OVERALL GOAL & OBJECTIVES

Antimicrobial stewardship (AS) is an emerging field that encompasses all strategies aimed at improving antimicrobial prescribing practices to achieve optimal outcomes. As the evidence demonstrating the effectiveness of AS intervention strategies has grown, the Infectious Diseases Society of America (IDSA) and the Society of Healthcare Epidemiology of America (SHEA) published a guideline for implementation of AS programs (ASPs) in 2007(1). This guideline for implementation of ASPs focuses on two core strategies: 1) Prospective audit with intervention and feedback (PAF) and 2) formulary restriction or preauthorization. This guideline does not distinguish the needs of small, community hospitals (SCHs) from those of larger, urban hospitals. Individual ASPs formed from these guidelines have been shown repeatedly to reduce inappropriate antibiotic use (2, 3) and positively impact other clinical endpoints (*Clostridium difficile* infection, adverse drug reactions, cost, etc.) (4).

Antibiotic stewardship programs should not be limited to large, tertiary care hospitals in urban settings. Little is known about antibiotic utilization rates in SCHs, although available evidence suggests that stewardship interventions are needed in these settings. For example, in Minnesota, antibiotic utilization rates in SCHs was shown to be higher than large, urban hospitals and varied greatly between hospitals (5). Small, community hospitals are also much more likely to not have an ASP when compared to large, academic medical centers (6, 7) and few have infectious disease pharmacists or physicians to support stewardship efforts. The high antibiotic utilization and limited stewardship oversight in SCHs makes implementation of ASPs in these communities a high priority. **The challenge of developing ASPs in SCHs is to provide an appropriate level of stewardship interventions while optimizing staffing and stewardship needs.** Small, community hospitals need to develop stewardship programs that conform to their size, antibiotic utilization patterns, and infrastructure limitations if they hope to be both sustainable and successful; however, data on what is most effective are not available.

The focus of this project is the development, implementation and evaluation of effective and sustainable AS interventions that conform to the size, staffing, and infrastructure of SCHs.
Intermountain Healthcare is a nonprofit, integrated healthcare network based in Salt Lake City, UT, and includes 22 hospitals (21 in Utah, 1 in Idaho), a medical group with more than 185 physician clinics, and an affiliated health insurance company. The Intermountain AS Committee was established in 2009 and established a goal to develop ASPs for all 22 hospitals (21 acute care hospitals and 1 specialty orthopedic hospital) in the system. In support of this goal, infectious diseases (ID) pharmacists and physicians were hired to develop ASPs for the large, regional, urban medical centers. Currently, each large hospital (n=6) has their own ASP in varying stages of development and implementation with 3 of 6 institutions utilizing a validated information technology (IT) antibiotic utilization surveillance system to monitor antibiotic usage(8). However, none of the 15 SCHs, ranging from 8 – 126 beds and collectively accounting for 27% of all admissions to Intermountain facilities, have any formal ASPs in place.

Most ASPs within large medical centers are tailored to characteristics of their healthcare environment. Variation in regional antibiotic prescribing patterns, prevalence of multidrug resistant organisms, commitment of hospital administration, specialty care centers (transplant,

oncology, trauma, etc.) and infectious disease specialist involvement make most ASPs unique to their medical center and are, thus, difficult to compare. Very few randomized clinical trials have evaluated the effectiveness of specific AS interventions across acute care hospitals (9). **To our knowledge, the AS needs of SCHs have not been systematically evaluated in a healthcare network and no randomized clinical trial has been performed evaluating the implementation of AS interventions in SCHs. Optimizing resource utilization is imperative in SCHs if an ASP is going to be sustainable and successful.**

The key objectives for our initiative include:

1. Expand our information technology (IT) antibiotic utilization surveillance system to incorporate Intermountain's 15 SCHs. Expanding our surveillance system to the SCHs within our system will allow for internal benchmarking antibiotic usage across hospitals and evaluating AS interventions in these SCH, as well as allow individualized feedback.
2. Within our 15 SCHs, we will perform a cluster-randomized, controlled trial evaluating three AS strategies of varying resource utilization (low – medium – high). **Our primary goal is to define an AS strategy for small hospitals that optimizes clinical stewardship outcomes while minimizing resource utilization.**

The outcomes of this trial will better define the methods used to evaluate antimicrobial utilization and implementation of ASPs in SCHs. This information will be rapidly generalizable to SCHs across the United States facing similar challenges with lack of specialized providers and limited staffing.

