ORIGINAL ARTICLE

The State of Antimicrobial Stewardship Programs in California

Kavita K. Trivedi, MD;[1] Jon Rosenberg, MD[1]

OBJECTIVE. To assess antimicrobial stewardship programs (ASPs) and strategies in California general acute care hospitals and to describe the effect of state legislation (Senate Bill 739) requiring hospitals to develop processes for evaluating the judicious use of antimicrobials.

DESIGN. Web-based survey of general acute care hospitals.

PARTICIPANTS. All 422 general acute care hospital campuses in California were invited to participate.

RESULTS. Responses from 223 (53%) of California's general acute care hospital campuses were included and were statistically representative of all acute care hospital campuses by region but not bed size or rurality. Community hospitals represented 73% of respondents. Fifty percent of hospitals described a current ASP and 30% reported planning an ASP; of these, 51% reported measuring outcomes. Twenty percent of hospitals reported no planned ASP or uncertainty whether an ASP existed and described barriers including staffing constraints (47%), lack of funding (42%), and lack of initiation of a formal proposal to start an ASP (42%). Of 135 responding hospitals, 22% reported that Senate Bill 739 influenced initiation of their ASP.

CONCLUSIONS. Although many studies have been published that describe hospital-specific ASPs, most have been described within academic centers, and there are limited assessments of ASP strategies across hospital systems. Our study verifies that many ASPs exist in California, particularly in community settings where a scarcity of antimicrobial restriction was thought to exist. Additionally, Senate Bill 739 appears to have played a role in initiating many hospital ASPs, which supports the adoption of similar legislation in other states and nationally.

Infect Control Hosp Epidemiol 2013;34(4):379-384

Antimicrobial use optimization in acute care hospitals is widely accepted to decrease antimicrobial resistance patterns, decrease the development of secondary infections, reduce adverse medication effects, and thereby decrease healthcare costs in this setting.[1-3] Antimicrobial stewardship programs (ASPs) are intervention-based programs designed to promote and measure the appropriate use of antimicrobials. This quality improvement activity assists clinicians in selecting the appropriate agent, dose, duration, and route of administration to optimize clinical outcomes while minimizing the selection of pathogenic organisms and emergence of resistance. Importantly, there is an increasing linkage between ASPs and hospital patient safety and quality initiatives.[1,4-6]

State health departments can play a central role in eliminating healthcare-associated infections (HAIs) because they are responsible for protecting patients across the continuum of care.[7] Increasingly, state health departments are being required to publicly report on HAIs in healthcare settings, serving as the cornerstone of state HAI surveillance and prevention programs. California Senate Bill (SB) 739 (Health and Safety Code §§ 1288.5–1288.9, 2006) established the California Department of Public Health (CDPH) HAI program to conduct surveillance, prevention, and public reporting of HAIs in general acute care hospitals statewide. In addition, California SB 739 mandated that, by January 2008, all general acute care hospitals develop processes for evaluating the judicious use of antibiotics and monitor results using appropriate quality improvement committees (California Health and Safety Code section 1288.8[a]). Although the law neither specifies processes nor addresses noncompliance, it provides a statutory incentive for hospital administrators to establish active ASPs. California is the only US state with this type of legislation.

The CDPH HAI program developed the California ASP Initiative in February 2010 to assist, develop, and strengthen ASPs in California health care facilities.[8,9] One of the first activities of the initiative was to assess ASPs and their strategies in California general acute care hospitals. Another goal was to describe the effect of state legislation on and identify barriers to the initiation and development of these programs.

METHODS

A web-based survey tool was disseminated to California general acute care hospitals during the period May 2010–September 2011. Participation was voluntary, and various communications encouraged participation, including emails to hospital infection control programs, presentations at regional

Affiliation: 1. Healthcare-Associated Infections Program, California Department of Public Health, Richmond, California.

Received June 26, 2012; accepted December 3, 2012; electronically published February 8, 2013.

© 2013 by The Society for Healthcare Epidemiology of America. All rights reserved. 0899-823X/2013/3404-0008$15.00. DOI: 10.1086/669876

https://doi.org/10.1086/669876 Published online by Cambridge University Press

infectious diseases and infection control meetings, and word of mouth. Instructions specified that a single survey be filled out by one person at each hospital who understood the systems and programs in place or planned to oversee the judicious use of antimicrobials.

