U.S. Department of Veterans Affairs

Public Access Author manuscript

J Am Med Dir Assoc. Author manuscript; available in PMC 2020 May 18.

Published in final edited form as:

J Am Med Dir Assoc. 2020 January ; 21(1): 115–120. doi:10.1016/j.jamda.2019.07.003.

Trends in Collection of Microbiological Cultures Across Veterans Affairs Community Living Centers in the United States Over 8 Years

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Abstract

Objectives: To describe and evaluate changes in the collection of microbiological cultures across Veterans Affairs (VA) Community Living Centers (CLCs) nationally.

Design: Descriptive study.

Setting: 146 VA CLCs.

Participants: We identified both positive and negative microbiological cultures collected during VA CLC admissions from January 2010 through December 2017.

Measures: We measured the average annual percentage change (AAPC) in the rate of cultures collected per 1000 bed days and per admission, overall and stratified by culture type (ie, urine, blood, skin and soft tissue, and respiratory tract). AAPCs were also calculated for the proportion and rate of positive cultures collected, overall and stratified by culture type and organism (ie, *Escherichia coli*, *Proteus mirabilis*, *Staphylococcus aureus*, *Enterococcus* spp, *Pseudomonas*

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aeruginosa, *Klebsiella* spp, *Enterobacter* spp, *Morganella morganii*, *Citrobacter* spp, *Serratia marcescens*, and *Streptococcus pneumoniae*). Joinpoint regression software was used to assess trends and estimate AAPCs and 95% confidence intervals (CIs).

Results: Over 8 years, 355,329 cultures were collected. The rate of cultures collected per 1000 bed days of care decreased significantly by 6.0% per year (95% CI -8.7%, -3.2%). The proportion of positive cultures decreased by 0.9% (95% CI -1.4%, -0.4%). The most common culture types were urine (48.4%), followed by blood (27.7%). The rate of cultures collected per 1000 bed days of care decreased per year by 6.3% for urine, 5.0% for blood, 4.4% for skin and soft tissue, and 4.9% for respiratory tract. In 2010, *S aureus* was the most common organism identified, and in all subsequent years *E coli* was the most common.

Conclusion and implications: We identified a significant reduction in the number of cultures collected over time among VA CLCs. Our findings may be explained by decreases in the collection of unnecessary

Keywords

Long-term care facilities; microbiologic culture collection trends; Veterans Affairs; Community Living Centers

Diagnostic uncertainty contributes to antibiotic overuse in long-term care facilities (LTCFs).

¹ The presentation of common infections, such as urinary tract infections (UTIs), lower respiratory tract infections, and skin and soft tissue infections, may be atypical among older patients.^{1,2} The signs and symptoms of infection in older adults may include acute confusion or subtle changes in physical state or functioning without classic signs of infection, such as fever and chills, which may jeopardize accurate diagnosis.^{1,2} Cognitive impairment often limits the ability of residents to articulate their symptoms, which may further complicate clinical assessments.³⁻⁶ These issues may prompt LTCF clinicians to respond to any change in status with collection of microbiological cultures, particularly urine cultures. If cultures result in positive growth due to colonization and/or contamination vs true infection, this can lead to inappropriate and unnecessary antibiotic therapy.¹

Despite the impact clinical microbiological cultures may ultimately have on antibiotic use, there have been no long-term studies describing the trends in the collection of cultures among LTCFs in the United States at the national level. Quantifying these trends may inform future targets for diagnostic stewardship intervention among LTCFs.^{7,8} Diagnostic stewardship has the same goal as antibiotic stewardship to improve antibiotic use, but intervenes at the level of the diagnostic test to improve the way in which tests are ordered, preformed, and reported.⁸ Additionally, over the past decade, the importance of antibiotic stewardship and infection control has been increasingly recognized, and may have led to reductions in the collection of cultures.^{9,10} Thus, the objective of this study was to describe national trends in the rates of microbiological cultures collected at Veterans Affairs (VA) LTCFs (referred to as Community Living Centers or CLCs in the VA Healthcare System) nationally from 2010 to 2017.

