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Research

Reducing unnecessary urine culturing and antibiotic overprescribing in long-term care: a before-and-after analysis

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Abstract

Background: Antibiotic use in long-term care homes is highly variable. High rates of antibiotic use are associated with antibiotic resistance and *Clostridium difficile* infection. We asked 2 questions regarding a program designed to improve diagnosis and management of urinary tract infections in long-term care: whether the program decreased urine culturing and antibiotic prescribing rates and whether specific strategies of the program were more or less likely to be adopted.

Methods: The study included 10 long-term care homes in Ontario, Canada, between December 2015 and May 2017. We assessed the implementation of the program's 9 strategies via semistructured interviews with key informants. Using a before-and-after study design, and on the basis of monthly facility-level records, we measured changes in the rates of urine specimens sent for culture and susceptibility testing, prescriptions for antibiotics commonly used to treat urinary tract infections and total antibiotic prescriptions, using Poisson regression.

Results: Participating homes implemented an average of 6.1 of the 9 strategies. Urine culturing decreased from 3.20 to 2.09 per 1000 resident-days from the baseline to the intervention phase (adjusted incidence rate ratio [$IRR_{adjusted}$] = 0.72, 95% confidence interval [CI] 0.63–0.82), urinary antibiotic prescriptions fell from 1.52 to 0.83 per 1000 resident-days ($IRR_{adjusted}$ = 0.60, 95% CI 0.47–0.74) and total antibiotic prescriptions fell from 3.85 to 2.60 per 1000 resident-days ($IRR_{adjusted}$ = 0.74, 95% CI 0.65–0.83). After adjusting for secular trends, these reductions were not statistically significant.

Interpretation: We demonstrated a reduction in urine culturing and antibiotic use following implementation of the Urinary Tract Infection Program. This initial analysis supports a broader implementation of this program, although ongoing evaluation is required to monitor secular trends in urine culturing and antibiotic use.

Rates of antibiotic use in long-term care homes are highly variable and this variability is not associated with characteristics of long-term care residents.[1] However, high rates of antibiotic use are associated with antibiotic resistance and *Clostridium difficile* infection.[2–4] Antibiotic-associated adverse events could be reduced if antibiotic overuse in long-term care was reduced.[5] Over 30% of antibiotics prescribed in long-term care are for urinary indications.[6] One practice that can contribute to overuse is the treatment of asymptomatic bacteriuria.[7,8] Asymptomatic bacteriuria is the presence of bacteria in the urine in the absence of clinical signs and symptoms of a urinary tract infection.[7] The prevalence of asymptomatic bacteriuria in long-term care residents is high: it is estimated that 15%–30% of men and 25%–50% of women have the condition.[9,10] Several randomized controlled trials have found that the systematic screening and treatment of asymptomatic bacteriuria in long-term care is not beneficial to residents.[11,12] The Infectious Diseases Society of America and the Association of Medical Microbiology and Infectious Disease Canada both discourage this practice.[8,13] In many long-term care homes, treatment of asymptomatic bacteriuria accounts for most urinary antibiotic use.[14]

Public Health Ontario, an arm's length government agency that provides scientific expertise and technical support to front-line health care workers, developed a multistrategy Urinary Tract Infection Program to improve diagnosis and management of urinary tract infections in noncatheterized residents of long-term care homes. The program built on several studies showing that interventions designed to improve diagnosis and management of urinary tract infections are effective at reducing antimicrobial use in long-term care homes.[5,15,16] Rather than focusing on a single guideline, the program focused on 5 practice changes by incorporating 9 strategies to address specific barriers to practice change.[17] We aimed to address 2 questions before further rollout of the program in the province: first, whether the program decreased

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urine culturing and antibiotic prescribing rates in long-term care homes, and second, whether specific strategies of the program were more or less likely to be adopted by homes.