EVIDENCE OF NEED FOR IMPROVEMENT

Our proposed study will focus our outcome measurements in 3 areas: 1) Health economics (antimicrobial cost containment and resource utilization), 2) Improved patient outcomes and safety and 3) Containment of antimicrobial resistance. Our baseline data in all three of these measures have identified many areas needing improvement.

Utilization and Health economics

Intermountain Healthcare was recruited from a past Prevention Epicenter Program, funded by the CDC, to develop methods to obtain uniform measures of antimicrobial use. Intermountain utilized its extensive Electronic Data Warehouse (EDW) to generate antimicrobial utilization rates from electronic medication administration records. Monthly utilization data are stratified by hospital, unit description, and antibiotic class. Utilization data generated by computer code were validated through manual data validation (i.e. chart review) and found to overestimate counts of antimicrobial-days and patient-days receiving antimicrobials by less than 1% (8). Currently, Intermountain tracks antimicrobial utilization at only 2 of the 15 SCHs, Alta View and Riverton Hospitals (67 and 89 beds respectively). An example of antibiotic utilization rates of two urban medical centers and two SCHs can be found in table 1 of the appendix. Antibiotic utilization rates are largely undefined in SCHs. Expanding our IT antibiotic utilization surveillance system to the remaining 13 SCHs will allow us to define the scope of antibiotic utilization in these hospitals and investigate the impact of three AS interventions on antimicrobial utilization patterns.

Patient outcomes and safety

The impact of ASPs on patient outcomes and safety is ultimately the most important outcome, although more difficult to evaluate. The most readily available safety outcome is hospital acquired *C. difficile* infection (CDI) rates. Table 1 shows both community-associated and hospital-associated *C. difficile* rates for two of our SCHs. Rates of hospital-acquired CDI in these small hospitals are comparable to the hospital-acquired CDI rates in our main academic medical center in Salt Lake City (3.58 – 13.35 cases of CDI/10,000 patient days).

Table 1: Quarterly *C. difficile* rates (cases per 10,000 patient days) for 2011 and 2012 for two small, community hospitals.

Hospital	**Q1-2011**	**Q2-2011**	**Q3-2011**	**Q4-2011**	**Q1-2012**	**Q2-2012**	**Q3-2012**	**Q4-2012**
Alta View								
HA	6.1	2.8	8.9	5.8	12.2	6.2	12.2	13.8
CA	9.1	14.0	20.8	8.7	3.0	34.1	30.4	24.2
Total	**15.2**	**16.9**	**29.7**	**14.5**	**15.2**	**40.3**	**42.6**	**38.0**
Riverton								
HA	0.0	0.0	2.6	10.0	2.4	6.9	0.0	7.3
CA	7.9	4.9	7.9	17.5	12.1	6.9	9.8	21.9
Total	**2.3**	**7.8**	**20.6**	**23.0**	**11.3**	**11.8**	**27.8**	**20.5**

HA = hospital acquired
CA = community acquired

Containment of antimicrobial resistance

Intermountain healthcare is an integrated healthcare system. Using real time IT alerts, we monitor the incidence of multi-drug resistant organisms (MDROs) through the entire network and collect individual isolates from our large medical centers for further epidemiologic testing. We currently have an active monitoring system for emerging MDROs (10) that includes vancomycin-resistant enterococcus (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), extended spectrum *beta*-lactamase producing gram-negative infections (ESBL), and carbapenem-resistant Enterobacteriaceae (CRE)and *Acinetobacter spp.* Since July 1, 2011, 106 cases of carbapenem-resistant *Acinetobacter spp.* and *Klebsiella pneumoniae* have been identified across the network, 11 cases occurring in SCHs. All SCHs send clinical culture specimens to either their regional medical center or the central laboratory at Intermountain Medical Center. Microbiology laboratory procedures and availability are standardized across all hospitals in the Intermountain network.