Methods

We conducted a longitudinal study to describe annual trends in the collection of microbiological cultures among VA CLCs nationally. The study was approved by our Institutional Review Board (IRB) and Research and Development (R&D) Committee prior to initiation. National VA clinical and administrative data, including hospital and long-term care admissions, outpatient visits, medication administrations and dispensings, and laboratory results, were used in this study. All microbiology results among LTCF admissions entered in the electronic medical record were included in the study. From these data, we included all cultures collected during a stay at a VA CLC facility between January 1, 2010, and December 31, 2017. Cultures from 146 VA CLCs and from all culture types were included. We included all cultures, even in the case of multiple cultures from the same patient, on the same day, of the same culture type. VA bed days were captured from Veterans Health Administration Support Services Center.

For each calendar year, we calculated the number of cultures collected, including positive and negative cultures, as well as the rate of cultures collected per admission and per 1000 bed days of care. We described the number of cultures collected per admission per year, which accounts for turnover but not for occupancy, and the number of cultures collected per bed days of care per year, which accounts for occupancy but not for turnover.^{11,12} Positive cultures were those in which any organism was recovered from the culture by the microbiological laboratory that tested the specimen, and negative cultures were those in which no organisms were identified.

Cultures were categorized by culture type and organism. Culture types were grouped into broad categories (urine, blood, skin and soft tissue, or respiratory tract) based on the body site where the specimen was collected (eg, an expectorated sputum or endotracheal aspirate was grouped into respiratory tract and a skin swab or skin lesion aspirate was grouped into skin and soft tissue). “Other” was used to group cultures that did not fit into these broad categories. Positive cultures were grouped into the following organism categories: *Escherichia coli*, *Proteus mirabilis*, *Staphylococcus aureus*, *Enterococcus* spp, *Pseudomonas aeruginosa*, *Klebsiella* spp, *Enterobacter* spp, *Morganella morganii*, *Citrobacter* spp, *Serratia marcescens*, *Streptococcus pneumoniae*, and other (positive for any another organism). Culture types and bacterial organisms were selected a priori because of their clinical importance and prevalence in the CLC setting.^{13,14} Polymicrobial cultures were counted as a single positive culture; however, each organism identified was counted and categorized separately into organism types.

Average annual percent changes (AAPCs) were calculated for the rate of cultures collected per admission and per 1000 bed days over the study period, overall and stratified by culture type and organism.^{15,16} AAPCs were also calculated for proportion of positive cultures collected and the rate of positive cultures collected. The AAPC is calculated as a weighted average of the average percent change (APC) segments from a joinpoint model with the weights equal to the duration of each APC segment. The Joinpoint Regression Program, version 4.6.0.0 (National Cancer Institute, Bethesda, MD), was used to calculate AAPCs and 95% confidence intervals (CIs). Significance was set at $P < .05$.

Results

Between 2010 and 2017, a total of 355,329 cultures were collected from residents admitted to 146 VA CLCs. Positive microbial growth was reported in 42.0% of cultures (n = 149,069). The number of cultures collected per admission was 1.6 in 2010 and 0.9 in 2017 and decreased significantly by 8.3% per year (95% CI -9.6%, -6.9%; Table 1). Similarly, the number of cultures collected per 1000 bed days of care decreased significantly by 6.0% per year (95% CI -8.7%, -3.2%; Table 2).

Trends in Cultures Collected by Culture Type

The most common culture type collected (both positive and negative) during the study period was urine (48.4%, n = 172,081), followed by blood (27.7%, n = 98,422), other (11.8%, n = 42,093), skin and soft tissue (8.5%, n = 30,292), and then respiratory tract (3.5%, n = 12,441). The annual rates and trends in cultures collected by culture type are presented in Table 1 (rates per admission) and Table 2 (rates per 1000 bed days). The rate of cultures collected per 1000 bed days of care decreased by 6.3% per year for urine (95% CI -8.2%, -4.4%), 5.0% per year for blood (95% CI -5.8%, -4.3%), 4.4% per year for skin and soft tissue (95% CI -6.6%, -2.3%), and 4.9% per year for respiratory tract (95% CI -6.9%, -2.7%; Table 2).