Methods

Setting and participants

A purposive sampling strategy was used to recruit long-term care homes in Ontario, Canada. Our power analysis determined that 10 months of follow-up (equally split between baseline and intervention periods) among 10 homes would be sufficient to identify a clinically important 25% drop in urine culturing and a slightly smaller effect than seen in prior interventions of this nature,[14] with 90% power. Because over 30% of antibiotic prescribing in long-term care is for urinary indications, we estimated that a 25% drop in urine culturing would translate to a decrease of at least 7.5% in the rate of antibiotic use. We opted to recruit 15 homes to account for potential loss to follow-up. Public Health Ontario staff identified an initial list of homes that had previously expressed interest in making improvements to their practices in this area and that varied by region, size and ownership type. A stakeholder relations database is routinely used at Public Health Ontario to document all communications, including requests for education. This database was used to retrieve names of 15 homes located in 4 different regions of Ontario that had previously expressed interest in this topic. To be eligible to participate, the home had to identify at least 3 staff health care providers who would participate on an implementation team and be able to provide monthly laboratory and pharmacy reports. Homes met with Public Health Ontario staff to establish a plan for the implementation of the program in mid-2016. The monthly number of urine cultures sent, number of antibiotic prescriptions and count of residents were collected from December 2015 to May 2017.

Intervention design

The Urinary Tract Infection Program was designed by Public Health Ontario in consultation with long-term care home stakeholders to improve or change 5 practices: (1) obtain urine cultures only when residents have the indicated clinical signs and symptoms of a urinary tract infection; (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 urinary tract infection; and (5) cease urine culture screening (i.e., on admission or annually) if residents don't have clinical signs and symptoms of a urinary tract infection. Elements 1–3 are further described in the Urinary Tract Infection Program algorithm (a link to the algorithm can be found at www.publichealthontario.ca/en/health-topics/antimicrobial-stewardship/uti-program).

To support these practices, 9 strategies were identified. These strategies were selected from the implementation science literature to address specific barriers and facilitators identified by stakeholders: 7 strategies were informed by the Rx for Change database[17] and 2 additional implementation strategies, "champions" and "coaching," were added to address outstanding barriers. These strategies include securing buy-in for the changes, reviewing and revising organizational policies and procedures, selecting champions and involving local opinion leaders, delivering education to staff, providing information and education to residents and families, identifying and supporting coaches to reinforce key practices, improving the documentation and communication of resident symptoms, and distributing and posting educational resources as reminders. Appendix 1, available at www.cmajopen.ca/content/7/1/E174/suppl/DC1, outlines each recommended strategy.

Each home recruited to pilot the program followed a similar implementation process. They established a team of at least 3 staff to support the implementation of the program and were supported by 2 staff from Public Health Ontario with expertise in infection control. The teams included the director of care or associate director of care with additional members varying across homes (i.e., nurse practitioners, physicians, nurses, staff involved in quality improvement initiatives). Staff from Public Health Ontario facilitated 3 in-person meetings (1–2 h in duration) to deliver information about the problem of overprescribing antibiotics and specific practices that can contribute to overprescribing in long-term care. This implementation process can be replicated by other long-term care homes as it is fully documented in an online program implementation guide.[18] At the first meeting, the team was asked to review baseline alignment with 5 practice changes that could address the problem of overprescribing antibiotics in long-term care. At the second meeting, Public Health Ontario staff facilitated a discussion about facility-specific barriers and facilitators to aligning with the practice changes (e.g., knowledge gaps among staff, pressures from families to prescribe antibiotics, poor documentation and communication about symptoms) and selecting practice changes. At the last meeting, the team established an action plan for the strategies selected.

Outcomes

For the measurement of adherence to the 9 strategies, 2 months after the completion of the planning process, interviews were conducted with at least 1 member of the long-term care home's implementation team by a member of the research team at Public Health Ontario with expertise in qualitative interviews (J.Q.). A semistructured interview guide was used to gather information about which implementation strategies were used by the long-term care home. Interviews were audio taped and coded using the classification guide (Appendix 1). The classification guide provides information on what constitutes adherence for each strategy. For example, for the strategy involving champions, the classification guide states the following: "Key informant identifies name(s) of implementation champion(s); AND documents examples of responsibilities of the implementation champion; AND identifies at least one example of how champions helped facilitate the change process." The coding was completed independently by 2 Public Health Ontario staff (J.Q. and

A.C.) and disagreements were resolved by consensus-based discussion.

