Reducing Unnecessary Urine Culturing and Antibiotic Overprescribing in Long-term Care: Outcomes of an Implementation Science Informed Quasi-Experimental Study

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Abstract

BACKGROUND: Antibiotic use in long-term care homes is highly variable and high rates of antibiotic use are associated with antibiotic resistance and *C. difficile* infection. Treatment of asymptomatic bacteriuria accounts for the majority of urinary antibiotic use in long-term care facilities. We sought to measure the impact of a multi-component program designed to improve diagnosis and management of urinary tract infections (UTIs) in non-catheterized residents of long-term care homes.

METHODS: We conducted a quasi-experimental study comparing urine culturing and antibiotic prescribing rates before and after implementation of the UTI Program. The population included residents of 10 long-term care homes in Ontario, Canada, between December 2015 and May 2017. The UTI Program recommended nine strategies to decrease urine culturing and antibiotic prescribing among patients that did not meet criteria for a UTI. We measured home-level monthly rates of urine specimens sent for culture and susceptibility testing, prescriptions for antibiotics commonly used to treat UTIs, and total antibiotic prescriptions.

RESULTS: Homes implemented an average of 6.1 out of the 9 strategies. Urine culturing fell from 3.20 to 2.09 per 1,000 resident-days from the baseline to the intervention phase ($IRR_{adjusted}$=0.72, 95% confidence interval [CI]: 0.63–0.82), urinary antibiotic prescriptions fell from 1.52 to 0.83 per 1,000 resident-days ($IRR_{adjusted}$=0.59, 95%CI: 0.46–0.73) and total antibiotic prescriptions fell from 3.85 to 2.60 per 1,000 resident-days ($IRR_{adjusted}$=0.73, 95%CI: 0.65–0.82).

INTERPRETATION: We demonstrated a reduction in urine culturing and antibiotic use following implementation of a multi-component program for improving the diagnosis and treatment of UTIs.

Introduction

Rates of antibiotic use in long-term care facilities are highly variable[1] and high rates of antibiotic use are associated antibiotic resistance and *C. difficile* infection.[2,3] Over 30% of antibiotics prescribed in long-term care are for urinary indications.[4] One practice that can contribute to the overuse of antibiotics for urinary indications is the treatment of asymptomatic bacteriuria.[5,6]

Asymptomatic bacteriuria refers to the presence of bacteria in the urine in the absence of clinical signs and symptoms of a urinary tract infection (UTI).[5] The prevalence of asymptomatic bacteriuria in long-term care residents is high; estimated at 15-30% of men and 25-50% of women.[7,8] Several randomized control trials have found that the systematic screening and treatment of asymptomatic bacteriuria in long-term care is not beneficial to residents.[9,10] The Infectious Diseases Society of America and the Association of Medical Microbiology and Infectious Disease Canada both discourage this practice.[6,11] In many long-term care facilities, treatment of asymptomatic bacteriuria accounts for the majority of urinary antibiotic use.[12]

Public Health Ontario (PHO), an arm's length government agency that provides scientific expertise and technical support to front-line healthcare workers, developed a multi-component UTI program to improve diagnosis and management of UTIs in non-catheterized residents of long-term care homes (LTCHs). The program built on several studies showing that interventions designed to improve diagnosis and management of UTIs are effective at reducing antimicrobial use in long-term care homes.[13–15] The purpose of this pilot study was to measure the impact of a multi-component UTI program on urine culturing and antibiotic prescribing rates.

Methods

Setting and participants

A purposive sampling strategy was used to recruit 12 LTCHs in the province of Ontario, Canada. PHO staff identified an initial list of LTCHs that had previously expressed interest in making improvements to their practices in this area and that would provide variation by region, size and ownership type. To be eligible to participate in the pilot, the LTCH had to identify at least 3 staff healthcare providers to participate on an implementation team and be able to provide monthly lab and pharmacy reports. LTCHs met with PHO staff to establish a plan for the implementation of the program in mid-2016. The monthly number of urine cultures sent, antibiotic prescriptions, and count of residents were collected from December 2015 to May 2017.