The survey tool collected information on hospital demographic characteristics, including hospital size, self-identified hospital classification, and teaching status (Appendix A, available online as a PDF). Data on regional location and rurality of hospitals were also collected. Presence of electronic data capture systems was assessed.

Data on the presence or absence of an ASP and influence of SB 739 on the development of an ASP were also collected. The definition of an ASP was nonspecific in the survey tool to include all interpretations of an ASP. However, hospitals were classified as having an ASP only if respondents were able to identify personnel dedicated to the oversight of antimicrobial use and a specific ASP strategy. In addition, information on ASP strategies used, outcome measures followed, and barriers identified was collected. Both hospital and respondent personal identifiers were optional. Demographic characteristics of hospital respondents were compared with characteristics of all California hospitals according to the 2010 general acute care hospital database compiled by the CDPH HAI program to determine representativeness.

Data were analyzed using SAS, version 9.3 (SAS Institute). The hospitals that reported current ASPs and that were planning ASPs versus those that reported no ASPs were compared across various demographic characteristics to determine factors associated with having an ASP. Relative risk (RR), 95% confidence interval (CI), and P value were calculated using the χ^2 test or Fisher exact test when applicable.

RESULTS

Characteristics of Hospital Respondents

Two hundred and sixty-one healthcare facilities responded to the survey. Eight responses were duplicates, and 10 responses were from facilities other than general acute care hospitals. Responses were received from 243 (58%) of the 422 general acute care hospital campuses and 63% of 383 reporting hospitals (39 campuses were operating under consolidated licenses in California in 2010). Eighteen hospital respondents did not report whether they had an ASP and were excluded from additional analysis; 2 additional hospital respondents did not indicate personnel dedicated to the oversight of antimicrobial use nor a specific ASP strategy and therefore were excluded from additional analysis. Survey respondents from the remaining 223 hospitals in California reported occupation and type of hospital; hospital classifications were not mutually exclusive (Table 1).

Only 1% of hospitals represented pediatric institutions. The median range of licensed beds from respondent hospitals was 201–300. Hospitals self-identified rurality, region, presence of electronic data capture, and teaching status. Forty-nine percent of hospitals reported a pharmacist dedicated to the oversight of antimicrobial use. Eighty-eight percent of hospitals reported infectious diseases consultation availability.

Overall, 50% of hospitals reported a current ASP, 30% reported planning an ASP, and 20% reported not having an ASP or being unsure whether their institution had an ASP. Of 135 hospitals that responded, 22% were influenced by SB 739 to initiate an ASP.

Representativeness of Hospital Respondents

According to the CDPH 2010 hospital file, the median bed size of California hospitals was 122, compared with 201–300 licensed beds in this survey. The regional location of California hospitals is 48% Southern, 34% Northern, and 17% Central, which does not differ significantly for hospital respondents (χ^2, 1.85; $P = .40$). However, 14% of hospitals in California are classified as rural, compared with 19% in this survey ($P = .04$). Lastly, 57% of hospitals self-reported as teaching sites, but only 13% reported fellows, residents, and pharmacy residents; both of these percentages are higher than the 7% of hospitals in California that are classified as limited teaching institutions by the Centers for Disease Control and Prevention's National Healthcare Safety Network criteria ($P \leq .001$ for both).

Characteristics of Antimicrobial Stewardship Programs

Of 49 hospitals responding with a current ASP, 57% reported initiating the ASP on or after January 2008; the earliest ASP began in a teaching hospital in 1972; the earliest ASP in a community setting began in an urban 301–400 licensed bed hospital in 1985. Of 93 hospitals responding, 77% reported an ASP oversight committee.

Of hospitals with an ASP or planning an ASP ($n = 176$), primary strategies were reported in 92 hospitals (52%; Table 2). Criteria used by the ASP to target cases for review included antimicrobials with a high potential for misuse (41%), high-cost antimicrobials (35%), specific resistance profiles (34%), broad-spectrum antimicrobials (33%), and antimicrobials with high potential for adverse effects (28%). The most common ASP personnel were infectious diseases physicians (44%), pharmacists (40%), infection preventionists (31%), infectious diseases pharmacists (29%), and microbiologists (26%). Full-time equivalent (FTE) employees compensated for ASP duties varied. Among hospitals with an ASP who responded, 73% of ASP physicians, 80% of ASP pharmacists, and 17% of ASP data analysts were dedicated a portion of FTEs to the ASP. Only 5 hospitals with an ASP identified infection preventionist FTEs.

