The SHIELD Orange County Project: Multidrug-resistant Organism Prevalence in 21 Nursing Homes and Long-term Acute Care Facilities in Southern California

James A. McKinnell,¹ Raveena D. Singh,² Loren G. Miller,¹ Ken Kleinman,³ Gabrielle Gussin,² Jiayi He,² Raheeb Saavedra,² Tabitha D. Dutciuc,² Marlene Estevez,² Justin Chang,² Lauren Heim,² Stacey Yamaguchi,² Harold Custodio,² Shruti K. Gohil,² Steven Park,⁴ Steven Tam,⁵ Philip A. Robinson,⁶ Thomas Tjoa,² Jenny Nguyen,² Kaye D. Evans,⁴ Cassiana E. Bittencourt,⁴ Bruce Y. Lee,⁷ Leslie E. Mueller,⁷ Sarah M. Bartsch,⁷ John A. Jernigan,⁸ Rachel B. Slayton,⁸ Nimalie D. Stone,⁸ Matthew Zahn,⁹ Vincent Mor,^{10,11,12} Kevin McConeghy,^{10,11,12} Rosa R. Baier,^{10,12} Lynn Janssen,¹³ Kathleen O'Donnell,^{9,13} Robert A. Weinstein,^{14,15} Mary K. Hayden,¹⁵ Micaela H. Coady,¹⁶ Megha Bhattarai,¹⁶ Ellena M. Peterson,⁴ and Susan S. Huang,^{2,17} for the Centers for Disease Control and Prevention Safety and Healthcare Epidemiology Prevention Research Development (SHEPHERD) Program⁸

¹Infectious Disease Clinical Outcomes Research, LA Biomed at Harbor-University of California Los Angeles Medical Center, Torrance; ²Division of Infectious Diseases, University of California Irvine School of Medicine; ³University of Massachusetts Amherst School of Public Health and Health Sciences; ⁴University of California Irvine Health, Orange; ⁵Division of Geriatrics, Department of Medicine, University of California Irvine, Orange, and ⁶Hoag Hospital, Newport, California; ⁷Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland; ⁸Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia; ⁹Epidemiology and Assessment, Orange County Health Care Agency, Santa Ana, California; ¹⁰Department of Health Services, Policy and Practice, Brown University School of Public Health; ¹¹Center of Innovation in Long-Term Services and Supports, Veterans Affairs Medical Center, Providence VA Medical Center, and ¹²Center for Long-Term Care Quality and Innovation, Brown University School of Public Health, Providence, Rhode Island; ¹³Healthcare-associated Infections Program, Center for Healthcare Quality, California Department of Public Health, Richmond, California; ¹⁴Cook County Health and Hospitals System, and ¹⁵Department of Medicine, Rush University Medical Center, Chicago, Illinois; ¹⁶Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, Massachusetts; and ¹⁷Health Policy Research Institute, University of California Irvine School of Medicine

Background. Multidrug-resistant organisms (MDROs) spread between hospitals, nursing homes (NHs), and long-term acute care facilities (LTACs) via patient transfers. The Shared Healthcare Intervention to Eliminate Life-threatening Dissemination of MDROs in Orange County is a regional public health collaborative involving decolonization at 38 healthcare facilities selected based on their high degree of patient sharing. We report baseline MDRO prevalence in 21 NHs/LTACs.

Methods. A random sample of 50 adults for 21 NHs/LTACs (18 NHs, 3 LTACs) were screened for methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* spp. (VRE), extended-spectrum β -lactamase-producing organisms (ESBL), and carbapenem-resistant Enterobacteriaceae (CRE) using nares, skin (axilla/groin), and peri-rectal swabs. Facility and resident characteristics associated with MDRO carriage were assessed using multivariable models clustering by person and facility.

Results. Prevalence of MDROs was 65% in NHs and 80% in LTACs. The most common MDROs in NHs were MRSA (42%) and ESBL (34%); in LTACs they were VRE (55%) and ESBL (38%). CRE prevalence was higher in facilities that manage ventilated LTAC patients and NH residents (8% vs <1%, $P < .001$). MDRO status was known for 18% of NH residents and 49% of LTAC patients. MDRO-colonized adults commonly harbored additional MDROs (54% MDRO+ NH residents and 62% MDRO+ LTACs patients). History of MRSA (odds ratio [OR] = 1.7; confidence interval [CI]: 1.2, 2.4; $P = .004$), VRE (OR = 2.1; CI: 1.2, 3.8; $P = .01$), ESBL (OR = 1.6; CI: 1.1, 2.3; $P = .03$), and diabetes (OR = 1.3; CI: 1.0, 1.7; $P = .03$) were associated with any MDRO carriage.