STUDY DESIGN AND ANALYTIC METHODS

Study design and intervention

Intermountain Healthcare formed a corporate AS Committee in 2009 in response to the growing need for monitored antimicrobial use. This committee is responsible for the development and evaluation of ASPs across Intermountain's 21 acute care hospitals. Under the direction of the corporate AS committee and with support from hospital administration, ID trained pharmacists and physicians have developed / are developing ASPs at the 6 large Intermountain medical centers. The remaining 15 SCHs within the Intermountain system do not currently have any dedicated AS staff or antimicrobial oversight. This proposed initiative

was developed to address the stewardship needs of our SCHs by evaluating the clinical and health economic impact of three AS interventions. The three AS interventions have three distinct levels of resource utilization and complexity and are outlined in Table 2. **We hypothesize that the "Medium Resource Utilization" interventions will provide substantial clinical and economic results and the minimal additional benefit seen with the "High Resource Utilization" will not be offset by the substantial increase in resource requirements.** Intermountain's 15 SCHs will be included in this parallel group, cluster randomized trial of three AS interventions. Each of the 15 hospitals will be randomized to one of three AS interventions as described in Table 2. The randomization will be stratified based on hospital size to ensure each cluster has similar bed-days of care and surgical services available. The study duration will be two years. The first 6 months will be used to develop educational materials, train staff pharmacists, expand our IT resources to SCHs, apply for internal review board approval through each regional medical center, and gather baseline data. The following 15 months will be the intervention period in which each cluster will implement a different AS strategy (low, medium, high resource utilization). The remaining 3 months will be used for data analysis and dissemination of results.

Table 2: Description of three antimicrobial stewardship strategies with escalating resource requirements.

Low Resource Utilization	***Medium Resource Utilization***	***High Resource Utilization***
Monthly hospital abx utilization report	Monthly hospital abx utilization report	Monthly hospital abx utilization report
48 hour abx "timeout" initiated by floor staff pharmacist	48 hour abx "timeout" initiated by floor staff pharmacist	48 hour abx "timeout" initiated by floor staff pharmacist
	PAF – lite: Clinical pharmacists will audit a limited number of antimicrobial agents* and provide feedback to providers.	PAF: Clinical pharmacists will audit all antimicrobial agents and provide feedback to providers.
	Restriction (requiring local pharmacy review) of selected antimicrobials**	Restriction (requiring Infectious Diseases approval) of selected antimicrobials**
		ID trained study staff to review positive blood culture results, cultures with MDROs, and requests for outpatient based parenteral antibiotic therapy.

*Vancomycin, imipenem, meropenem, piperacillin-tazobactam, aminoglycosides
**Linezolid, daptomycin, ceftaroline, tigecycline, echinocandins, voriconazole, and amphotericin compounds
Abx = antibiotic
PAF = prospective audit and feedback
MDROs = multidrug resistant organisms

All hospital administrators, pharmacists, and clinicians will receive monthly antibiotic utilization reports. Utilization reports will quantify antibiotic use in days of therapy and will be stratified by antibiotic type and floor type. Utilization reports will not graphically display individual hospital antibiotic usage rates compared to the other SCHs to avoid confounding. Administrators, pharmacists, and clinicians can use the utilization data independently from the study.

All hospitals in the three intervention groups will also incorporate a 48 hour antibiotic time-out

into clinical practice. This antibiotic time-out will be initiated on all patients that have been on any antibiotic for > 48 hours by hospital staff pharmacists. The purpose of the antibiotic time out is to review current antimicrobials and assess necessity, review dose if kidney function has changed, review culture data to determine if the prescribed antibiotics provided adequate coverage or could be narrowed, determine if antibiotics could be given orally, review planned duration, and evaluate for redundant coverage (double anaerobic coverage). This review corresponds to the five antibiotic "rights": right drug, right patient, right dose, right route, and right duration. Instructions for an effective antibiotic time out will be developed and standardized to be used in multidisciplinary rounds and/or in individual consultation with medical providers. Staff pharmacists will identify patients on antibiotics > 48 hours with the use of our automated daily antibiotic reports. Daily antibiotic reports have been developed by the medical informatics staff at Intermountain and are currently in use by ASPs in the urban medical centers. The daily antibiotic report identifies all patients on antimicrobials and provides details how long patients have been on antimicrobial therapy. The antibiotic report is generated daily at 6:30am. The variables included in the antibiotic utilization report are listed in the Appendix, table 2.