Outcomes measured by hospitals with an ASP or planning an ASP included antimicrobial resistance patterns (39%), antimicrobial utilization (36%), antimicrobial costs (35%), *Clostridium difficile* infection rates (32%), adverse effects (22%), and ASP recommendations implemented (18%). Of the 63 hospitals monitoring antimicrobial use, 17% reported monitoring defined daily doses, and 13% reported monitoring days of therapy; others did not respond. Forty-nine per-

https://doi.org/10.1086/669876 Published online by Cambridge University Press

TABLE 1. Survey and General Acute Care Hospital (GACH) Respondent Characteristics, California, 2010

Characteristic	No. (%) of survey/GACH respondents
No. of respondents	223 (53)
Occupation of respondents	
Infection preventionist	82 (37)
Pharmacy director, supervisor, or clinical coordinator	59 (26)
Infectious diseases physician	24 (11)
Clinical pharmacist	18 (8)
Infectious diseases pharmacist	15 (7)
Healthcare epidemiologist	11 (5)
Type of hospital[a]	
Community	162 (73)
City/county	24 (11)
University/university affiliated	21 (9)
Long-term acute care	18 (8)
Critical access/district	7 (3)
Rehabilitation	4 (2)
Surgical	3 (1)
Licensed beds	
≤100	44 (20)
101–200	63 (28)
201–300	34 (15)
301–400	41 (18)
401–500	20 (9)
501–600	14 (6)
≥601	7 (3)
Locus	
Urban	90 (40)
Suburban	85 (38)
Rural	43 (19)
Region	
Southern	110 (49)
Northern	82 (37)
Central	31 (14)
Electronic data capture	
Laboratory	173 (78)
Pharmacy	167 (75)
Medication administration record	129 (58)
Health record	121 (54)
Prescription order entry	85 (38)

[a] Not mutually exclusive.

cent of hospitals with an ASP did not report measuring any outcomes data to assess the utility of the ASP. However, for the hospitals that measured outcomes, many had observed a positive trend in outcomes data since the initiation of the ASP, including improved antimicrobial use (74%), decreased antimicrobial costs (63%), increased frequency of the primary physician's acceptance of ASP recommendations (58%), and improved antimicrobial susceptibility patterns (47%). Additionally, of 93 hospitals, 38% reported using computer software to interface with electronic records that facilitated the ASP.

Last, hospitals with an ASP were more likely than hospitals without an ASP to have an electronic health record (88% vs 71%; RR, 1.2 [95% CI, 1.1–1.4]) and an electronic medication administration record (85% vs 72%; RR, 1.2 [95% CI, 1.02–1.4]). Additionally, hospitals with an ASP were also more likely to have an electronic health record, computerized prescription order entry system, and electronic medication administration records (92% vs 75%; RR, 1.2 [95% CI, 1.1–1.4]).

Characteristics of Hospitals without Antimicrobial Stewardship Programs

Of 45 hospitals that reported no ASP or were unsure that their institution had an ASP, 15 (33%) reported a pharmacist dedicated to the oversight of antimicrobial use. Twenty-five hospitals (55%) identified primary strategies to restrict the use of antimicrobials (Table 2). Barriers reported to estab-

https://doi.org/10.1086/669876 Published online by Cambridge University Press

TABLE 2. General Acute Care Hospital Respondent Antimicrobial Use Oversight and Strategies, Sorted by Presence of an Antimicrobial Stewardship Program (ASP), California, 2010