Intervention design

The UTI Program focused on five recommended practice changes: (1) obtain urine cultures only when residents have the indicated clinical signs and symptoms of a UTI; (2) obtain urine specimens according to a midstream procedure or an "in-and-out" catheterization; (3) prescribe antibiotics only when specified clinical criteria have been met; (4) cease the use of dipsticks for the diagnosis of UTI; and (5) cease urine culture screening (i.e. on admission or annually) if residents don't have clinical signs and symptoms of a UTI. An algorithm was established for the program to guide best practices in the assessment and management of potential UTIs for non-catheterized residents.[16] The algorithm was based on the 2005 Loeb criteria with additional considerations for residents with advanced dementia.[7,17] Accepted clinical signs and symptoms of a UTI are defined as: new difficult or painful urination (acute dysuria) alone and/or two or more of the following: fever, new flank pain or suprapubic pain, new or increased urinary frequency/urgency, gross hematuria, and acute onset of delirium in residents with advanced dementia. The program was targeted at physicians, nurses, administrators, pharmacists, and other front-line workers, residents, and families of residents.

The program recommended nine strategies that LTCHs could use to support practice changes (Table 1). A broad range of barriers to improving urinary antibiotic prescribing were identified by healthcare workers in a survey conducted in 2013. Then, we conducted an intervention mapping process to connect practice change barriers to recommended strategies using behaviour change theory.[15,18,19] For each LTCH, the implementation planning process[16] involved three one-hour meetings that were facilitated by PHO staff. During this process, the LTCH implementation team completed an assessment of readiness and baseline alignment with the five practice changes, identified barriers and facilitators to practice change specific to the home, and determined a plan to implement the strategies.

Strategy implementation

A classification guide was designed to assess whether each of the 9 recommended strategies was implemented by each home; the assessments were based on notes from the implementation planning process and interviews with PHO and LTCH staff. The assessments were completed independently by two PHO staff reviewers (JQ and AC) and disagreements were resolved by negotiation.

Outcomes

The outcomes for the evaluation were the home-level monthly rates (per 1,000 resident-days) of: (1) urine specimens sent for culture and susceptibility testing, (2) prescriptions for antibiotics commonly used to treat urinary tract infections (defined as ciprofloxacin, norfloxacin, nitrofurantoin, trimethoprim with or without sulfamethoxazole, and fosfomycin and referred to as “urinary antibiotics” in this study), and (3) prescriptions for any antibiotic. The number of urine cultures sent were identified from the monthly laboratory reports, while antibiotic prescriptions were identified from monthly pharmacy reports, which were made available for all participating LTCHs, and sent to PHO for abstraction. Pharmacy reports were reviewed and abstracted by a PHO pharmacist. To focus on antibiotics prescribed for the treatment of acute uncomplicated infections, including UTIs, only oral antibiotics prescribed for a duration of 3 to 14 days were included, with the exception of fosfomycin which is commonly prescribed as a one day course for treatment of UTIs. Resident-days refer to the number of days that each resident stayed at an LTCH within a given month, summed across all residents.

Other covariates

LTCH size, was measured as a linear covariate equal to the mean number occupied beds over the study period. A harmonic oscillator was used to capture winter seasonality, which has been documented for antibiotic prescribing;[20] the phase shift was adjusted to allow peaks to be centered at January 1st of each year.[21]

Statistical Analysis

For each home, we identified the implementation period as those months spanning from the 1st implementation planning meeting until two months after the 3rd implementation planning meeting. Months before the implementation period were termed the *baseline* period, and months after the implementation period were termed the *intervention* period. All intervention effect analyses compared the baseline periods to intervention periods. Our a priori power analysis suggested that 10 months of follow-up (equally split between baseline and intervention periods) among 10 LTCHs would be sufficient to identify a 25% drop in urine culturing with 90% power, we opted to recruit 15 homes to account for potential loss to follow up.