Conclusions. The majority of NH residents and LTAC patients harbor MDROs. MDRO status is frequently unknown to the facility. The high MDRO prevalence highlights the need for prevention efforts in NHs/LTACs as part of regional efforts to control MDRO spread.

Keywords. chlorhexidine; decolonization; public health; MRSA; CRE; long term care.

The threat of antibiotic resistance in the US healthcare system has been recognized by the Centers for Disease Control and Prevention (CDC) [1], Infectious Disease Society of America [2], Society for Healthcare Epidemiology of America [3],

and the US government [4]. CDC estimates that 2 million Americans become infected with bacteria that are resistant to antibiotics each year, and 23 000 people die from these infections [1].

Nursing home (NH) and long-term acute care facility (LTAC) patients and residents are disproportionately affected with morbidity and mortality from multidrug-resistant organism (MDRO) infections [5–9]. Although infection prevention and antimicrobial stewardship strategies can reduce the impact of MDRO infections [10, 11], resources for these programs are focused in short-term acute care hospitals (ACHs) [12]. An investigation in Maryland showed a 4-fold

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Correspondence: J. A. McKinnell, Infectious Disease Clinical Outcomes Research (ID-CORE), LA Biomed at Harbor-UCLA Medical Center, 1124 West Carson St, Box 466, Torrance CA 90502 (dr.mckinnell@yahoo.com).

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difference in infection control, full-time equivalents in ACHs compared to NHs [13].

Limiting infection control and stewardship resources for NHs and LTACs has serious implications for the entire US health system [14]. Patients and residents in these settings are transferred frequently and serve as a source of MDRO transmission [7–9, 15–22]. For example, methicillin-resistant *Staphylococcus aureus* (MRSA) spread from ACHs to NHs within the Veterans Affairs medical system [23]. Other MDROs have spread from hospitals into NHs [24, 25]. More recently, NH residents and LTAC patients were associated with transmission of carbapenem-resistant Enterobacteriaceae (CRE) across a region [26]. Investment of resources in regional infection prevention programs that focus on NHs and LTACs has potential to attenuate the spread of MDROs and prevent morbidity and mortality across the US healthcare system [15, 27].

The Shared Healthcare Intervention to Eliminate Life-threatening Dissemination of MDROs in Orange County (SHIELD OC) is a large Southern California regional public health collaborative funded and supported by CDC and endorsed by the Orange County Health Care Agency and the California Department of Public Health. SHIELD OC involves 38 out of 104 healthcare facilities in Orange County, California. SHIELD OC Participants include 18 NHs, 3 LTACs, and 17 short-term acute care hospitals. Orange County has a population of 3.1 million persons and is the 6th most populous US county. Healthcare facilities were invited to participate based upon their high degree of direct and indirect patient sharing with one another [28]. Participants in the SHIELD OC collaborative project initiated a quality improvement performance improvement (QAPI) project focused on chlorhexidine bathing and nasal decolonization. SHIELD OC will measure the regional impacts of a coordinated infection prevention initiative on MDRO carriage and infection [28]. Herein we report baseline colonization prevalence of common and emerging MDROs among NH and LTAC facilities participating in SHIELD OC.

METHODS

NH and LTAC facilities were provided the opportunity to conduct a point prevalence assessment of MDRO carriage. Sampling of patients in contact precautions was conducted in the 17 ACHs and will be published separately. The SHIELD OC program provided supplies, logistics, and microbiologic laboratory testing. SHIELD OC was a voluntary regional public health collaborative and was determined to be non-research and exempt from institutional review board oversight by the CDC and UCI institutional review boards.

