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Comparing Influenza Vaccination History Information Sources Over Four Influenza Seasons, 2018–2024

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Background

Connecticut (CT) participates in the Influenza Hospitalization Surveillance Network (FluSurv-NET), a population-based surveillance program which monitors influenza-associated hospitalizations among residents of the Lower CT River Valley, Naugatuck Valley, and South Central CT county-equivalent regions. Program staff attempt to ascertain influenza vaccination history for each influenza-associated hospitalization case to understand seasonal influenza vaccine effectiveness. The vaccine history for each case-patient is determined by checking the patient's electronic medical record (EMR) and the CT immunization information system (CT WiZ). If those are unsuccessful, staff contact the case-patient (or medical proxy) and/or the case-patient's primary care provider (PCP)/ long term care facility (LTCF). The number of follow up calls that are made is determined using a standard protocol.

Finding vaccination history information can be challenging and requires substantial staff time. Vaccination history might not be recorded in the medical record during the hospital stay. Calling case-patients and providers can be a burden to staff resources and has mixed success. Additionally, the reliability of each source may change over time due to EMR and CT WiZ data modernization efforts, state policies expanding vaccination reporting, and shifting public willingness to participate in interviews with public health staff.

This analysis sought to examine the level of success in finding influenza vaccination history data by different data sources over time and by case-patient demographic characteristics.

Methods

Retrospective data from three recent influenza seasons (2021–2022, 2022–2023, and 2023–2024) and a pre-pandemic season (2018–2019) were used to assess source completeness over time. The 2019–2020 and 2020–2021 seasons were omitted due to modified FluSurv-NET protocol during the COVID-19 pandemic and low influenza activity, respectively. For each influenza-associated hospitalization, staff recorded the outcome of checking vaccination status by potential source of vaccine information. Each source's completeness was assessed as the proportion of cases for which staff could establish a vaccine status using that source out of all cases for which that source was checked. If staff identified a vaccination date within the influenza season but before the hospitalization, the case was considered vaccinated. The case was considered unvaccinated if staff found an affirmative indication that the case was unvaccinated for that influenza season. The statistical significance of observed differences across seasons was assessed using the Cochran-Armitage test for trend. The statistical significance of the association between source completeness and demographic characteristics (age group, sex, race/ethnicity, and residence type) for cases from the 2023–2024 season (n=713) was assessed using chi-square tests.

For a subset of 2023–2024 influenza-associated hospitalizations that required additional follow-up beyond checking the EMR and CT WiZ (n=227), staff prospectively recorded the number of calls placed and time, in minutes, spent contacting case-patients and/or their providers (including time on hold and leaving a message). The median time spent per call was calculated and differences in time per call by recipient were assessed using the Wilcoxon rank-sum test.

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Results

The success of finding vaccination status in CT WiZ increased each season, from 15.0% in 2018–19 to 50.6% in 2023–24 ($P < .001$; Table 1). Meanwhile, the success of obtaining vaccination status by calling PCPs/LTCFs decreased each season, from 77.9% to 16.7% ($P < .001$). The availability of vaccination status in the EMR was highest in 2018–19 at 62.1% of cases, remaining between 48%–58% complete in more recent seasons ($P = .003$). Vaccination status obtained via attempted case-patient interview showed little variation over time, remaining at about 46%–53% successful.

Several notable associations were found between source completeness and demographic characteristics during the 2023–2024 season (Table 2).

By age, the EMR was most likely to have vaccination status documented for case-patients aged 5–17 years (70.7%, $P < .01$). CT WiZ was most likely to have vaccination status for case-patients aged 65 and older (57.7%) and least likely to have it for those aged 18–49 years (28.0%, $P < .001$). Calling PCPs/LTCFs was most likely to result in obtaining vaccination histories for case-patients who were 65 and older (26.8%) compared to calls to all other age groups which were less than 10% successful ($P < .01$). No significant association was found between case-patient/proxy interview and age.

By sex, case-patient/proxy interview was more likely to result in obtaining vaccination history for females (52.9%) compared to males (39.3%, $P = .04$). Other sources had similar completeness for males versus females.

By race and ethnicity, CT WiZ was most likely to have vaccination history for non-Hispanic White case-patients (54.1%), followed by Hispanic case-patients (52.5%), non-Hispanic Black case-patients (40.7%), and those who identified with another race (27.8%, $P = .01$). The other sources showed some variation but none that were significantly different across racial and ethnic groups.