Medium resource utilization group: In addition to the above interventions, the acute care pharmacists in hospitals randomized to the medium resource utilization group will incorporate 1) a limited PAF protocol and 2) require pharmacy approval of selected antimicrobial agents. The limited PAF protocol (PAF – lite) will have clinical pharmacists audit four broad-spectrum agents plus vancomycin and provide feedback to clinicians after 48 hours of antimicrobial use. Feedback will occur during multidisciplinary rounds or in individual consultation. Medium resource utilization group hospitals will also institute protocols that will restrict selected high cost antibiotics. Restriction protocols will be developed for linezolid, daptomycin, ceftaroline, tigecycline, echinocandins, voriconazole and amphotericin based compounds. These protocols will outline the appropriate use of these high cost antibiotics as determined by the corporate antibiotic stewardship committee and restrict use to designated conditions. Orders for these restricted antibiotics will require review by local, clinical pharmacists but will not require approval by one of the ID trained study pharmacists or clinicians. An ID clinician or pharmacist, including pediatric specialists for pediatric patients, from one of the regional medical centers will be available 7 days a week to answer any stewardship related clinical questions from the onsite clinical pharmacy staff.

Clinical pharmacists involved in the above AS interventions will be required to participate in a 10 hour AS training. This educational program will be developed by the study team and include on-line learning modules, lectures via teleconference (using Intermountain's telemedicine capabilities), pre and post-test, and case-based learning. The learners will also be provided a pocket size reference guide containing all AS restriction protocols and Intermountain treatment guidelines. This reference will also be available online via Intermountain's Intranet.

High resource utilization group: The high resource utilization group will perform the same tasks and receive the same educational materials as the medium resource utilization group with the following additional interventions:

1. Clinical pharmacists will audit ALL antimicrobial prescriptions and provide feedback to clinicians after 48 hours of antimicrobial use.
2. Prescribers ordering a restricted antibiotic must obtain approval by one of the ID trained study pharmacists or clinicians. On site staff pharmacists will not fill an order for these antibiotics unless approved by a member of the AS team.
3. An ID trained study pharmacist or clinician will review all positive blood cultures and all cultures with pre-defined multi-drug resistant organisms (VRE, MRSA, ESBL, CRE and *Acinetobacter*). The study personnel will review the medical record and discuss the care of the patient with the medical provider if recommendations are warranted.
4. All patients being discharged on IV antibiotic therapy will be discussed with a clinical member of the AS team to ensure appropriateness of IV antibiotic choice and duration of therapy, , as well as outpatient monitoring.

Study Population

All of Intermountain's SCHs were selected to participate in this study. *The Orthopedic Specialty Hospital* will not be included in this study due to its specialty orthopedic services and lack of adult general medical or surgical patients. Hospitals participating in the initiative with bed size and days of care are listed in the appendix, table 3. The patient population of these hospitals reflects the demographics of Utah (80.4% non-Hispanic white, 13.0% Hispanic, 0.9% non-Hispanic Black, 1% non-Hispanic American Indian and Alaska Native, 2% non-Hispanic Asian, 0.9% non-Hispanic Native Hawaiian and Other Pacific Islander, 0.1% from some other race, and 1.8% of two or more races).

Outcome measures

Our primary objective of this intervention is to evaluate the outcome and economic benefits of low, medium, and high resource utilization ASPs when compared to baseline data. The effectiveness of AS interventions in our SCHs will be measured by the change in the following outcomes:

<u>Health economics (Primary Endpoint):</u> A primary endpoint of this intervention is to evaluate the economic benefits of low, medium, and high resource utilization ASPs when compared to baseline data. We will collect the following data to assess this outcome:

1. Using a validated process (8), antibiotic utilization will be measured by electronic medication administration records at each of the study hospitals and will be reported as days of therapy. Antibiotic utilization reports are currently generated for 2 of the 15 SCHs. During the first 6 months of the study, our IT study personnel will expand our antibiotic utilization surveillance to include the remaining SCHs. Antibiotic utilization will be stratified by hospital level, unit level, and drug level (i.e. *beta*-lactam plus inhibitor, fluoroquinolones, etc.). Changes in antibiotic utilization will be compared to baseline data for each hospital. In addition, the magnitude of change in antibiotic utilization per cluster will be compared with the 'low resource utilization' group used as the referent group.
2. Using Intermountain's sophisticated cost-accounting system that enables detailed micro-costing of medical costs and antimicrobial administration, we will evaluate

antimicrobial use (days of therapy) and costs in each group compared to a baseline period prior to the start of the intervention. Cost analysis will include the estimated number of doses avoided based on baseline trends as well as aggregate savings on antimicrobial waste and administration costs (11).