Point Prevalence MDRO Sampling

A 1-day point prevalence sampling of 50 NH residents and LTAC patients at 18 NHs and 3 LTACs was conducted between

September 2016 and March 2017. Point prevalence sampling was conducted for pre-intervention purposes and was done by the facility as a QAPI program. LTAC patients and NH residents were informed of sampling verbally and in writing and allowed to refuse, but no written consent was deemed necessary for the low-risk procedure of nares and body swab collection. The SHIELD OC team trained facility nurses on swabbing technique, and each nurse was required to show return demonstration of the proper swab techniques at the start of the point prevalence day. A swabbing team consisted of the trained nurse who performed all swabbing and 2 SHIELD OC project coordinators.

Selection of patients for swabbing was based upon a random sample of occupied beds (excluding hospice) until 50 persons were swabbed. Facility nurses performed bilateral nares swabs for MRSA, as well as bilateral axilla/groin and peri-rectal swabs, which were processed for MRSA, vancomycin-resistant *Enterococcus* spp. (VRE), extended-spectrum β -lactamase producing organisms (ESBLs), and CRE. All swabs (BBL CultureSwab, Becton Dickinson, Sparks, Maryland) were premoistened prior to swabbing and processed within 6 hours of sampling. No protected health information was included on swabs.

Microbiologic Testing

Swabs were cultured for ESBL and CR Enterobacteriaceae, VRE, and MRSA. The media used and order of inoculation was: MacConkey agar with a cefpodoxime disk (2 μ g); MacConkey agar with a meropenem disk (2 μ g); *Campylobacter* agar (BD BBL, Becton Dickinson) with 10% sheep blood with vancomycin 10 μ g, cephalothin 15 μ g, trimethoprim 5 μ g, polymyxin-B 2.5 units, amphotericin-B 2 μ g; and Spectra MRSA (Thermo Fisher Scientific, Waltham, Massachusetts) [29]. Isolates on Spectra agar that were the typical morphology and color were not further confirmed. Isolates with atypical morphology or color on Spectra were confirmed as *S. aureus* by a tube coagulase or matrix assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF-MS). In addition, with atypical isolates, methicillin resistance was confirmed by a standardized disk diffusion test using a cefoxitin disk. The identification of enterococci isolated on *Campylobacter* agar was verified by conventional biochemical and/or MALDI-TOF-MS. Vancomycin resistance was not confirmed given the known ability of this agar to detect VRE [30]. Isolates identified by the initial ESBL screen were further identified by MALDI-TOF-MS or the VITEK2 GN-card (bioMérieux, Marcy-l'Étoile, France) and phenotypic testing for the presence of ESBL using disk diffusion with cefotaxime and ceftazidime with and without clavulanic acid or the VITEK2 AST-GN69 card. Isolates identified as a CRE by the initial screen were further identified by MALDI-TOF-MS or the VITEK2 AST-GN69 card and disk diffusion using meropenem, and, if needed due to a questionable result,

the disk diffusion was repeated using meropenem, ertapenem, and imipenem.

Collection of Clinical Data

NH resident and LTAC patient characteristics were collected from the medical record by study staff using a standardized form. Medical devices (eg, central venous catheters, urinary catheters, drains, tubes, or ventilators) and wounds were recorded by direct observation of each resident during sampling. Prior knowledge of MDRO status was determined from review of the medical record, as well as infection prevention and surveillance records. Additional variables abstracted from chart review included age, sex, length of stay, total care requirement (bed bound), incontinence, and presence of selected comorbidities (eg, diabetes). Patient data were de-identified at each facility prior to analysis by the SHIELD OC team.

Collection of Facility-level Data

Facility-level NH characteristics were collected from admission assessments in the Centers for Medicare and Medicaid Services minimum data set (MDS) for the most recent year available, 2016 (http://www.resdac.org/MDS/data_available.asp), including the number of licensed beds, average daily census, mean length-of-stay, mean resident Elixhauser comorbidity score [31], and percentage of patients and residents with comorbidities. LTAC characteristics were obtained from the California Office of Statewide Health Planning and Development for the most recent year available, 2016 (<http://www.oshpd.ca.gov>). NH data on annual

admissions, admissions per bed per year, occupancy ratio, proportion of patients and residents with Medicare, proportion of patients and residents with Medicaid, average resource utilization group (RUG-III) scores, mean activities of daily living (ADL) index, and average acuity index, were obtained for 2017 from LTCFocus.org. The RUG-III score approximates the relative nursing staff time associated with resident care, with a higher score indicating higher required resources. The ADL index measures resident independence for bed mobility, transfer, locomotion, dressing, eating, toilet use, and personal hygiene. Each ADL is scored from 0 to 4, and the overall ADL index ranges from 0 (completely independent) to 28 (completely dependent). The facility acuity index is a measure of the care needed by an NH's residents, based on ADLs and the number of residents receiving special treatment. The proportion of adults who required mechanical ventilation was obtained at the time of surveillance. CMS 5-Star Quality Rating was obtained for 2017 (<https://www.medicare.gov/nursinghomecompare>).

