concerning HIV/AIDS. *Health Educ J* 1992; **51**: 135–8.

26 Lecky DM, McNulty CAM, Touboul P *et al*. Qualitative evaluation of e-Bug: an educational pack, teaching about prudent antibiotic use and hygiene, in the Czech Republic, France and England. *J Antimicrob Chemother* Supplement, in press.

27 Goossens H, Guillemot D, Ferech M *et al*. National campaigns to improve antibiotic use. *Eur J Clin Pharmacol* 2006; **62**: 373–9.

28 Prince M. Does active learning work? A review of the research. *J Engr Educ* 2004; **93**: 223–31.

29 Hewitt M, Denman S, Hayes L *et al*. Evaluation of 'Sun-safe': a health education resource for primary schools. *Health Educ Res* 2001; **16**: 623–33.
30 Cebotarenco N, Bush PJ. Reducing antibiotics for colds and flu: a student taught programme. *Health Educ Res* 2008; **23**: 146–57.
31 Apostolidou M, Fontana D. Teacher attitudes towards health education in Greek-speaking Cyprus schools. *Health Educ* 2003; **103**: 75–82.
32 Hameen-Anttila K, Airaksinen M, Timonen J *et al*. Medicine education for school children: what do the teachers think? *Health Educ* 2006; **10**: 480–90.
33 Hameen-Anttila K, Juvonen M, Ahonen R *et al*. What school children should be taught about medicines – combined opinions of children and teachers. *Health Educ* 2005; **105**: 424–36.
34 Hameen-Anttila K, Juvonen M, Ahonen R *et al*. How well can school children understand medicine related topics? *Patient Educ Couns* 2006; **60**: 171–8.
35 Menacker F, Aramburuzabala P, Bush PJ *et al*. Children and medicines: what they want to know and how they want to learn. *J Soc Adm Pharm* 1999; **16**: 38–52.
36 Curtis V, Cairncross S. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *Lancet Infect Dis* 2000; **3**: 275–81.
37 Luby S, Agboatwalla M, Feikin D *et al*. Effect of hand washing on child health: a randomised controlled trial. *Lancet* 2005; **366**: 225–33.
38 CDC. What you can do to stay healthy. http://www.cdc.gov/h1n1flu/ (16 February 2010, date last accessed).

39 East of England Strategic Health Authority press release March 2007. Coughs and sneezes spread diseases. http://www.eoe.nhs.uk/news_archive.php?area_id=9&id=24 (16 February 2010 date last accessed).

40 Denman S. Health promoting schools in England—a way forward in development. *J Public Health Med* 2000; **21**: 215–0.

41 Ferech M, Coenen S, Malhotra-Kumar S *et al*. on behalf of the ESAC Project Group. European Surveillance of Antimicrobial Consumption (ESAC): outpatient antibiotic use in Europe. *J Antimicrob Chemother* 2006; **58**: 401–7.