3. Study personnel and staff pharmacists will keep detailed time logs of time spent working on the initiative and stewards efforts. Time spent on the AS efforts will be factored into the cost savings analysis.

Patient outcomes and safety: Improving clinical outcome and limiting unintended consequences of antimicrobial use through antimicrobial stewardship efforts are the most important goals of stewardship (12). The clinical outcomes of the three AS interventions in this initiative will be measured by:

1. Change or containment (if incidence found to be rising) in hospital acquired and community-acquired CDI rates. The identification of *C. difficile* cases will be through an electronic surveillance tool (already in place) that monitors positive laboratory test results. The monitor will identify only one positive test per person per day. CDIs will be validated by study staff.
2. Change in adverse antimicrobial drug events, focusing on rash, upper extremity deep venous thrombosis secondary to peripherally inserted central catheters, and acute kidney injury will be monitored by a validated monitoring system (13).
3. Hospital readmission rates obtained from administrative data.
4. Average hospital length of stay obtained from administrative data.
5. Change in proportion of patients being discharged with parenteral antibiotic therapy. The medical informatics department will create a natural language programming tool that scans every discharge summary for key phrases indicating outpatient IV antibiotic therapy. These generated reports will be reviewed by study personnel on a monthly basis. This reporting system will be used for all three clusters although the high resource utilization cluster will create an additional database of patients they discussed with medical providers regarding IV antibiotic therapy.

Containment of antimicrobial resistance: As discussed above, Intermountain performs real time surveillance of all clinical cultures to identify MRSA, VRE, ESBL, and carbapenem-resistant bacteria for all hospitals within the system. These automated generated reports are reviewed by the infection preventionist at each facility. The study team will receive a daily report of all MDRO positive cultures for each cluster. Each culture in the report will contain the following clinical information: Name, medical record number, date, culture result, susceptibility report, and source of culture. A minimum of 30 days between positive cultures of the same organism from the same site will be required to define a separate episode of infection. Duplicate cultures of the same organism from the same clinical infection will be excluded, regardless of time. A database of all MDRO positive cultures will be maintained by the study coordinator and all MDRO positive cultures, in all three arms, will be reviewed on a monthly basis by the study team. Incidence rates will be calculated per MDRO evaluated and for cumulative MDRO infections and followed through the study period.

The rates of MDRO infections in the SCHs are significantly lower than our large urban medical centers. Due to these baseline low rates, a change in MDRO infection rates will be difficult to demonstrate. As such, continued containment of drug resistance throughout our SCH will be a secondary objective. As part of this initiative, we will begin coordinating with all regional medical centers (provides microbiology testing for all SCHs) to collect MDRO isolates and cryopreserve them in the ID Epidemiology laboratory at LDS Hospital. MDRO isolates will be used for molecular typing and compared to isolates from the large, urban medical centers (isolates already typed). Prospectively typing MDROs will allow us to build a molecular library for each facility and region allowing for a more comprehensive analysis of MDROs in SCHs.

Analysis Plan

Data will be obtained primarily from Intermountain's EDW and manual collection by study personnel. Daily active electronic surveillance of all cultures in HELP/2 (Intermountain's electronic medical record) identifies MDROs (MRSA, VRE, ESBL, carbapenem resistant organisms). This reporting system is in place at all sites and will be used to track incidence of MDROs across study sites and clusters. *C. difficile* cases will be identified through active laboratory surveillance incidence rates calculated per study site and cluster. Daily antibiotic reports are generated by searching active inpatient medications in HELP/2 and reports are generated in Excel. Monthly antibiotic utilization data will be collected in days of therapy and obtained from electronic medication administration records as previously described. Adverse drug events will be monitored by study personnel via a validated process (13). Administrative data (length of stay, readmission rates, patient-days per hospital) and billing data will be obtained from the EDW by our study personnel. Prospective audit and feedback interventions will be tracked manually and entered into an Excel database at each site. Requests for restricted medications will also be tracked manually at each site and approval status monitored. Patients on outpatient based antibiotic therapy will be identified by natural language programming scanning all discharge summaries for all study sites involved. Requests for outpatient parenteral antibiotic therapy in the high resource utilization cluster will be manually logged in a shared database. Physician and pharmacy time will be manually recorded and collected.