Strategy	No. (%) of respondents		
	Current/planned ASP (n = 176)	No ASP (n = 45)	P
Pharmacist dedicated to antimicrobial use oversight	92 (52)	15 (33)	.06
Infectious diseases consultation available	159 (90)	34 (76)	.09
Antimicrobial oversight committee	72 (77)[a]	16 (53)	<.01
Strategy[b]			
None	0	5 (11)	<.01
Primary	92 (52)	25 (55)	.69
Formulary restriction	78 (44)	22 (49)	.58
Infectious diseases consultation	54 (69)	11 (50)	.09
Audit	48 (62)	6 (27)	<.01
Prior approval required	42 (54)	8 (36)	.15
Automatic stop orders	36 (46)	10 (45)	.95
Verbal approval required	22 (28)	2 (9)	.06
Other	9 (5)	1 (5)	.33
Preauthorization	57 (32)	9 (20)	.10
Postprescription review with feedback	45 (26)	5 (11)	.04
Supplemental			
Education	71 (40)	14 (31)	.26
Dose optimization/automatic dose adjustments	69 (39)	10 (22)	.03
Guidelines and clinical pathways	69 (39)	13 (29)	.20
Intravenous-to-oral conversion protocols	64 (36)	9 (20)	.04
Time-sensitive automatic stop orders	55 (31)	14 (31)	.99
Streamlining/de-escalation	50 (28)	2 (4)	<.01
Antimicrobial order forms	43 (24)	15 (33)	.23

[a] Only 93 hospitals responded.
[b] Not mutually exclusive.

lishing an ASP were staffing constraints (47%), lack of funding (42%), lack of initiation of a formal proposal (42%), ASP not a priority (24%), no administrative support (18%), and no medical staff support (18%). Hospitals without an ASP were more likely than hospitals with an ASP to have less than 200 licensed beds (33% vs 9%; RR, 3.8 [95% CI, 2.0–7.3]) and less than 100 licensed beds (43% vs 15%; RR, 3.0 [95% CI, 1.8–4.9]). These hospitals were also more likely than hospitals with an ASP to be in rural areas of California (40% vs 16%; RR, 2.5 [95% CI, 1.5–4.2]).

DISCUSSION

To our knowledge, this is the first published assessment of ASPs in a single state across hospital systems. These survey results indicate that many ASPs are active in California hospitals, using strategies and personnel as published in the 2007 Infectious Diseases Society of America (IDSA) and the Society of Healthcare Epidemiology of America (SHEA) guidelines.[1] Furthermore, many of the hospitals that were identified as not having an ASP did have elements of an ASP with either a pharmacist dedicated to antimicrobial use oversight or implementation of a primary strategy to restrict the use of antimicrobials. In addition, community hospitals are actively engaged in ASP activities despite reporting barriers, such as lack of resources and limited published guidance.

Small hospitals and rural hospitals were more likely not to have an ASP, and thus outreach should be focused on these institutions. Leaders in ASPs across the country should hypothesize and test alternate ways of providing stewardship in facilities with limited resources in terms of pharmacist and physician availability. Options may be telemedicine, remote consulting when electronic record systems are in place, or identification of "low-hanging fruit" that a nurse or a nonpharmacist would be able to perform. Additionally, electronic records do appear to facilitate ASPs, and a hospital is more likely to have an ASP with electronic data capture in place; however, ASP-specific software is not required.

A promising finding is the hospitals that reported a positive trend in outcomes after initiation of their ASP. Although only anecdotal, these data present evidence across multiple hospital systems that ASPs can improve both antimicrobial use and susceptibility patterns. However, many hospital-based ASPs in California (49%) are not focused on measuring outcomes. As we have seen from other hospitals that have lost support for their ASPs, it is important to measure a process or outcome to demonstrate value of the ASP to the administration

https://doi.org/10.1086/669876 Published online by Cambridge University Press

for continued support.[10] These measures are also crucial in getting clinician buy-in for increased implementation of ASP recommendations.