In unadjusted models, we fit Poisson random effects level change models of the monthly rates of urine culturing and antibiotic prescribing.[22] These models included fixed effects terms for intercept at baseline, and intervention level change. Random effects captured inter-home variation in baseline rates, and intervention level changes. In adjusted models, we fit analogous models that also included fixed effects for LTCH size and seasonality.[22]

The impact of the intervention was the estimated fixed effect of the intervention period, compared to the baseline period, measured using the incidence rate ratio (IRR). Unadjusted and adjusted models were fit using Markov Chain Monte Carlo sampling using the rstanarm package in R,[23] using default weakly informative priors on all parameters (normal[0, 10] for intercept, normal[0,2.5] for other fixed effects, half-cauchy[0, 5] for random effects, and an LKJ(1) prior for the random effects correlation matrix[24]). As a sensitivity analysis to better understand the impact of urine culturing practices on antibiotic prescribing, we fit additional Poisson random effects models for urinary and total antibiotic prescribing that included a fixed effect term for the phase-specific urine culturing rates.

Results

In total 15 homes were approached to participate in the UTI Program, of which 12 agreed to participate (Figure 1). As of September 2017, 10 out of 12 LTCHs that were recruited completed implementation, totalling 163 LTCH-months and 793,200 resident-days (Figure 1, Table 2) of follow-up. All of the LTCHs were freestanding, unaffiliated with a hospital; 5 were private, 3 were non-profit and 2 were municipally run. Over the study period, 2,093 urine cultures were collected across the homes (2.64 per 1,000 person-days), and 2,535 antibiotic prescriptions were dispensed (3.20 per 1,000 resident-days), of which 947 (37%) were for antibiotics commonly used to treat UTIs (1.19 per 1,000 resident-days).

The LTCH-specific implementation periods began between June and September 2016, and lasted between 4 and 6 months. All homes transitioned to the intervention period by January 2017. Over the study period there was a decrease in the rates of urine culturing, urinary antibiotic prescribing, and total antibiotic prescribing (Figure 2).

Strategy implementation

Homes implemented an average of 6.1 out of the 9 strategies. The most frequently implemented strategies (Table 1) were selecting and empowering champions, carrying out local consensus processes, delivering classroom education to staff, and identifying and supporting coaches to reinforce key practices and support staff, each of which were implemented by 8 of the 10 homes. The least frequently implemented strategy was integrating process surveillance and providing regular feedback to staff, which was only implemented by 4 of the 10 homes.

Intervention effect analysis

Urine culturing fell from 3.20 per 1,000 resident-days to 2.09 per 1,000 resident-days from the baseline to the intervention phase. Similarly, urinary antibiotic prescriptions fell from 1.52 per 1,000 resident-days to 0.83 per 1,000 resident-days and total antibiotic prescriptions fell from 3.85 per 1,000 resident-days to 2.60 per 1,000 resident-days (Table 2). Unadjusted and adjusted models yielded similar estimates of intervention effect. The adjustment models, that controlled for seasonality in urine culturing and antibiotic prescribing and home size, estimated a 29% decline in urine culturing (IRR=0.72, 95%CI: 0.63–0.82), a 41% decline in urinary antibiotic prescriptions (IRR=0.59, 95%CI: 0.46–0.73), and a 27% decline in total antibiotic prescriptions (IRR=0.73, 95%CI: 0.65–0.82) across the participating homes.

LTCH-level variation in urine culturing and antibiotic prescribing

There was substantial variation in urine culturing and antibiotic prescribing across homes, and homes with higher rates of urine culturing also had higher antibiotic prescribing (Figure 3). This association held true for both urinary antibiotic prescribing (IRR per 1/1,000 increase in urine culturing = 1.26, 95%CI: 1.07–1.47) and for total antibiotic prescribing (IRR per 1/1,000 increase in urine culturing = 1.17, 95%CI: 1.04–1.33).