Statistical Analysis

For each NH and LTAC, the prevalence of overall and individual MDROs (MRSA, VRE, ESBL, and CRE) were calculated as the proportion of swabbed patients and residents who were colonized at any body site with any MDRO or an individual MDRO, respectively. The median and range of overall and individual MDRO prevalence were then calculated across all facilities. The percent of NH residents or LTAC patients found to harbor an MDRO previously unknown to the facility was assessed.

Table 1. Characteristics of the Nursing Home/Long-term Acute Care Facilities

Variable	All Nursing Homes Median (Range)	NH Without Ventilator Beds Median (Range)	NH With Ventilator Beds Median (Range)	LTAC Median (Range)
N	18	14	4	3
Mean age	77 (69, 85)	79 (69, 85)	71 (69, 74)	72 (71, 73)
% Male	45 (31, 51)	39 (31, 48)	48 (47, 51)	53 (53, 53)
% Long-stay ^a	75 (70, 80)	75 (70, 79)	74 (72, 80)	5 (3, 7)
% Medicare	16 (6, 57)	16 (6, 57)	14 (7, 20)	69 (68, 75)
% Medicaid	58 (17, 76)	55 (17, 76)	67 (60, 76)	0 (0, 6)
% Diabetes	33 (23, 57)	32 (23, 43)	53 (36, 57)	13 (9, 16)
% Chronic lung disease	17 (10, 38)	15 (10, 29)	23 (11, 38)	21 (19, 23)
% Renal insufficiency	13 (2, 33)	13 (2, 23)	14 (5, 33)	23 (21, 24)
% Ventilated	0 (0, 58)	0 (0, 0)	32 (10, 58)	40 (37, 52)
Licensed beds (N)	118 (59, 250)	106 (59, 250)	135 (99, 202)	59 (48, 109)
Average daily census (N)	122 (56, 231)	101 (56, 231)	138 (109, 214)	63 (39, 89)
Occupancy ratio	0.83 (0.62, 0.98)	0.82 (0.62, 0.98)	0.92 (0.83, 0.97)	0.93 (0.84, 0.93)
Mean length-of-stay	201 (185, 227)	199 (185, 227)	215 (191, 223)	31 (29, 32)
Total annual admissions	361 (104, 602)	368 (104, 602)	249 (128, 394)	462 (425, 945)
Admissions/bed/year (N)	2 (1, 7)	2 (2, 7)	2 (1, 3)	7 (5, 9)
Elixhauser comorbidity score [31]	3 (2, 5)	3 (2, 4)	3 (2, 5)	3 (3, 3)
Average RUG-III index (N)	1 (1, 1)	1 (1, 1)	1 (1, 1)	...
CMS 5-star quality rating	3 (1, 5)	3 (1, 5)	4 (3, 5)	...
ADL index (N)	12 (10, 15)	12 (10, 13)	14 (12, 15)	...
Average acuity index (N)	13 (11, 18)	13 (11, 14)	16 (13, 18)	...

Abbreviations: ADL, activities of daily living; LTAC, long-term acute care facility; NH, nursing home; RUG-III, Resource Utilization Groups version III.

^a % long stay refers to the proportion of patients and residents with a length-of-stay >100 days.

To evaluate person-level and NH/LTACs characteristics associated with MDRO carriage, multivariate analyses of swab data were performed using generalized linear mixed models. Models accounted for clustering at the patient/resident and NH/LTAC levels. Analyses were performed for five outcomes: MRSA, VRE, ESBL, CRE, and any MDRO. Variables were retained in the models regardless of *P*-value unless there was evidence of collinearity or the variable caused the models to not converge. All analyses were conducted using SAS version 9.3 (SAS Institute, Cary, North Carolina).