California is the first and thus far only US state with legislation targeting the judicious use of antimicrobials; however, results from this survey indicate community hospitals in California have been engaged in ASP implementation since the 1980s. This indicates that some California community hospitals recognized ASPs as important programs in their facilities without the statutory incentive, whereas others were encouraged to adopt and develop ASPs after the legislation was passed. Similarly, in response to a higher rate of antibiotic use than that found in other European countries and increasing antimicrobial resistance, French hospitals have been required to implement ASPs to improve antibiotic use since 2001.[11-13] Publications from France indicate that ASP-specific regulation has helped to create incentives to comply with guidelines on the prudent use of antibiotics; furthermore, in the context of financial limitations, regulatory requirements are essential in assisting hospitals to prioritize actions that address patient safety.[14] Although not required, legislation and regulation regarding ASPs does appear to facilitate these patient safety programs, and our study is consistent with the French experience. The response to SB 739 in California with regard to ASPs supports the adoption of similar state and national ASP policy throughout the United States, furthering the recommendations made by the policy statement released by SHEA, IDSA, and the Pediatric Infectious Diseases Society in April 2012 for ASPs to be required through regulatory mechanisms.[15]

However, despite the statutory incentive of SB 739, barriers still exist to adopting ASPs in California. Staffing constraints and lack of funding and administrative support plague some California hospitals; however, many ASPs have demonstrated cost savings and thereby pay for themselves.[2,16,17] Increased collaboration between hospitals that are successful in implementing ASPs and those that are not is needed to increase the prevalence of robust programs. State departments of public health can be uniquely situated to initiate and support these collaborations, which are particularly important among acute care hospitals and neighboring long-term care facilities.[18]

ASP prevalence in national surveys has varied. A 2008 survey of Premier, IDSA, and SHEA members reported ASPs in 74% of 357 US hospitals,[6] whereas in a 2010 national pharmacy survey, 43.5% of 566 US hospitals reported an ASP, with variation based on hospital size.[19] However, in both of these surveys, the definition of an ASP was unclear and may have been interpreted differently by various respondents. Hospital classifications were not available for either of these studies, so practical guidance for community hospitals remains limited. In 2001, Zillich et al[20] reported only 55% of antimicrobial prescriptions reviewed in US general hospitals were consistent with clinical practice guidelines for antimicrobials; however, this survey did not collect data on the prevalence of formal ASPs. More recently, an assessment of ASPs in the US described 61% of infectious diseases physicians from 46 states reporting an ASP at their institution via an electronic survey by the IDSA Emerging Infections Network (EIN).[21] However, these results are not generalizable to all US hospitals, because EIN members are more likely to be interested in infection control and therefore to respond to a query regarding ASPs. Our survey received reasonable participation from California hospitals and included a representative sample of all hospitals in California with respect to regional variation but not bed size or rurality.

Other limitations of this study include self-report bias and duplicate hospitals reporting, because hospitals were not required to provide facility identifiers. When determining representativeness, the CDPH 2010 hospital database was used as a comparison, which identifies only hospitals and their campuses that are licensed. In this survey, we were not able to control for multiple campuses responding that may have represented a single license. The definition of teaching status was not provided on the survey; therefore, a broad interpretation was used. Any unintended consequences of SB 739 were also not explored. Last, given our survey design and the nature of descriptive studies, there were missing data in the survey, which limits additional in-depth analyses.

In conclusion, many ASPs are active in California, particularly in community settings, but small hospitals and rural hospitals may require focused outreach to overcome specific difficulties with ASP implementation. Although the California legislation was influential in stimulating the development of ASPs in some hospitals, the movement toward ASPs appears to have preceded the legislation, which indicates that the need for ASPs may have already been recognized. Our statewide assessment of ASPs can provide a template for other states to conduct similar surveys and identify specific types of hospitals or areas that require additional attention. Hospitals, other healthcare facilities, public health agencies, and professional organizations should take advantage of this need and work together to overcome the barriers that continue to exist to improve broad acceptance and full implementation of ASPs.

ACKNOWLEDGMENTS

We would like to acknowledge review by Arjun Srinivasan and Ronda Sinkowitz-Cochran from the Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

Address correspondence to Kavita K. Trivedi, MD, Public Health Medical Officer, Healthcare-Associated Infections Program, California Department of Public Health, 850 Marina Bay Parkway, Building E, 1st Floor, Richmond, CA 94804 (ktrivedi@cdph.ca.gov).