Interpretation

Rates of urine culturing and antibiotic prescribing declined after the implementation of a program designed to improve diagnosis and management of urinary tract infections in non-catheterized residents of long-term care homes. The recommended implementation strategies, with the exception of process surveillance and feedback reporting to staff, were implemented by the majority of homes. LTCH rates of urine culturing were strongly associated with antibiotic prescribing, and inter-home variation in rates of antibiotic prescribing and urine culturing persisted after implementation of the program, suggesting that it may be possible to further reduce urine culturing and antibiotic prescribing in certain homes.

Comparison with other studies

The UTI Program was informed by a previous review[13] showing that implementation of syndrome-specific interventions targeting prescribing for urinary tract infection were effective, yielding reductions in urine culturing and prescribing for urinary indications, and total antibiotic use. One cluster randomized controlled trial of 20 LTCHs[25] showed that a UTI-targeted intervention in Canada and the United States was associated with an 18% decline in urine culturing rates (from 2.5 to 2.0 per 1,000 resident-days) and a 10% decline in total antibiotic use (from 3.9 to 3.5 courses per 1,000 resident-days), though this latter finding was not statistically significant. Another single centre non-randomized study[12] demonstrated a 59% decline in urine culturing rates and 30% decline in total antibiotic use. Our study demonstrated reductions in urine culturing, urinary antibiotic use, and total antibiotic use of 28%, 41%, and 27%, respectively. Our findings highlight the importance of investing time and providing support to build readiness for change and offering implementation interventions that target a broader range of barriers to practice change to reduce antibiotic use for asymptomatic bacteriuria. Furthermore, the persistent inter-home variation observed between antibiotic use and urine culturing suggest that there are further opportunities to reduce urine culturing and subsequent unnecessary antibiotic prescribing.

The UTI Program had 9 recommended strategies and our pilot found that, with one exception, these strategies were implemented in the majority of homes. However, the strategy of *integrating process surveillance and providing regular feedback to staff* was implemented in only 4 of the 10 homes. Feedback from homes suggested that adherence to this strategy could be improved by ensuring that new documentation requirements are as simple as possible and integrated into existing processes to minimize the additional work involved in tracking symptoms. This could include integrating documentation of relevant symptoms into electronic medical records using prompts when requesting a urine culture.[26] Assessment of the strategy implementation also found that oftentimes homes were not conducting feedback reporting to LTCH staff, in part because of the lack of time and expertise required to compile, tabulate, and interpret the data. As such, central preparation of home-specific feedback reports could improve program implementation.[27]

Our study also found substantial variation in rates of urine culturing and that these rates of urine culturing were associated with both total and especially urinary antibiotic prescribing. While it is known that receipt of a urine culture may act as a gateway to antibiotic exposure among individual residents,[5,6] this is the first study to show that homes with systematically higher rates of urine culturing also tend to have higher rates of antibiotic utilization. This provides evidence of the importance of urine culturing practices as a driver of home-level antibiotic use and complements previous studies demonstrating that patient-characteristics are not primary drivers of antibiotic prescribing[1] or duration of antibiotics prescribed.[28] Further, plans to expand the UTI Program to the province's 625 LTCHs could prioritize homes with high baseline urine culturing or urinary antibiotic prescribing rates because these homes could achieve the largest absolute reductions in antibiotic use.

Limitations

First, we used a before-after design, meaning that, without a parallel arm that did not experience the intervention, we could not control for time-trends in antibiotic use that were independent of the intervention. However, similar levels of urine culturing and antibiotic use were reported in 2005, suggesting that time-trends were non-existent or weak.[25] Second, the format and comprehensiveness of pharmacy reports differed depending on the LTCH's pharmacy provider and therefore interpretation was required during the data abstraction process. Third, this study did not capture downstream impacts of the intervention, including potential harms due to antibiotic overuse (*C. difficile* infection) or due to less antibiotic use (emergency department visits). Finally, this study was unable to consider the long-term sustainability of the pilot program.

Conclusion

We demonstrated a decline in urine culturing rates and antibiotic use following implementation of a multi-component program focused on improving the diagnosis and treatment of UTI. This pilot data supports a broader implementation of this program to decrease inappropriate urine culturing and antibiotic use in LTCHs.