Three indicators were defined to detect improvements in the assessment and management of urinary tract infections, including home-level monthly rates (per 1000 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; referred to as urinary antibiotics in this study) and (3) prescriptions for any antibiotic. The numbers of urine cultures sent and antibiotic prescriptions were determined from the monthly laboratory reports and pharmacy reports. Pharmacy reports were reviewed and abstracted by a Public Health Ontario pharmacist. To focus on antibiotics prescribed for the treatment of acute uncomplicated infections, including urinary tract infections, we included only oral antibiotics prescribed for 3 to 14 days, with the exception of fosfomycin, which is commonly prescribed as a 1-day course for treatment of urinary tract infections. The term *resident-days* refers to the number of days that each resident stayed at a home within a given month, summed across all residents.

Covariates

Covariates included home size (mean number of occupied beds over the study period) and ownership (municipal, private or nonprofit) as these variables have been shown to be associated with antibiotic prescribing.[4] Similarly, a harmonic oscillator was used to capture winter seasonality, which has been documented for antibiotic prescribing;[19] the phase shift was adjusted to centre peaks at Jan. 1 of each year.[20]

Statistical analysis

For each home, we identified the implementation period as the time from the first implementation planning meeting until 2 months after the third implementation planning meeting. Months before the implementation period were termed the baseline period, and months after the implementation period were termed the intervention period. The main analysis used a before-and-after study design; all intervention effect estimates compared the home baseline periods with intervention periods, and the implementation period was considered as a washout because there was ambiguity as to which intervention period the home should be assigned.[21]

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, implementation and intervention level change. We accounted for clustering by including random effects for each long-term care home, but we did not have resident-level records. In adjusted models, we fit analogous models that also adjusted for the 3 covariates (home size, home ownership and winter seasonality).[22] The intervention effect was the estimated rate in the intervention period compared with that in 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] These priors enable efficient and stable model fitting, and they are conservative for the fixed effects of interest in that they provide results that, if different at all, are slightly closer to the null than maximum likelihood estimates.[25]

Sensitivity analyses

To account for potential secular trends, we fit interrupted time series models to measure the intervention effect. These interrupted time series analyses were analogous to the unadjusted and adjusted Poisson models except that they included a parameter corresponding to a linear trend for calendar month in addition to the step changes for intervention period. To better understand whether urine culturing rates predicted antibiotic prescribing, we conducted a cross-sectional sensitivity analysis of the data. For this analysis, we fit home-level Poisson random-effects models for urinary and total antibiotic prescribing that included home urine culturing rate as a predictor.

Ethics approval

This study was approved by the research ethics board of Public Health Ontario.

Results

Fifteen long-term care homes were approached to participate in the Urinary Tract Infection Program, of which 12 agreed to participate (Figure 1). By September 2017, 10 of the 12 homes that were recruited had completed implementation. These homes were as follows: (1) The Glebe Centre,

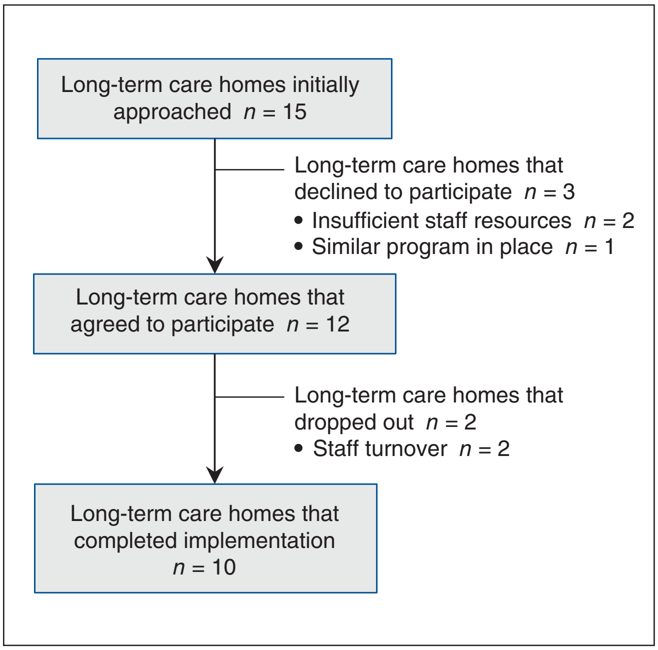

Figure 1: Long-term care homes approached and included in the study.