By residence type, the EMR was least likely to have vaccination history documented for case-patients who resided in a LTCF at the time of their hospitalization (30.8%, $P < 0.01$). CT WiZ was also least likely to have vaccination history for LTCF residents (34.6%, $P = .11$) though this was not significantly different from the CT WiZ completion rate for other residence types. Case-patients residing in a LTCF were most likely to have vaccine history successfully obtained from calling their PCP/LTCF (53.6%, $P < .001$).

For the hospitalized influenza cases from the 2023–2024 season with information on the time spent per call (n=227), the median time it took to complete a PCP/LTCF call was twice as long as the median call time to case-patients/proxies (4 mins vs. 2 mins, $P < .001$, Table 3).

Discussion

CT WiZ, the state immunization information system, is an increasingly useful tool for public health surveillance. This reflects the success of a 2022 statute which expanded reporting requirements to include all vaccinations for all age groups, resulting in a consolidated record from pharmacy, provider, and other vaccine administration locations. Public health staff can find vaccination information faster and more efficiently without needing to contact individual clinics, saving clinicians time as well. This might explain why contacting providers has been less helpful in recent seasons; if a case-patient's vaccination status is not in CT WiZ, it is likely because they are unvaccinated, and PCPs rarely have different information.

Vaccine status can only be determined in the affirmative from CT WiZ if the person has a documented vaccine. Therefore, the differences in likelihood of finding vaccine history in CT WiZ by age and race/ethnicity are likely explained by differences in influenza vaccine uptake in the general population. Older adults and non-Hispanic White adults tend to have higher influenza vaccination coverage,[1] so they are more likely to have vaccination history successfully obtained from CT WiZ.

Calls to case-patients/proxies were more likely to yield vaccination history and took less time compared to calls to PCPs/LTCFs. This might be because people who have no documented vaccination in CT WiZ are usually unvaccinated, which they can quickly confirm over the phone. Calling providers takes longer because staff usually wait on hold before getting transferred to the right person and then wait for the provider to look up the case-patient, all contributing to a longer call. While contacting PCPs/LTCFs is becoming less useful over time, in 2023–2024, it remained an important source of vaccine information for case-patients 65 years and older and those living in LTCFs. Case-patients living in LTCFs were also less likely to have their vaccine status documented in their EMR or CT WiZ, even though this population typically has higher influenza vaccine coverage compared to the general adult population (61% for nursing home residents[2] vs. 46% for adults 18 years and older,[1] 2024–2025 season).

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Taken together, these findings identify important insights into the usefulness of different sources of information for vaccination status and the relative difficulty of obtaining information over the phone. This analysis helped FluSurv-NET use a data-driven approach to adapt protocols and improve the efficiency of collecting vaccination history. Periodically evaluating traditional public health surveillance processes is a useful practice to adapt to a landscape where health information is increasingly modernized.

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Table 1. Overall completeness of four sources of vaccine information, Connecticut, 2018–2024

	2018–2019	2021–2022	2022–2023	2023–2024	*P* value
EMR	62.1% (699/1125)	48.7% (73/150)	58.4% (250/428)	54.8% (391/713)	.003
CT WiZ	15.0% (9/60)	33.3% (53/159)	38.2% (164/429)	50.6% (361/713)	< .001
Case-patient/ proxy interview	46.4% (110/237)	46.4% (26/56)	53.0% (70/132)	45.6% (103/226)	.937
Primary care provider/LTCF	77.9% (445/571)	35.2% (32/91)	27.4% (52/190)	16.7% (36/219)	< .001

Notes: Completeness for each source was calculated as the number of cases with vaccination information (vaccination date or documented not vaccinated) using that source divided by the number of cases for which the source was checked. *P* values generated from Cochran-Armitage test for trend.

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Table 2. Association between source completeness and demographic characteristics for 2023-2024 influenza season