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Tables and Figures

Table 1. Urinary Tract Infection Program recommended strategies, and the number of long-term care homes implementing each strategy (N=10 homes).

Planning and Strategies	Definition	N
Establishing buy-in and support		
Reviewing and revising organizational policies and procedures	Reviewing existing policies and procedures to ensure best practices are documented and inconsistencies with current practice recommendations are updated.	6
Selecting and empowering champions	Selecting staff members who will dedicate themselves to supporting practice changes and the implementation of the program including opportunities to strengthen buy-in.	8
Involving local opinion leaders	Identifying influential colleagues (physicians, nurse practitioners) that can help secure buy-in for the program and be involved in delivering education.	6
Carrying out local consensus processes	Reaching out to all staff members directly involved in the assessment and management of UTIs to ensure they have received information about the program and support recommended practice changes.	8
Educating and developing skills		
Delivering classroom education to staff	Providing a formal educational session to staff (30-45 minutes) on the problem and best practices using the UTI Program resources (e.g., PowerPoint slides, fact sheets, and algorithm).	8
Providing information and education to residents and families	Distributing information about the program to residents and families and providing group and one-on-one education to families (e.g., family council meetings).	7
Identifying and supporting coaches to reinforce key practices and support staff	Identifying staff members who can provide one-on-one education and support to colleagues following a group educational session.	8
Monitoring practice and supporting staff		
Integrating process surveillance and providing regular feedback to staff	Assessing compliance to the practice changes using a recommended process surveillance form. Documenting when residents are being assessed for a UTI, relevant symptoms and whether urine is collected and antibiotics prescribed; reviewing forms to assess alignment with recommended criteria; and providing feedback to staff.	4
Distributing and posting educational resources as reminders to staff about key practices	Ongoing distribution and posting of educational materials to remind staff of practice changes.	6

UTI, urinary tract infection

Table 2. Urine cultures sent and antibiotic prescriptions across the study phases (N=10 long-term care homes)

		By phase*			Baseline vs. Intervention (IRR)	
	Total	**Baseline**	**Impleme ntation**	**Intervent ion**	**Unadjusted**	**Adjusted**
Outcomes (per 1,000 resident-days)						
Urine cultures sent	2.64	3.20	2.35	2.09	0.70 (0.61 to 0.79)	0.72 (0.63 to 0.82)
Urinary antibiotic prescriptions	1.19	1.52	1.09	0.83	0.59 (0.46 to 0.72)	0.59 (0.46 to 0.73)
Total antibiotic prescriptions	3.20	3.85	2.82	2.60	0.74 (0.66 to 0.82)	0.73 (0.65 to 0.82)
Follow-up						
LTCH-months	163	70	42	52	NA	NA
Person-days (000s)	793.2	344.8	198.2	250.2	NA	NA