(2) Perth Community Care Centre, (3) Vera M. Davis Community Care Centre, (4) Woodhall Park Care Community, (5) Malton Village Long Term Care Centre, (6) Victoria Village Manor, (7) Ivan Franko Home, (8) Shalom Village, (9) Chartwell Wenleigh Long Term Care Residence and (10) St. Joseph's Villa — Dundas. All of the homes were free-standing and not located on a hospital campus. Five were private, 3 were nonprofit and 2 were municipally run. They had an average of 162 beds (Table 1). There was a total of 163 home-months and 793 200 resident-days of follow-up (Table 2). Over the study period, 2093 urine cultures were collected across the homes (2.64 per 1000 resident-days) and 2535 antibiotic prescriptions were dispensed (3.20 per 1000 resident-days), of which 947 (37%) were for antibiotics commonly used to treat urinary tract infections (1.19 per 1000 resident-days).

All homes began implementation within 1 month of August 2016 and all homes transitioned to the intervention period within 1 month of December 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

At the final planning meeting with Public Health Ontario, all homes were interested in establishing a plan for all 9 implementation strategies. Two months after the last planning meeting with Public Health Ontario, homes adhered to an average of 6.1 out of the 9 strategies (Table 3). Most strategies were adhered to by a majority of the homes, except integrating process surveillance and providing regular feedback to staff, which was only adhered to by 4 homes.

Intervention effect analysis

Unadjusted and adjusted models yielded similar estimates of intervention effect (Table 2). The adjusted models estimated a 28% decline in urine culturing (IRR = 0.72, 95% confidence interval [CI] 0.63–0.82), a 40% decline in urinary antibiotic prescriptions (IRR = 0.60, 95% CI 0.47–0.74) and a 26% decline in total antibiotic prescriptions (IRR = 0.74, 95% CI 0.65–0.83) across the participating homes.

Interrupted time series analysis

In the adjusted interrupted time series analyses, the measured impact of the intervention was not statistically significant (IRR for urine culturing = 0.83, 95% CI 0.64–1.07; IRR for urinary antibiotic prescriptions = 1.02, 95% CI 0.74–1.44; IRR for total antibiotic prescriptions = 0.97, 95% CI 0.78–1.21). The underlying secular trends showed strong year-over-year decreases (IRR per year for urine culturing = 0.68, 95% CI 0.42–1.04; IRR per year for urinary antibiotic prescriptions = 0.53, 95% CI 0.37–0.76; IRR per year for total antibiotic prescriptions = 0.72, 95% CI 0.53–0.95).

Cross-sectional analysis

Homes with higher rates of urine culturing also had higher antibiotic prescribing (Figure 3), which was true both for urinary antibiotic prescribing (IRR per 1/1000 increase in urine culturing = 1.26, 95% CI 1.07–1.47) and for total antibiotic prescribing (IRR per 1/1000 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 noncatheterized 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 the participating homes.

The Urinary Tract Infection Program was informed by a previous review[5] that showed that implementation of

Table 1: Characteristics of the 10 long-term care homes that completed implementation of the program

Home	Ownership	No. of beds	Location*	Female residents,* %	Residents older than 85 yr,* %
1	Nonprofit	250	Urban	76	48
2	Private	120	Rural	62	42
3	Municipal	65	Urban	82	55
4	Private	150	Urban	78	57
5	Municipal	160	Urban	63	49
6	Nonprofit	130	Urban	62	54
7	Private	80	Urban	74	81
8	Private	110	Urban	66	51
9	Private	160	Urban	70	62
10	Nonprofit	390	Urban	70	45

*Data collected using the Your Health System Interactive Tool (https://yourhealthsystem.cihi.ca) of the Canadian Institute for Health Information.