	EMR	CT WiZ	Case-patient/ proxy interview	Primary care provider/LTCF
Age (in years)				
<5	60.0% (18/30)	56.7% (17/30)	42.9% (3/7)	9.1% (1/11)
5–17	70.7% (41/58)	43.1% (25/58)	50.0% (8/16)	4.5% (1/22)
18–49	57.3% (47/82)	28.0% (23/82)	58.3% (28/48)	8.3% (2/24)
50–64	57.4% (81/141)	45.4% (64/141)	39.6% (19/48)	4.3% (2/47)
≥65	50.7% (204/402)	57.7% (232/402)	42.1% (45/107)	26.8% (30/112)
P value	< .01	< .001	.34	< .01
Sex				
Female	56.4% (204/362)	51.9% (188/362)	52.9% (55/104)	14.5% (16/110)
Male	53.3% (187/351)	49.3% (173/351)	39.3% (48/122)	18.9% (20/106)
P value	.41	.48	.04	.40
Race/Ethnicity				
Hispanic	62.3% (76/122)	52.5% (64/122)	51.4% (18/35)	10.8% (4/37)
Black	61.0% (72/118)	40.7% (48/118)	41.7% (20/48)	11.4% (5/44)
White	51.1% (224/438)	54.1% (237/438)	46.2% (60/130)	20.3% (24/118)
Other	66.7% (12/18)	27.8% (5/18)	50.0% (3/6)	18.2% (2/11)
P value	.05	.01	.84	.40
Residence Type				
Private	56.8% (362/637)	52.0% (331/637)	47.5% (97/204)	11.7% (21/179)
LTC Facility	30.8% (16/52)	34.6% (18/52)	26.7% (4/15)	53.6% (15/28)
Homeless	58.8% (10/17)	47.1% (8/17)	20.0% (1/5)	0.0% (0/7)
Other/Unk	42.9% (3/7)	57.1% (4/7)	50.0% (1/2)	0.0% (0/2)
P value	.05	.01	.84	.40

Notes: Completeness for each source was calculated as the number of cases with vaccination information (vaccination date or documented not vaccinated) using that source divided by the number of cases for which the source was checked. *P* values from chi-square tests for association between source and demographic.

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Table 3. Estimating duration of calls, by recipient, 2023-2024 influenza season

	Case-patient/ proxy interview	Primary care provider/LTCF
Calls placed	480	270
Total Time	18 hours, 55 minutes	25 hours, 1 minute
Time per call, Median (IQR)*	2 (2-3)	4 (3-5)

Note: *Significant difference ($P < .001$), Wilcoxon rank-sum test.

Changes in the Prevalence of Health Care-Associated Infections and Antimicrobial Use in Connecticut Hospitals between 2015 and 2023

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Background

Antimicrobial stewardship and the reduction of healthcare-associated infections (HAIs) are vital for ensuring patient safety in hospital settings and for curbing the emergence and spread of antimicrobial-resistant pathogens. The Centers for Disease Control and Prevention's (CDC) Emerging Infections Program (EIP) has conducted three point prevalence surveys (2011, 2015 and 2023) to assess changes in antimicrobial use (AU) and HAI prevalence in a subset of acute-care hospitals at EIP sites in 10 U.S. states.

Results from the 2011 and 2015 prevalence surveys indicated that AU prevalence remained the same with 50% of all patients receiving antimicrobials at the time of each survey.[1] HAI prevalence, however, significantly decreased between the first two surveys; the likelihood of a patient having a HAI was 16% lower in 2015 than in 2011.[2] Unpublished results from the most recent multi-state full-scale prevalence survey in 2023 show a similar pattern; between 2015 and 2023, AU prevalence remained the same, while HAI prevalence continued to decline.

The goal of this analysis was to: 1) examine Connecticut-specific changes in the prevalence of HAIs and AU between the 2015 and 2023 prevalence surveys and 2) identify changes in the types of antimicrobials prescribed.

Methods

All acute care hospitals in Connecticut were invited to enroll in the 2015 and 2023 prevalence surveys. Participating hospitals selected a survey date between May 1 and September 30 of the survey year. A census generated on the morning of the survey date was used to randomly select 75 patients from small and medium-sized hospitals and 100 patients from large hospitals for inclusion in the study.

EIP staff reviewed medical records to abstract data on patient demographics, medical device use, and AU on the survey date and the day before. In 2015, patients receiving antimicrobials to treat an active infection were evaluated for HAIs.

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Patients that did not receive antimicrobials were assumed not to have an HAI and no further evaluation was performed. In 2023, all patients were evaluated for HAIs regardless of whether they received antimicrobials. HAI prevalence in 2023 was calculated using both the number of HAIs identified in all patients and the number of HAIs identified only in patients receiving antimicrobials to allow for comparison to 2015 HAI prevalence estimates. HAIs were identified using the National Healthcare Safety Network (NHSN) HAI reporting guidelines for the respective year.[3]

Patient characteristics, AU, HAIs, and risk factors for HAIs, including medical device use, were compared between survey years. The statistical significance of observed differences was assessed using the chi-square test. The statistical significance of observed changes in the administration of the following antimicrobial classes between survey years were compared using chi-square tests: fluoroquinolones, intravenous vancomycin, 1st generation cephalosporins, 2nd and 3rd generation cephalosporins, and carbapenems. To account for patients receiving multiple antimicrobials and antimicrobial types, the total number of antimicrobials administered was used for the denominator rather than the total number of patients. Changes in HAI types between years were also compared, but statistical testing was not performed due to small sample sizes. Similarly, the total number of HAIs identified was used for the denominator when comparing HAI types between years.