Our primary analysis will evaluate the change in total antimicrobial days of therapy over the study period. We will also evaluate change in antimicrobial classes administered over the study period. Days of therapy will be monitored during the baseline period (6 months) and during the intervention period (15 months). A mixed-effect model will be used to account for the random effects (random variation in baseline days of therapy) and fixed effects (randomization to one of three intervention clusters) of the study. Using this model, we will evaluate the change in antibiotic utilization pre- and post- intervention and also compare the magnitude of the fixed effects between the three study clusters. Each cluster will contain approximately 40,000 patient days of care per year based on total patient-days in the 15 SCHs in 2012. Baseline antimicrobial utilization is unknown for the majority of the small, community hospitals, but is estimated to range from 200 – 500 days of therapy / 1000 patient days of care. We predict the low resource utilization intervention will not appreciably change the rate of antimicrobial prescribing from baseline but the medium and high utilization interventions will reduce the

antimicrobial utilization by 10% and 20%, respectively. Our large study sample with significant antimicrobial prescribing provides us with the power to detect a difference between all three study groups.

Our cluster randomized study design and mixed-effects modeling strategy are powerful tools to control for systematic bias. Our stratified randomization procedure will ensure each cluster will be appropriately balanced in respect to patient-days of care and pediatric patients. Our parallel design will control for seasonal changes seen in antibiotic prescribing (i.e. influenza season) as seasonal changes should be uniform across the three clusters in this geographically similar area. These tools, with a large sample size and a significant study period will allow for a rigorous analysis and unbiased results.

Dissemination and Generalizability

The AS needs of large, urban medical centers vary widely between institutions depending on regional resistance rates, antibiotic prescribing culture, and the presence of specialty care centers (organ transplant center, trauma unit, oncology unit, etc.). The diverse AS challenges of these hospitals make it difficult to apply AS protocols broadly to large medical centers. Most SCHs care for a lower acuity patient population, lack specialty care centers (aside from cardiovascular medicine, obstetrics and gynecology, and general surgery), have fewer MDROs, lack infectious disease providers, and do not have onsite antibiotic stewardship committees. Because most SCHs share similar challenges, the findings from our study will be rapidly generalizable to these institutions and will have a direct impact on AS across the United States. The results of our study will be disseminated across the Intermountain Healthcare network via our weekly newsletter, *Stories.* In addition, a grand rounds presentation will be presented to faculty and administration at each participating hospital after the study has concluded. The results of our study will be submitted for oral presentation at the Infectious Disease Society of America / Society of Healthcare Epidemiology of America Annual Meeting. Our final analysis will be submitted for peer review and publication in a high impact factor medical journal.

Detailed Work Plan and Deliverables Schedule

Optimizing Antibiotic Stewardship in Community Hospitals is a multisite, collaborative project that will involve coordinated efforts from pharmacy leadership, administrative leadership, corporate AS committee team members, staff pharmacists in SCHs, and IT experts. The study team will be divided into committees to address the many aspects of this study.

1. Scientific Oversight Committee (SOC): This committee will be led by the principal investigator, Dr. Stenehjem. The SOC will be responsible for development of data collection forms, collaborating with IT to design our database structure, development of restriction criteria for designated antibiotics, study design, interim and final analysis, dissemination of results, maintaining the budget, and manuscript preparation.
2. Pharmacy Development and Implementation Committee (PDIC): This committee will be led by Whitney Redding, PharmD, co-investigator. The pharmacy team will be responsible for the development of an educational curriculum and teaching materials for the staff pharmacists at the SCHs, co-development of restriction protocols for selected antibiotics, implementation of PAF among the SCHs, facilitating training of new pharmacists in AS, and dissemination of

results.
Members of both the SOC and the PDIC will share the clinical responsibilities as outlined in the study design.
3. Information Technology Expansion Committee (ITEC): This committee will be led by Dr. Scott Evans. The medical informatics department will be responsible for expanding the electronic surveillance tools (antibiotic utilization and MDRO monitors) to all of the SCHs over the first 3 – 6 months of the study. After this initial phase, this committee will assist in the interim and final analysis, database formation and management, and electronic alert maintenance.