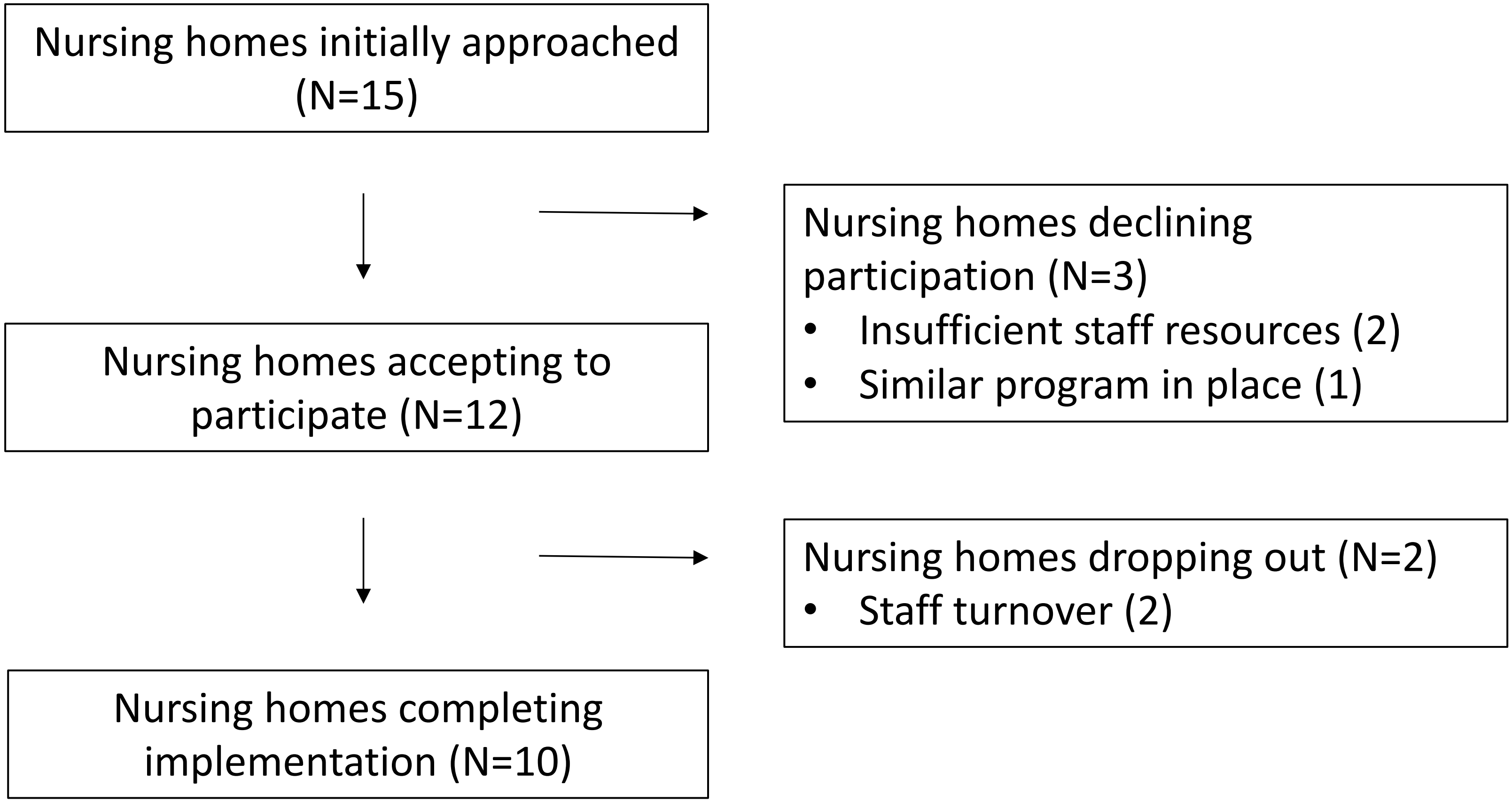
Abbreviations: LTCH, long-term care home