Trends in Positive Cultures Collected

The rates of positive cultures collected (per admission and per 1000 bed days) decreased over the study period, as did the proportion of positive cultures (AAPC = -0.9%, 95% CI -1.4%, -0.4%). The annual distribution and trends in rates (per 1000 bed days of care) of positive cultures are presented in Table 3. Similar results were observed in rates per admission but are not presented in the tables.

The proportion of positive cultures collected remained stable for urine cultures at about 53% (AAPC = 0.2%, 95% CI -0.1%, 0.5%) and skin and soft tissue cultures at about 62% (AAPC = 0.1%, 95% CI -1.0%, 1.2%). The proportion of positive cultures decreased over the study period for blood cultures from about 14% to 12% (AAPC = -1.7%, 95% CI -2.9%, -0.6%) and respiratory tract cultures from about 54% to 43% (AAPC = -2.8%, 95% CI -4.0%, -1.7%).

Trends in Cultures Collected by Species of Organism

In 2010, *S aureus* was the most common organism identified. In subsequent years, *E coli* was the most common organism identified. The annual distribution and trends in rates (per 1000 bed days of care) of positive cultures by species of organism are presented in Table 4. Similar results were observed in rates per admission but are not presented in the Tables. The rate of positive cultures decreased for most organisms (ie, *S aureus*, *Enterococcus* spp, *E coli*, *P mirabilis*, *P aeruginosa*, *Enterobacter* spp, *Citrobacter* spp, *M morgani*, and *S marcescens*) except for *S pneumoniae* and *Klebsiella* spp, which remained stable. The trends in rates (per 1000 bed days of care) of positive cultures by species of organism and culture type are presented in Table 5. The rate of positive cultures growing *S aureus* decreased for all culture types (urine, blood, skin and soft tissue, or respiratory tract).

Discussion

We identified a significant reduction in the rate of microbiological cultures collected over an 8-year period, which may be related to increased infection control and antibiotic stewardship throughout the VA health care system.¹⁷⁻¹⁹ Increased antibiotic stewardship efforts may lead to reduced culture collection rates through reduction of inappropriate or unnecessary microbiological cultures.

The overall rate of cultures collected over time was largely driven by a reduction in urine cultures, which may be related to an increased awareness of overdiagnosis and testing for UTIs over the study period.^{4,20} The appropriate diagnosis and treatment of UTIs has become one of the most important antibiotic stewardship targets among LTCFs because of the high prevalence of asymptomatic bacteriuria among residents.⁹ Previous smaller studies have demonstrated that UTI-focused antibiotic stewardship interventions are associated with reductions in the collection of urine cultures.^{4,20,21} For example, a single-center study in a VA CLC demonstrated a reduction in urine culture collection rate (from 3.7 to 1.5 per 1000 resident days) after implementation of a pathway to limit urine testing without urinary symptoms.²⁰ Our research shows this trend on a national scale and suggests that the trend toward reduced urine testing has been occurring across the entire VA CLC system.

In addition to a reduction in urine cultures, we also observed significant reductions in blood, skin and soft tissue, and respiratory tract cultures collected from VA CLC residents, which suggests that diagnostic stewardship may extend beyond urine testing. Similar to urine cultures, limiting overcollection of skin and soft tissue cultures is an important stewardship target in LTCFs.²² Wounds and pressure ulcers, which are common in older adults, are colonized by bacteria.²² As such, collection of microbiological samples from skin or wounds in the absence of signs or symptoms of infection could lead to inappropriate antibiotic use.^{3,13} For respiratory tract and blood cultures, the role of diagnostic stewardship on the culture reduction rates we observed in VA CLCs may be more related to efforts to reduce contamination rather than efforts to reduce unnecessary cultures. The role of respiratory tract cultures in LTCFs are generally limited, as residents are often not able to produce expectorated sputum and even when respiratory tract cultures are available they are often contaminated.²³ Similarly, the role of blood cultures in LTCFs is limited, as they generally have a low yield in LTCF residents and most residents with suspected bacteremia are transferred to acute care facilities.²³ Nonetheless, reduction of blood culture contamination is an important tenant of diagnostic stewardship and overall quality improvement in many health care settings.²⁴⁻²⁶ Interestingly, when stratified by culture type, we did find that the proportion of positive cultures collected remained stable for urine cultures and skin and soft tissue cultures, but the proportion of positive cultures decreased for blood cultures and respiratory tract cultures.