The proposed study will begin in July 2013. The initial 6 months will be the development phase. During the first three months of the development phase, the PDIC will develop the curriculum and educational materials for training the SCH staff pharmacists. The PDIC will educate the local staff pharmacists during the last three months of the development phase and prepare local staff for the project start date. The ITEC will expand the electronic surveillance tools to all SCHs during the development phase. During the end of development phase, the electronic surveillance tools will be field tested and validated by manual chart review. The ITEC team will obtain the antimicrobial utilization and MDRO data from January 2013 – December 2013. Administration and pharmacy leadership will meet with the hospital administration of SCHs to detail the study plan and discuss the randomization process. The SOC will be consulting with the PDIC in development of educational materials and designing the study database during the development phase. The SOC will work closely with the statistician and data analyst to ensure data is collected in a manner that will facilitate an interim analysis. The SOC will also disseminate the study's communication strategy to all hospital sites to ensure reliable communication with the study personnel. Randomization of hospitals will be performed within the first three months of the development phase.

The intervention phase of the initiative will be January 2014 through March 2015. Clinicians (pharmacists and physicians) will be divided by practice (adult and pediatric) and provide study support (consultation to SCH pharmacists, review of outpatient IV antibiotic requests, review of daily MDRO and blood cultures, and approval of restricted antibiotics) in one week blocks. The study clinicians will work directly with the study coordinator to ensure all data is entered correctly into the databases. Communication with study personnel will be done by pager through the Intermountain system or via study email. An interim analysis will be performed in June 2014 to assess readmission rates (to ensure readmission rates have not risen) and antimicrobial utilization. Data from this assessment will be shared with the entire study team and the study sponsor. We anticipate a gradual reduction in antimicrobial use over the intervention phase and do not expect to see significant differences of utilization at the interim analysis. The SOC will meet monthly (in person or via teleconference) to review challenges and feedback from local providers and to validate MDRO rates and review discharge summaries of patients flagged by our natural language processing software. The PDIC will meet quarterly to maintain educational services and provide continue medical education to frontline providers. Analysis of data and internal dissemination of results will be conducted from April - June 2015.

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Appendix

Table 1: Antimicrobial utilization rates (days of therapy / 1,000 patient days) of 4 Intermountain hospitals from January – August, 2012.

	Urban Medical Centers		Small Community Hospitals	
Antibiotic Class	**LDS**	**IMC**	**AV**	**Riverton**
Carbapenems	98.35	49.46	31.69	10.77
Fluoroquinolones	91.75	66.90	51.46	20.85
1st/2nd Generation Cephalosporins	77.06	128.34	122.93	50.98
Vancomycin	75.96	82.76	39.55	17.26
3rd/4th Generation Cephalosporins	47.40	67.79	49.02	46.11
B-lactam+inhibitor	41.22	67.04	47.42	26.88
Daptomycin	16.33	2.57	2.29	0.06
Total (all classes)	**813.84**	**719.32**	**465.83**	**294.68**

IMC – Intermountain Medical Cenetr
AV = Alta View
LDS = Latter Day Saints
PCMC = Primary Childrens' Medical Center

Table 2: Clinical variables reported in automatic daily antibiotic report. Daily antibiotic report will be delivered to each study hospital by 6:30am.

Patient Name
Room number
Medical Record Number
Age
Sex
Admit date
Height
Weight
Body surface area
Creatinine
Creatinine clearance
Medical Service
Antibiotic
Dose
Frequency given
Day of therapy on antibiotic
Date order written

Table 3. Intermountain's small, community hospitals participating in the initiative.

Hospital	Location	Total Staffed Beds	Patient Days 2012
Logan Regional	Logan, UT	126	24,992
American Fork	American Fork, UT	83	24,021
Riverton	Riverton, UT	89	16,625
Alta View	Sandy, UT	67	12,903
Garfield Memorial	Panguitch, UT	14	10,803
Valley View	Cedar City, UT	48	8,486
Cassia Regional MC	Burley, ID	25	5,880
Orem Community	Orem, UT	18	5,307
Fillmore Community	Fillmore, UT	8	4,585
Park City	Park City, UT	26	3,412
Sevier Valley	Richfield, UT	26	2,614
Heber Valley	Heber City, UT	20	1,952
Sanpete Valley	Mt. Pleasant, UT	15	1,763
Bear River Valley	Tremonton, UT	14	1,162
Delta Community	Delta, UT	20	949
		Total: 599	125,454