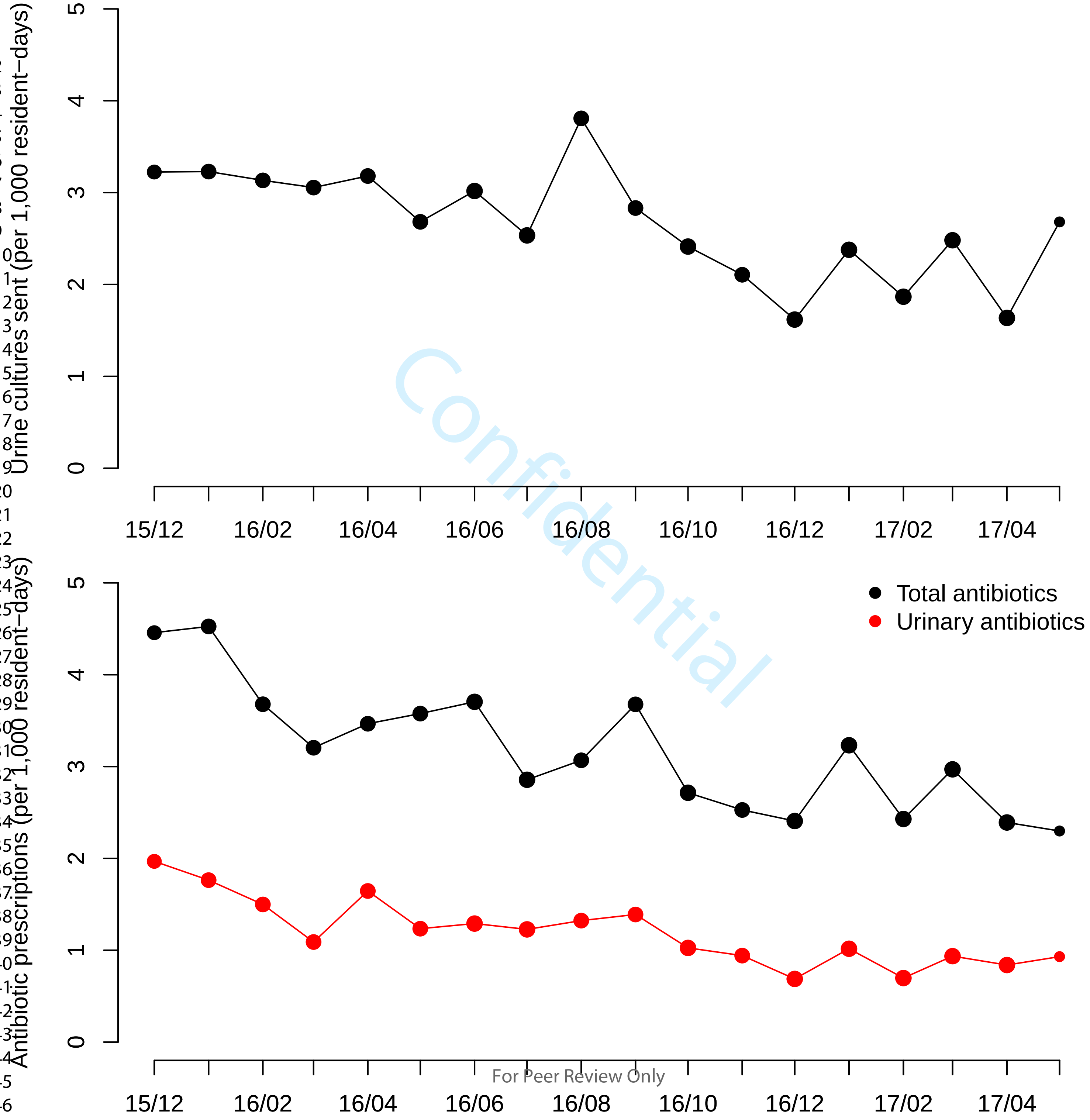
Figure Legends

Figure 1. Long-term care homes approached and included.