An important finding from this research is the overall reduction in the rate of positive cultures collected for particularly virulent organisms, such as *S aureus*, *Enterococcus* spp, *E coli*, and *P aeruginosa*, among the VA CLC population. Although we did not assess antibiotic resistance, previous work has demonstrated that the burden of infections due to methicillin-resistant *S aureus* has significantly declined in the VA since 2007 when a

prevention initiative was implemented among all VA medical centers.^{17,18,27,28} This initiative may have also led to reductions in other non-*S aureus* infections as well, through expanded infection control programs and resources.²⁹ However, similar trends have been observed nationally outside the VA, which may suggest shifts in strain epidemiology and may also contribute to our findings.³⁰ Further work in this area will need to occur to identify why the trends we observed occurred.

There are limitations inherent in our work. Our study included all cultures that were collected and did not assess the clinical significance of the cultures. Any culture in which any organism or any bacteria was recovered was defined as positive and, as such, we cannot distinguish what proportion of positive cultures represent true infection vs colonization or contamination. Additionally, in our assessment of culture by organism there may be an overestimation of bacteria in which multiple positive cultures are obtained from the same patient with the same results. Moreover, the indications for the cultures are unknown. For example, the collection of a urine culture may be indicated for a resident with sepsis, whether or not a positive result represents a UTI or asymptomatic bacteriuria. The generalizability of results among VA CLCs to community non-VA LTCFs may be limited. The residents of VA CLCs have more complex medical needs and the staffing levels are higher than in non-VA LTCFs.³¹ Finally, although many facilities ensure that culture results obtained from outside the VA system are captured within the electronic medical record, it is impossible to ascertain if all cultures collected at outside laboratories are included in this analysis. Finally, our categorization of cultures by source and organism are based on the ordering, interpretation, and reporting of the providers and microbiology laboratory that ordered and handled the clinical culture. Additionally, the specificity of the culture collection site varies, and we cannot always determine the specific body sites where cultures were collected (eg, sputum vs endotracheal among respiratory tract cultures, or skin swab vs lesion aspirate among skin cultures). As such, we used broad culture type categories (eg, urine, blood, skin and soft tissue, or respiratory tract).

We did not assess whether changes in culture collection corresponded with changes in antibiotic use, resource utilization and costs, or resident outcomes, such as hospitalizations, which should be explored further.

Conclusions and Implications

Our data revealed a significant reduction in the number of cultures collected among VA CLCs nationally over an 8-year period, with a large reduction in urine cultures. This reduction in cultures likely reflects a reduction in collection of unnecessary cultures in VA CLCs nationally and may be driven by increased awareness for overtesting and overtreatment of presumed UTI. Moreover, this reduction may have had important clinical and economic impact through reduction of additional unnecessary testing and antibiotic use, reduced resource utilization and costs, and improved overall resident care and outcomes.

Acknowledgments

This work is supported by a VA Health Services Research and Development (HSR&D) Merit Award (#15-120). The views expressed are those of the authors and do not necessarily reflect the position or policy of the United States

Department of Veterans Affairs. This material is based on work supported, in part, by the Office of Research and Development, Department of Veterans Affairs. This work was supported in part by funds and facilities provided by the Cleveland Department of Veterans Affairs (VA), the Cleveland Geriatric Research Education and Clinical Center (GRECC) and the Specialty Care Center of Innovation.

H.A. is supported in part by a Career Development Award, Department of Veterans Affairs. A.C. has received research funding from Pfizer, Merck (Cubist), and The Medicines Company. R.J. is the principal investigator on research grants from the Steris corporation and Pfizer; she has also participated in advisory boards for Pfizer and Merck. K.L. has received research funding or acted as a scientific advisor for Merck, Ocean Spray, Pfizer, and The Medicines Company. D.D. has funded projects from the Veterans Administration, the National Institute of Aging, and Meals on Wheels of America. All authors have funded projects from the Veterans Administration.