https://doi.org/10.1086/669876 Published online by Cambridge University Press

REFERENCES

1. Dellit TH, Owens RC, McGowan JE Jr, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis* 2007;44(2): 159–177.
2. Goff DA. Antimicrobial stewardship: bridging the gap between quality care and cost. *Curr Opin Infect Dis* 2011;24(suppl 1): S11–S20.
3. Ohl CA, Luther VP. Antimicrobial stewardship for inpatient facilities. *J Hosp Med* 2011;6(suppl 1):S4–S15.
4. Drew RH, White R, MacDougall C, Hermsen ED, Owens RC Jr. Insights from the Society of Infectious Diseases Pharmacists on antimicrobial stewardship guidelines from the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. *Pharmacotherapy* 2009;29(5):593–607.
5. Bal AM, Gould IM. Antibiotic stewardship: overcoming implementation barriers. *Curr Opin Infect Dis* 2011;24(4):357–362.
6. Pope SD, Dellit TH, Owens RC, Hooton TM. Results of survey on implementation of Infectious Diseases Society of America and Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Infect Control Hosp Epidemiol* 2009;30(1):97–98.
7. The Association of State and Territorial Health Officials; Centers for Disease Control and Prevention (CDC). *Policies for Eliminating Healthcare-Associated Infections.* Atlanta, GA: CDC, 2012.
8. Goldstein EJC, Trivedi K. Antimicrobial stewardship: the view from California. *Infect Dis Clin Pract (Baltim Md)* 2012;20:294–296.
9. California Department of Public Health. *The California Antimicrobial Stewardship Program Initiative.* http://www.cdph.ca.gov/programs/hai/Pages/AntimicrobialStewardshipProgramInitiative.aspx.
10. Standiford HC, Chan S, Tripoli M, Weekes E, Forrest GN. Antimicrobial stewardship at a large tertiary care academic medical center: cost analysis before, during, and after a 7-year program. *Infect Control Hosp Epidemiol* 2012;33(4):338–345.
11. Dumartin C, Rogues AM, Amadeo B, et al. Antibiotic usage in south-western French hospitals: trends and association with antibiotic stewardship measures. *J Antimicrob Chemother* 2011; 66(7):1631–1637.
12. Vander Stichele RH, Elseviers MM, Ferech M, Blot S, Goossens H. Hospital consumption of antibiotics in 15 European countries: results of the ESAC Retrospective Data Collection (1997–2002). *J Antimicrob Chemother* 2006;58(1):159–167.
13. European Surveillance of Antimicrobial Consumption (ESAC). *ESAC Yearbook 2008.* http://www.ecdc.europa.eu/en/activities/surveillance/esac-net/publications/documents/esac_yearbook_2008.pdf. ESAC, 2010. Accessed June 25, 2012.
14. Dumartin C, Rogues AM, Amadeo B, et al. Antibiotic stewardship programmes: legal framework and structure and process indicator in Southwestern French hospitals, 2005–2008. *J Hosp Infect* 2011;77(2):123–128.
15. Policy statement on antimicrobial stewardship by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA), and the Pediatric Infectious Diseases Society (PIDS). *Infect Control Hosp Epidemiol* 2012; 33(4):322–327.
16. McQuillen DP, Petrak RM, Wasserman RB, Nahass RG, Scull JA, Martinelli LP. The value of infectious diseases specialists: non-patient care activities. *Clin Infect Dis* 2008;47(8):1051–1063.
17. Goff DA, Bauer KA, Reed EE, Stevenson KB, Taylor JJ, West JE. Is the "low-hanging fruit" worth picking for antimicrobial stewardship programs? *Clin Infect Dis* 2012;55(4):587–597.
18. Septimus EJ, Owens RC Jr. Need and potential of antimicrobial stewardship in community hospitals. *Clin Infect Dis* 2011; 53(suppl 1):S8–S14.
19. Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: prescribing and transcribing, 2010. *Am J Health Syst Pharm* 2011;68(8):669–688.
20. Zillich AJ, Sutherland JM, Wilson SJ, et al. Antimicrobial use control measures to prevent and control antimicrobial resistance in US hospitals. *Infect Control Hosp Epidemiol* 2006;27(10):1088–1095.
21. Johannsson B, Beekmann SE, Srinivasan A, Hersh AL, Laxminarayan R, Polgreen PM. Improving antimicrobial stewardship: the evolution of programmatic strategies and barriers. *Infect Control Hosp Epidemiol* 2011;32(4):367–374.

https://doi.org/10.1086/669876 Published online by Cambridge University Press