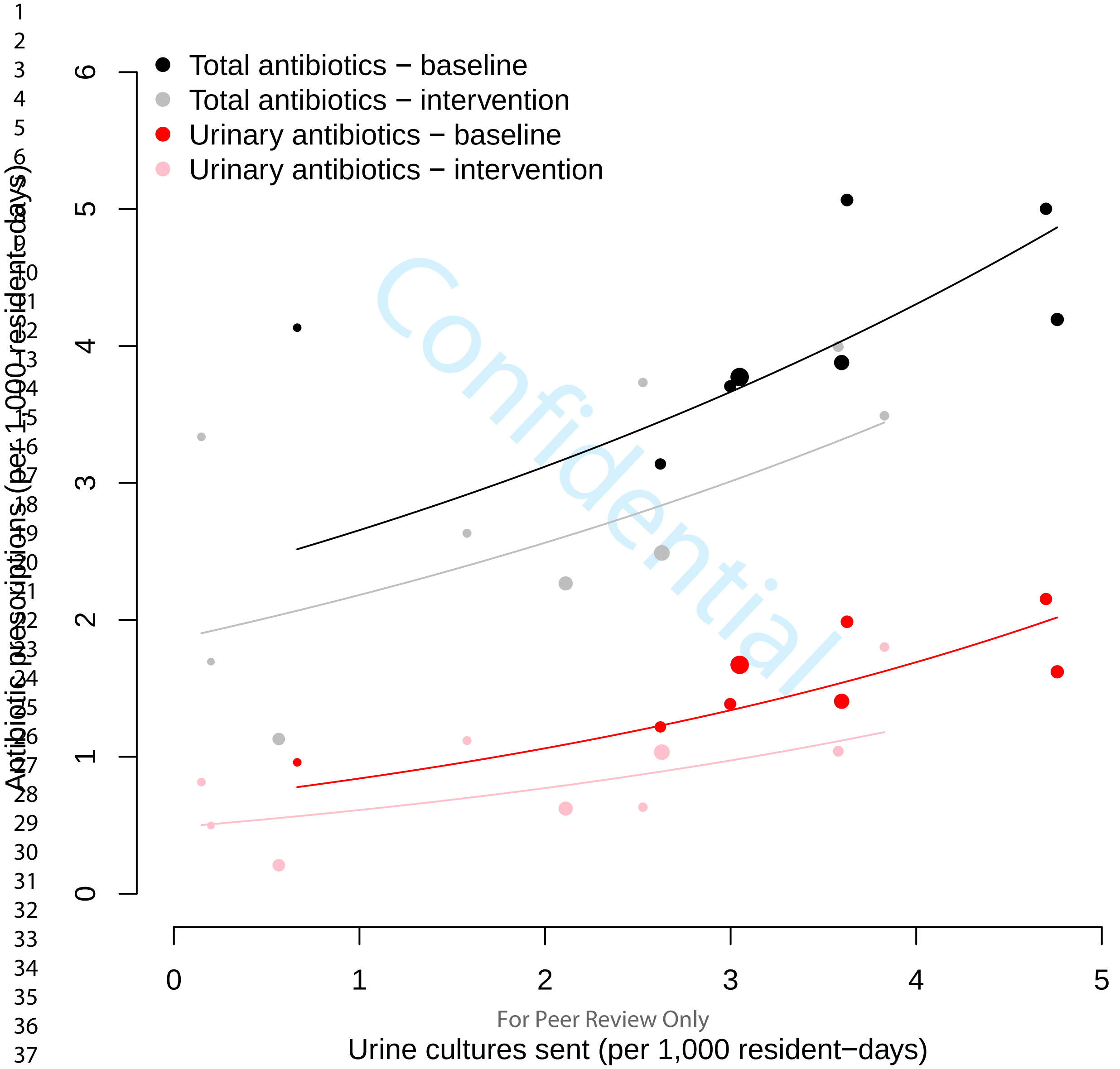
Figure 2. Variation in monthly rates (per 1,000 resident-days) of urine cultures sent and antibiotic prescriptions (N=10 long-term care homes).

Figure 3. Association between long-term care home-level urine culturing rates and antibiotic prescribing in the baseline and intervention periods (N=10 long-term care homes). Regression-based estimates are superposed.


Nursing homes initially approached (N=15)
Nursing homes declining participation (N=3)
• Insufficient staff resources (2)
• Similar program in place (1)
Nursing homes accepting to participate (N=12)
Nursing homes dropping out (N=2)
• Staff turnover (2)
Nursing homes completing implementation (N=10)



Urine cultures sent (per 1,000 resident−days)
0
1
2
3
4
5
15/12
16/02
16/04
16/06
16/08
16/10
16/12
17/02
17/04
Antibiotic prescriptions (per 1,000 resident−days)
Total antibiotics
Urinary antibiotics


Total antibiotics − baseline
Total antibiotics − intervention
Urinary antibiotics − baseline
Urinary antibiotics − intervention
Antibiotic prescriptions (per 1,000 resident−days)
0
1
2
3
4
5
6
0
1
2
3
4
5
Urine cultures sent (per 1,000 resident−days)