RESULTS

Of the 21 participating NH/LTACs sites in SHIELD OC, there were 14 NHs without ventilator beds, 4 NHs with ventilator beds (vNHs), and 3 LTACs. NH and LTAC characteristics are presented in Table 1. The mean age across sites was similar between NHs (77 years) and LTACs (72 years) ($P = .25$), although the mean proportion of male patients and residents in NHs was lower (45%) than LTACs (53%) ($P = .03$). Compared to LTACs, NHs had a higher average daily census (122 vs 63 $P = .050$), a longer length-of-stay (201 days vs 31 days, $P < .001$), and fewer admissions per year (361 vs 462, $P = .008$). NHs had a higher mean proportion of residents with diabetes than LTACs (33% vs 13%, $P = .004$), whereas renal insufficiency was more common in LTACs but did not reach statistical significance (23% vs 13%, $P = .09$).

A total of 3150 swabs were obtained from 1050 patients and residents, including 1050 nares swabs, 1050 combined axilla/groin swabs, and 1050 peri-rectal swabs. Of the NH residents and LTAC patients approached, 9% and 8% declined to participate, respectively. In sum, 2 LTACs and 2 nonventilator NHs had <50 patients/residents on the swabbing day and required a second visit 2 weeks later to complete the 50 swabs. Characteristics of NH residents and LTAC patients who were swabbed are listed in Table 2. The majority of NH residents and LTAC patients (67%, $n = 701$) had at least 1 MDRO; 41% ($n = 427$) had MRSA; 35% ($n = 366$) had ESBL, 22% ($n = 231$) had VRE, and 3% ($n = 31$) had CRE. NH residents and LTAC patients who were MDRO carriers were found to harbor an average of 1.5 MDROs. Twenty-seven percent ($n = 284$) of NH residents and LTAC patients were found to carry multiple MDRO pathogens. Of those who harbored multiple MDROs, the most common combinations were MRSA and ESBL ($n = 180$, 63%), MRSA and VRE ($n = 108$, 38%), and VRE and ESBL ($n = 88$, 31%).

In total, 238 (23%) NH residents and LTAC patients had a documented history of any MDRO colonization. Overall, 12% ($n = 127$) of NH residents and LTAC patients had a history of MRSA, 9% ($n = 98$) had a history of ESBL, 4% ($n = 42$) had a history of VRE, and 3% ($n = 29$) had a history of CRE. Among these NH residents and LTAC patients, 63% ($n = 151$) had body

Table 2. Characteristics of the Nursing Home/Long-term Acute Care Facility Patients and Residents Who Were Swabbed

Variable	NH and LTAC, N (%)
N	1050
Female	593 (56)
Age (years)	
≥80	519 (49)
60–79	375 (36)
<60	156 (15)
LOS (days)	
>100	501 (48)
>30–100	202 (19)
15–30	125 (12)
<15	222 (21)
MDRO history by chart review	
Any MDRO	238 (23)
MRSA	127 (12)
VRE	42 (4)
ESBL	98 (9)
CRE	29 (3)
Incontinence status	
Stool	687 (65)
Urine	564 (54)
Diabetes	360 (34)
Bed bound	281 (27)
Urinary catheter	254 (24)
GI device ^a	157 (15)
Central venous catheter	90 (9)
Wounds	230 (22)

Resident characteristics were obtained from chart review, staff interview, and direct observation of the resident for presence of wounds and devices.

Abbreviations: CRE, carbapenem-resistant Enterobacteriaceae; ESBL, extended-spectrum β -lactamase-producing organism; GI, gastrointestinal; LOS, length of stay; LTAC, long-term acute care facility; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; NH, nursing home; VRE, vancomycin-resistant *Enterococcus* spp.

^aGI device, naso-gastric tubes, oral-gastric tubes, oral-jejunal tubes, percutaneous gastric tubes.

cultures consistent with their prior history, including MRSA (64%, $n = 81$), ESBL (71%, $n = 70$), VRE (36%, $n = 15$), and CRE (41%, $n = 12$). Of all NH residents and LTAC patients with at least 1 MDRO, 91% ($n = 635$) had an MDRO that was unknown to the NH or LTAC. Of all MDRO pathogens detected, 83% ($n = 877$) were unknown to the NH or LTAC.