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Table 1

Annual Rates (Per Admission) and Trends in Cultures Collected at VA Community Living Centers Nationally From 2010 to 2017

Year	Overall Cultures	Urine Cultures	Blood Cultures	Skin Cultures	Respiratory Tract Cultures
2010	1.6	0.692	0.389	0.125	0.052
2011	1.4	0.648	0.373	0.111	0.049
2012	1.2	0.613	0.342	0.105	0.040
2013	1.1	0.577	0.315	0.097	0.040
2014	1.1	0.538	0.304	0.090	0.039
2015	1.0	0.505	0.300	0.094	0.036
2016	0.9	0.474	0.276	0.086	0.034
2017	0.9	0.429	0.262	0.080	0.034
AAPC (95% CI)	-8.3 (-9.6, -6.9) *	-6.4 (-6.8, -6.0) *	-5.4 (-6.2, -4.7) *	-5.6 (-6.9, -4.2) *	-5.9 (-7.8, -4.0) *

The Joinpoint Regression Program was used to calculate AAPC and 95% CIs. AAPC is calculated as a weighted average of the average percent change (APC) segments from a joinpoint model with the weights equal to the duration of each APC segment.

* Indicates significant trend at $P < .05$.

Table 2

Annual Rates (per 1000 Bed Days) and Trends in Cultures Collected at VA Community Living Centers Nationally From 2011 to 2017

Year	Overall Cultures	Urine Cultures	Blood Cultures	Skin Cultures	Respiratory Tract Cultures
2011	14.3	6.8	3.9	1.2	0.5
2012	13.4	6.6	3.7	1.1	0.4
2013	12.8	6.5	3.6	1.1	0.5
2014	12.0	6.1	3.4	1.0	0.4
2015	11.7	5.8	3.5	1.1	0.4
2016	10.5	5.3	3.1	1.0	0.4
2017	9.3	4.6	2.8	0.9	0.4
AAPC (95% CI)	-6.0 (-8.7, -3.2) *	-6.3 (-8.2, -4.4) *	-5.0 (-5.8, -4.3) *	-4.4 (-6.6, -2.3) *	-4.9 (-6.9, -2.7) *

The Joinpoint Regression Program was used to calculate AAPC and 95% CIs. AAPC is calculated as a weighted average of the average percent change (APC) segments from a joinpoint model with the weights equal to the duration of each APC segment.

* Indicates significant trend at $P < .05$.

Table 3

Annual Distribution and Trends in Positive Cultures Collected at VA Community Living Centers Nationally From 2011 to 2017

Year	Proportion of Positive Cultures, %	Positive Cultures per 1000 CLC Bed Days
2011	43.3%	6.2
2012	42.3	5.7
2013	42.8	5.5
2014	41.8	5.0
2015	41.2	4.8
2016	40.6	4.3
2017	40.1	3.8
AAPC (95% CI)	-0.9 (-1.4, -0.4) ^{*,†}	-7.0 (-9.7, -4.2) ^{*,‡}

The Joinpoint Regression Program was used to calculate AAPC and 95% CIs. AAPC is calculated as a weighted average of the average percent change (APC) segments from a joinpoint model with the weights equal to the duration of each APC segment.

* Indicates significant trend at $P < .05$.

[†] AAPC presented for change in the proportion of positive cultures collected from 2010 to 2017. The proportion of positive cultures in 2010 was 42.2%.

[‡] AAPC presented for change in the rate of positive cultures per 1000 bed days of care. Similar results were observed for rate per admission (data not presented in table).

Table 4

Annual Rates (per 1000 Bed Days) and Trends in Cultures Collected by Organism at VA Community Living Centers Nationally From 2011 to 2017