Table 2: Urine cultures sent, antibiotic prescriptions and amount of follow-up time across the study phases for the 10 long-term care homes that completed implementation of the program

		Phase			IRR, baseline v. intervention (95% CI)	
Variable	Total	Baseline	Implementation	Intervention	Unadjusted	Adjusted
Outcome, no. per 1000 resident-days						
Urine cultures sent	2.64	3.20	2.35	2.09	0.70 (0.61–0.79)	0.72 (0.63–0.82)
Urinary antibiotic prescriptions	1.19	1.52	1.09	0.83	0.59 (0.46–0.72)	0.60 (0.47–0.74)
Total antibiotic prescriptions	3.20	3.85	2.82	2.60	0.74 (0.66–0.82)	0.74 (0.65–0.83)
Follow-up						
Home-months,† no.	164	70	42	52	NA	NA
Resident-days,‡ no. (thousands)	793.2	344.8	198.2	250.2	NA	NA

Note: CI = confidence interval, IRR = incidence rate ratio, NA = not applicable.
†Months that each home participated in a given period of the study, summed across all homes.
‡Days that each resident stayed at a home within a given period, summed across all residents.

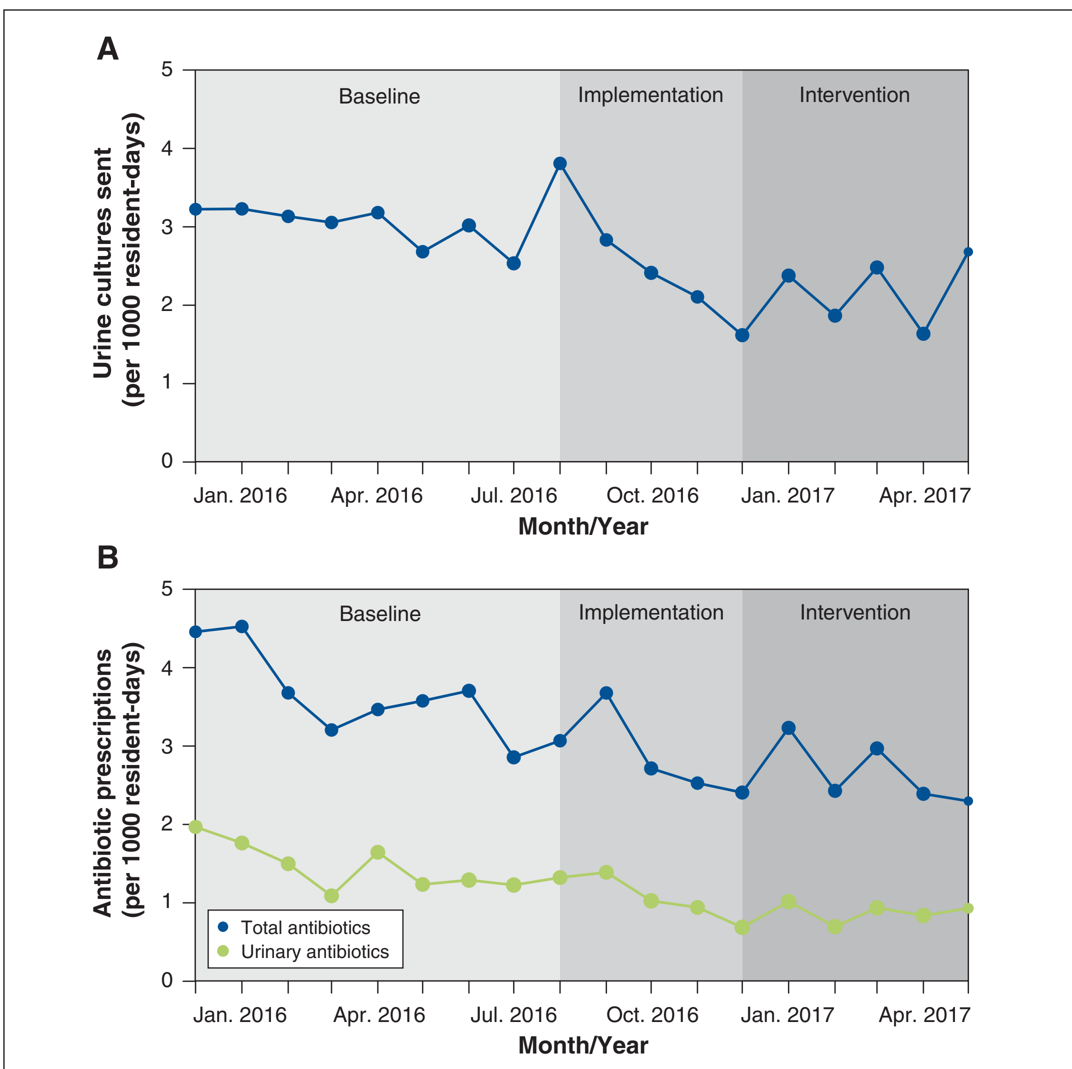

Figure 2: Variation in monthly rates (per 1000 resident-days) of (A) urine cultures sent and (B) antibiotic prescriptions in 10 long-term care homes.

Strategy	No. of homes that adhered
Reviewing and revising organizational policies and procedures	6
Selecting and empowering champions	8
Involving local opinion leaders	6
Carrying out local consensus processes	8
Delivering classroom education to staff	8
Providing information and education to residents and families	7
Identifying and supporting coaches to reinforce key practices and support staff	8
Integrating process surveillance and providing regular feedback to staff	4
Distributing and posting educational resources as reminders to staff about key practices	6

Table 3: Strategy adherence by the 10 long-term care homes that completed implementation of the program

syndrome-specific interventions targeting prescribing for urinary tract infection was effective, yielding reductions in urine culturing and antibiotic prescribing. One cluster randomized controlled trial of 20 homes[26] showed that an intervention targeted at urinary tract infections in Canada and the United States was associated with an 18% decline in urine culturing rates and a 10% decline in total antibiotic use, although the latter finding was not statistically significant. Another single-centre nonrandomized study[14] demonstrated a 59% decline in urine culturing rates and a 30% decline in total antibiotic use. Our study demonstrated reductions in urine culturing, urinary antibiotic use and total antibiotic use of 28%, 40% and 26%, respectively. Our findings highlight the importance of building a multistrategy program to reduce antibiotic use for asymptomatic bacteriuria. Furthermore, the persistent interhome variation observed for antibiotic use and urine culturing suggests that there are further opportunities to reduce urine culturing and antibiotic prescribing.

The program had 9 recommended strategies and we found that, with 1 exception, these strategies were implemented in the majority of homes. The strategy of integrating