Facility-specific MDRO point prevalence results are found in Table 3 grouped by NHs without ventilator residents, NHs with ventilator residents, and LTACs. Any MDRO carriage ranged from 44% to 88%, with >75% MDRO colonization prevalence seen in 2 NHs, 2 vNHs, and 2 LTACs. The prevalence of MDRO colonized persons with no history of any MDRO colonization was high in NHs (median 55%, range 42%–72%), vNHs (median 74%, range 66%–78%), and LTACs (median 66%, range 64%–76%). MRSA carriage was found in all facilities, ranging from 24% to 62% (median 36%). ESBL colonization ranged 0%–60% (median 36%) and exceeded MRSA colonization in 4 NHs, 2 vNHs, and 2 LTACs. CRE prevalence was rare in NHs

Table 3. Point Prevalence Multidrug-resistant Organism Carriage Among All Residents and Patients Swabbed at Nursing Homes and Long-term Acute Care Facilities

Facility Type	Chart History of Any MDRO N (%)	MDRO Carriage N (%)	MRSA Carriage N (%)	VRE Carriage N (%)	ESBL Carriage N (%)	CRE Carriage N (%)	MDRO Without MDRO History N (%)	Additional MDRO With MDRO History N (%)
Nursing home without ventilator beds								
1	5 (10)	22 (44)	12 (24)	3 (6)	10 (20)	0 (0)	21 (42)	1 (2)
2	3 (6)	22 (44)	15 (30)	1 (2)	12 (24)	1 (2)	21 (42)	2 (4)
3	3 (6)	26 (52)	18 (36)	6 (12)	7 (14)	0 (0)	24 (48)	1 (2)
4	6 (12)	28 (56)	23 (46)	10 (20)	0 (0)	0 (0)	25 (50)	3 (6)
5	13 (26)	29 (58)	17 (34)	8 (16)	12 (24)	0 (0)	23 (46)	3 (6)
6	7 (14)	29 (58)	19 (38)	17 (34)	9 (18)	0 (0)	29 (58)	4 (8)
7	11 (22)	29 (58)	17 (34)	9 (18)	20 (40)	0 (0)	27 (54)	5 (10)
8	12 (24)	29 (58)	17 (34)	5 (10)	16 (32)	0 (0)	28 (56)	9 (18)
9	12 (24)	32 (64)	21 (42)	10 (20)	12 (24)	0 (0)	26 (52)	4 (8)
10	9 (18)	32 (64)	18 (36)	8 (16)	18 (36)	0 (0)	28 (56)	5 (10)
11	8 (16)	34 (68)	18 (36)	7 (14)	19 (38)	0 (0)	31 (62)	4 (8)
12	7 (14)	34 (68)	31 (62)	5 (10)	14 (28)	0 (0)	33 (66)	4 (8)
13	11 (22)	38 (76)	26 (52)	7 (14)	27 (54)	0 (0)	34 (68)	5 (10)
14	13 (26)	41 (82)	18 (36)	15 (30)	27 (54)	1 (2)	36 (72)	6 (12)
Median % (range)	17 (6, 26)	58 (44, 82)	36 (24, 62)	15 (2, 34)	26 (0, 54)	0 (0, 2)	55 (42, 72)	8 (2, 18)
Nursing homes with ventilator beds								
15	9 (18)	36 (72)	28 (56)	7 (14)	24 (48)	5 (10)	33 (66)	6 (12)
16	11 (22)	37 (74)	26 (52)	12 (24)	20 (40)	5 (10)	35 (70)	8 (16)
17	4 (8)	39 (78)	24 (48)	7 (14)	28 (56)	0 (0)	39 (78)	4 (8)
18	20 (40)	44 (88)	30 (60)	11 (22)	33 (66)	6 (12)	39 (78)	14 (28)
Median % (range)	20 (8, 40)	76 (72, 88)	54 (48, 60)	18 (14, 24)	52 (40, 66)	10 (0, 12)	74 (66, 78)	14 (8, 28)
LTACs								
19	24 (48)	36 (72)	15 (30)	25 (50)	15 (30)	5 (10)	32 (64)	13 (26)
20	25 (50)	41 (82)	13 (26)	28 (56)	19 (38)	4 (8)	33 (66)	14 (28)
21	25 (50)	43 (86)	21 (42)	30 (60)	24 (48)	4 (8)	38 (76)	19 (38)
Median % (range)	50 (48, 50)	82 (72, 86)	30 (26, 42)	56 (50, 60)	38 (30, 48)	8 (8, 10)	66 (64, 76)	28 (26, 38)

Abbreviations: CRE, carbapenem-resistant Enterobacteriaceae; ESBL, extended-spectrum β -lactamase-producing Enterobacteriaceae; LTAC, long-term acute care facility; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant Enterococci.