Year	Organism	<i>Staphylococcus aureus</i>	<i>Enterococcus spp</i>	<i>Streptococcus pneumoniae</i>	<i>Escherichia coli</i>	<i>Proteus mirabilis</i>	<i>Pseudomonas aeruginosa</i>	<i>Klebsiella spp</i>	<i>Enterobacter spp</i>	<i>Morganella morganii</i>	<i>Citrobacter spp</i>	<i>Serratia marcescens</i>
2011		0.989	0.743	0.011	0.997	0.908	0.564	0.535	0.139	0.114	0.078	0.050
2012		0.841	0.750	0.014	0.930	0.819	0.535	0.493	0.143	0.117	0.078	0.047
2013		0.802	0.752	0.011	0.947	0.826	0.534	0.543	0.140	0.114	0.081	0.043
2014		0.738	0.625	0.007	0.881	0.759	0.451	0.511	0.140	0.099	0.074	0.042
2015		0.651	0.619	0.008	0.856	0.713	0.456	0.511	0.110	0.093	0.075	0.044
2016		0.593	0.533	0.011	0.771	0.684	0.462	0.479	0.114	0.074	0.064	0.040
2017		0.520	0.484	0.010	0.758	0.596	0.379	0.395	0.120	0.076	0.065	0.038
AAPC (95% CI)		-9.6 (-10.8, -8.5) *	-7.4 (-10.2, -4.6) *	-3.8 (-14.2, 7.8)	-4.5 (-5.8, -3.2) *	-6.1 (-7.6, -4.6) *	-5.7 (-8.3, -3.0) *	-3.6 (-7.2, 0.1)	-4.0 (-7.5, -0.3) *	-8.0 (-11.2, -4.6) *	-3.6 (-6.0, -1.1) *	-3.9 (-5.7, -2.2) *

The Joinpoint Regression Program was used to calculate AAPC and 95% 95% CIs. AAPC is calculated as a weighted average of the average percent change (APC) segments from a joinpoint model with the weights equal to the duration of each APC segment. AAPCs are presented for change in rates per 1000 bed days of care. Similar results were observed for rates per admission (data not presented in table).

* Indicates significant trend at $P < .05$.

Table 5

Trends in Rates (per 1000 Bed Days) of Positive Cultures by Organism and Culture Type Collected at VA Community Living Centers Nationally From 2011 to 2017

Culture Type	Organism	<i>Staphylococcus aureus</i> per 1000 CLC bed days	<i>Enterococcus</i> spp	<i>Escherichia Coli</i>	<i>Proteus mirabilis</i>	<i>Pseudomonas aeruginosa</i>	<i>Klebsiella</i> spp	<i>Enterobacter</i> spp	<i>Morganella morganii</i>	<i>Citrobacter</i> spp	<i>Serratia marcescens</i>
Urine		-8.0 (-9.8, -6.1)*	-7.5 (-11.3, -3.5)*	-4.9 (-6.3, -3.5)*	-6.8 (-8.9, -4.8)*	-5.7 (-8.1, -3.3)*	-3.7 (-7.1, -0.1)*	-4.5 (-10.0, 1.3)	-8.3 (-11.6, -4.9)*	-4.3 (-6.8, -1.7)*	-3.7 (-10.0, 3.1)
Blood		-6.0 (-11.5, -0.2)*	-8.2 (-14.7, -1.3)*	-2.7 (-8.2, 3.1)	-2.3 (-11.1, 7.4)	-10.9 (-23.4, 3.6)	-0.4 (-11.7, 12.3)	-6.6 (-18.7, 7.2)	-1.2 (-33.4, 46.4)	-1.2 (-48.6, 90.0)	-15.7 (-38.5, 15.6)
Skin		-6.7 (-8.6, -4.7)*	-3.7 (-6.2, -1.1)*	-0.6 (-3.1, 1.9)	-2.4 (-4.6, -0.2)*	-2.6 (-6.9, 1.9)	-1.6 (-8.8, 6.1)	2.8 (-3.2, 9.2)	-10.2 (-15.8, -4.2)*	3.8 (-4.5, 12.8)	-0.9 (-9.0, 7.9)
Respiratory tract		-9.8 (-12.7, -6.7)*	-11.0 (-41.4, 35.3)	-11.3 (-18.7, -3.2)*	-16.4 (-24.3, -7.7)*	-10.4 (-14.8, -5.7)*	-10.2 (-12.8, -7.5)*	-17.6 (-21.8, -13.1)*	-10.1 (-38.4, 31.2)	-17.9 (-32.9, 0.4)	-8.0 (-19.7, 5.4)

Values presented are AAPC and 95% CIs, calculated using the Joinpoint Regression Program. AAPC is calculated as a weighted average of the average percent change (APC) segments from a joinpoint model with the weights equal to the duration of each APC segment. AAPCs are presented for change in rates per 1000 bed days of care. Similar results were observed for rates per admission (data not presented in table).

* Indicates significant trend at $P < .05$.