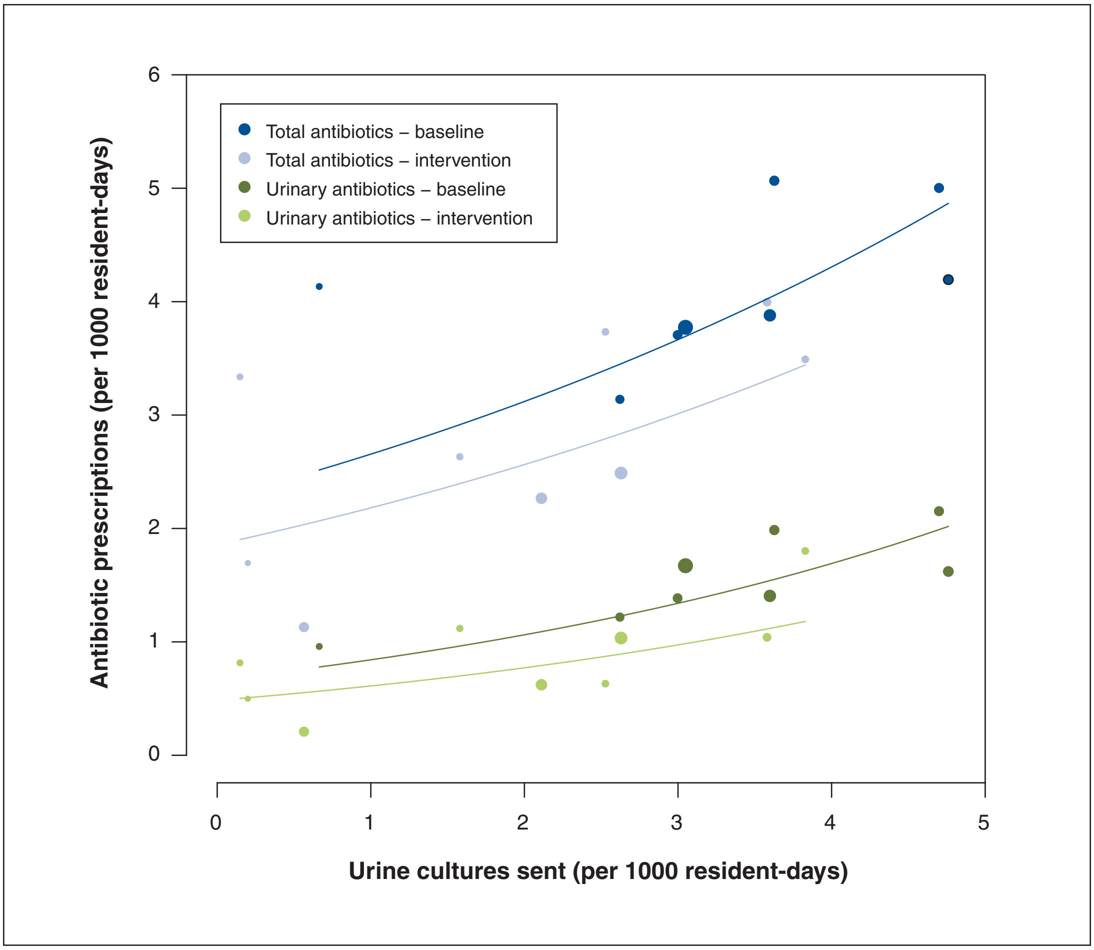

Figure 3: Association between urine culturing rates and antibiotic prescribing at the level of the long-term care home in the baseline and intervention periods, for 10 long-term care homes. Regression-based estimates are superposed.

process surveillance and providing regular feedback to staff was implemented in only 4 of the 10 homes. Discussion with the homes suggested that adherence to this strategy could be improved (a) by ensuring that new documentation requirements are simple and integrated into existing processes[27] and (b) via central preparation of home-specific feedback reports because of the lack of time and expertise within homes.[28] Aspects of this program could inspire changes in other health care settings as the overuse of antibiotics for urinary tract infections is not unique to Canada[14,29] or to long-term care settings.[30]

We also found substantial variation in the rates of urine culturing and that these rates were associated with both total and especially urinary antibiotic prescribing. This helps explain studies showing high variation in antibiotic use in long-term care.[1,4] Stewardship programs 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

This study used a before-and-after design, meaning that, without a parallel arm that did not experience the intervention, we could not control for time-varying covariates related to the intervention. As a sensitivity analysis, we fit an interrupted time series model, which measured the impact of the program on top of estimated secular trends. This analysis estimated implausibly large secular trends (year-over-year reductions in total antibiotic prescriptions of 47%), which wiped away the estimated reductions. However, an Ontario study from 2005 reported similar levels of antibiotic use (3.7 per 1000 resident-days), contradicting the sensitivity analysis models and suggesting that the true secular trends were probably weak.[26] In light of this, we cannot infer causality in terms of the program's effect on antibiotic use reduction. Nevertheless, this study demonstrated that most of the implementation strategies were feasible and that the program was associated with reductions in both urine culturing and antibiotic use.

Further, while this study included certain potential confounders, other factors related to home urine culturing rates may have explained the interhome variation. We did not have resident-level data and therefore there may have been some unaccounted-for clustering. The format and comprehensiveness of pharmacy reports differed depending on the home's pharmacy provider and therefore interpretation was required during the data abstraction process. Owing to the small numbers of homes in this analysis we could not determine which strategies worked and which ones did not. This study did not capture downstream impacts of the intervention, including potential harms due to antibiotic overuse or due to less antibiotic use. The participating homes volunteered to participate and may not reflect the general population of homes, although we did ensure the sample was diverse in terms of size, ownership and region. Finally, this study was unable to consider the long-term sustainability of the program and ongoing evaluation will be necessary.

Conclusion

We demonstrated a decline in urine culturing rates and antibiotic use following implementation of a multistrategy program to improve the diagnosis and treatment of urinary tract infections. Ongoing evaluation is required to monitor secular trends in urine culturing and antibiotic use; however, this initial analysis supports a broader implementation of this program to decrease inappropriate urine culturing and antibiotic use in long-term care.

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