(<1%) compared to vNHs (median 10%, range 0%–12%), and LTACs (median 8%, range 8%–10%).

Multivariable models identified several person-level characteristics associated with MDRO carriage (Table 4). Medical devices were associated with each MDRO. Specifically, central venous catheters (odds ratio [OR] = 2.4; confidence interval [CI]: 1.3, 4.3; $P = .005$) were associated with VRE carriage, and gastrointestinal (GI) devices were associated with MRSA (OR = 1.4; CI: 1.0, 2.0; $P = .04$), ESBL (OR = 1.7; CI: 1.1, 2.5; $P = .009$), and CRE (OR = 19.7; CI: 3.5, 109.4; $P < .001$). In addition, a history of a specific MDRO was highly associated with a current positive culture for the MDRO, with the exception of VRE.

DISCUSSION

In a systematic assessment of key MDROs across a large number of facilities in Southern California, MDRO colonization was found in the large majority of NH residents and LTAC patients. Although MDROs have been known to be found in

NHs/LTACs [7–9, 15–22], the scope and pervasiveness of the problem has not been previously described. Our observed colonization prevalence of 67% far exceeds the observed MDRO colonization prevalence of 10%–20% seen in similar studies from acute care hospitals [32, 33]. MDRO prevalence was consistently high across all sites in this multisite, large-scale regional surveillance study, which suggests that the findings are generalizable to similar facilities in other areas. It further highlights that MDRO pathogens are far more prevalent in the NH/LTAC setting than in short-term acute care settings, where most infection control and stewardship efforts are currently focused.

Our results raise important questions about how best to address MDRO prevalence and risk of spread in NH and LTAC settings. Our observed prevalence of 67% MDRO colonization was nearly 3 times higher than the 23% of people with a prior history of MDRO colonization, suggesting these facilities grossly underestimate their MDRO burden. An MDRO registry may be helpful in identifying these patients as some may have had a prior positive culture at another facility. Multivariate

Table 4. Multivariable Regression for Factors Associated With Multidrug-resistant Organism Colonization in Nursing Homes and Long-term Acute Care Facilities

Variable	OR (95% CI)	P Value
Any MDRO		
Diabetes	1.3 (1.0, 1.7)	.03
History of MRSA	1.7 (1.2, 2.4)	.004
History of VRE	2.1 (1.2, 3.8)	.01
History of ESBL	1.6 (1.1, 2.3)	.03
Swab location		
Axilla/groin	1.0	
Nares	0.3 (0.3, 0.4)	<.001
Peri-rectal	1.4 (1.1, 1.7)	
Any MRSA		
Diabetes	1.3 (1.0, 1.8)	.05
GI device ^a	1.4 (1.0, 2.0)	.04
Incontinence of stool	1.5 (1.1, 2.0)	.01
History of MRSA	2.6 (1.7, 3.9)	<.001
Swab location		
Axilla/groin	1.0	
Nares	1.0 (0.8, 1.2)	.03
Peri-rectal	0.8 (0.6, 0.9)	
Season		
Winter	1.0	
Fall	0.6 (0.4, 0.9)	.01
Any VRE		
Female	0.7 (0.5, 0.9)	.03
Age per decade	0.8 (0.7, 0.9)	<.001
Length-of-stay	0.98 (0.97, 0.98)	<.001
Central venous catheter	2.4 (1.3, 4.3)	.005
Swab location		
Axilla/groin	1.0	
Peri-rectal	2.0 (1.5, 2.6)	<.001
Any ESBL		
GI device	1.7 (1.1, 2.5)	.009
History of ESBL	4.1 (2.5, 6.7)	<.001
History of VRE	2.6 (1.3, 5.3)	.008
Swab location		
Axilla/groin	1.0	
Peri-rectal	1.9 (1.5, 2.4)	<.001
Occupancy ratio	2.0 (1.0, 3.9)	.04
Admissions/bed/year	0.01 (<0.001, 0.4)	.02
Any CRE		
GI device	19.7 (3.5, 109.4)	<.001
History of CRE	29.8 (8.5, 103.6)	<.001
History of VRE	4.8 (1.3, 17.9)	.02

Abbreviations: CI, confidence interval; CRE, carbapenem-resistant Enterobacteriaceae; ESBL, extended-spectrum β -lactamase-producing Enterobacteriaceae; GI, gastrointestinal; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio; VRE, vancomycin-resistant *Enterococci*.

Models adjust for clustering by person and by site. Variables were entered into the model unless there was evidence of collinearity. Only significantly associated variables shown.

^aGI device, naso-gastric tubes, oral-gastric tubes, oral-jejunal tubes, percutaneous gastric tubes.

models identified patient characteristics associated with MDRO colonization, notably medical devices and history of MDRO colonization. Nevertheless, although multivariate models found some predictors of MDRO status, these models are hard to translate into targeted intervention approaches for MDRO.

The high absolute MDRO prevalence may obviate the value of “targeted” enhanced infection control strategies in favor of universal approaches.

Implementation of enhanced infection prevention protocols is complex in NHs/LTACs and, at least in the NH setting, must respect that for some individuals, the NH may represent a person’s home [34]. Rigorous application of contact precautions and universal chlorhexidine bathing has been effective in controlling CRE in LTACs in the Chicago region [35]. However, contact precautions for the majority of NH residents is often not practical and raises concerns for unique harms in this setting [34]. The SHIELD OC initiative will evaluate a regional intervention involving universal application of chlorhexidine bathing and nasal decolonization in an effort to reduce both MDRO colonization and affect regional MDRO infections. However, additional research into other universally adoptable interventions such as antimicrobial stewardship, better environmental cleaning protocols, more rigorous application of routine infection prevention protocols, or other novel infection prevention protocols are also warranted.

The surveillance data collected as part of SHIELD OC are valuable to better understand the burden of MDROs in Orange County. The epidemiology of individual MDRO pathogens may be explained by differences in medical devices or patient history of MDROs, which are more associated with 1 or another MDRO. Alternatively, it may simply reflect referral or patient transfer patterns not captured in this analysis [15]. In general, MRSA was the predominant MDRO across all facilities. However, ESBL predominated in several. The implication of high ESBL colonization is that these patients may become infected and thereby exposed to more carbapenem therapy, which can further drive emergence of CRE. Unlike other MDROs, there may be an opportunity to contain CRE in this region due to the low rates and recent introduction of the pathogen into California. It is notable that CRE concentrated in LTACs and vNHs, compared to NHs without ventilator beds, suggesting there may still be some opportunity for targeted CRE prevention efforts [22]. In fact, colonization with CRE was more commonly known to the facility, which likely reflected an ongoing effort by LTACs to conduct screening for CRE on admission and communication CRE status on transfer to other healthcare facilities [27, 36].

Our data represent the largest MDRO point prevalence study published to date in NH and LTAC settings. Our study is limited in that we conducted surveillance only within a subset of more highly connected facilities southern California. Nevertheless, our findings are supported by similar studies in California, Illinois, Maryland, Massachusetts, Michigan, and Washington [7–9, 15, 16, 18, 19, 37–41]. Our study is strengthened by the fact that our surveillance was systematic and included tests for peri-rectal colonization, which have not been universally done in other settings [39]. Our study is further strengthened by the low refusal rate of 8% for the point prevalence study and our

ability to conduct all patient sampling for all but 4 facilities in a single day. The low refusal rate and true single day point prevalence estimates suggest that our data are likely representative of the NH and LTAC populations. The representativeness was largely due to facility support and the fact that specific consent was not required for the low risk procedure of patient sampling to support a QAPI initiative.

In summary, MDRO colonization prevalence is high within the NH and LTAC setting, far exceeding published reports in acute care hospitals. These data demonstrate the importance of NH/LTACs as a dominant MDRO reservoir in the healthcare system. There is an urgent need to engage NH/LTAC facilities in the effort to improve regional burden of colonization and infection with MDROs. The SHIELD OC initiative will assess one strategy to address MDROs, namely, widespread use of decolonization products in NH/LTACs and hospitals. Investment in universal strategies of infection prevention and antimicrobial stewardship that are applicable to NHs and long term acute care hospitals are greatly needed and arguably overdue.

Notes

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