Multivariable log-binomial regression modeling with backward selection of variables was used to identify patient and hospital factors associated with AU and HAI prevalence. Based on the results of previous analyses of national data from the 2011 and 2015 prevalence surveys,[1,2] the following variables were identified as possible covariates and included in the starting models: presence of a urinary catheter, presence of a central line, mechanical ventilation, time from admission to survey date, hospital size, and admission to a critical care unit on the survey date or day before. Variables that did not significantly affect the model fit were dropped from the final model. All statistical analyses were completed using SAS version 9.4.

Results

A total of 15 acute care hospitals participated in the 2015 prevalence survey and 1,050 patients were surveyed. For the 2023 survey, 24 hospitals participated and 1,620 patients were surveyed. Patients surveyed in 2015 were more likely to be receiving mechanical ventilation on the survey date or the day before compared to patients in 2023 (5.6% vs 3.5%; $P < .001$). There was no significant difference in urinary catheter (2015 vs 2023: 15.2% vs 15.9%; $P = .69$) or central line use (2015 vs 2023: 15.7% vs 13.6%; $P = .13$; Table 1).

Patients were just as likely to receive antimicrobials on the day of or day before the survey date in 2015 as in 2023 (46.2% vs 46.6%; $P = .83$). There was a significant decrease in the administration of 1st generation cephalosporins between 2015 and 2023 (15.0% vs. 11.6%, respectively; $P = .02$) and fluoroquinolones (10.4% vs. 3.5%, $P < .001$), and an increase of 3rd and 4th generation cephalosporins (15.4% vs. 25.6%; $P < .001$). Between 2015 and 2023, the use of intravenous vancomycin (12.3% vs. 10.2%; $P = .12$) and carbapenems (2.4% vs 2.2%; $P = .76$) remained the same (Figure 1).

Patients in 2015 were more likely to have an HAI compared to patients in 2023 (4.0% vs 2.1%; $P < .01$). In 2023, one patient with an HAI was not receiving antimicrobials to treat an active infection. Excluding this patient from the 2023 HAI prevalence estimate had a minimal effect, decreasing the prevalence from 2.1% to 2.0%. Between 2015 and 2023, the proportion of HAIs caused by urinary tract infections, bloodstream infections, and pneumonia increased, while the proportion of HAIs caused by gastrointestinal infections and surgical site infections decreased (Figure 2).

Patients in 2023 were 58% less likely to have an HAI than patients in 2015, with a prevalence ratio of 0.42 (95% CI, 0.26 to 0.69; $P < .001$) after adjusting for age, presence of a urinary catheter, and time from admission to survey date. Patients were just as likely to receive antimicrobials in 2023 as in 2015, with a prevalence ratio of 0.99 (95% CI, 0.84 to 1.16; $P = .90$) after adjusting for age, presence of a urinary catheter, presence of a central line, and time from admission to survey date.

Discussion

The prevalence of healthcare-associated infections decreased by almost 50% in CT hospitals between the 2015 and 2023 surveys. This promising trend may be a result of improvements in infection control practices in CT hospitals between survey years and the state's ongoing commitment to HAI control and prevention. Connecticut's HAI Prevention Plan was updated in 2015 outlining plans to restructure the HAI Advisory Committee to include additional stakeholders and to institute targeted HAI prevention programs focused on training and enhanced surveillance.[4]

Although overall AU remained the same between survey years, there were differences in the prevalence of use of certain antimicrobial classes. Fluoroquinolone prevalence decreased, perhaps due to a greater understanding of the adverse side effects linked to their use. Providers prescribed fewer 1st generation cephalosporins like cefazolin and prescribed more

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3rd and 4th generation cephalosporins like ceftriaxone and cefepime, which generally have greater activity against antibiotic resistant organisms. Vancomycin and carbapenem use remained the same despite a national increase in the burden of hospital-onset vancomycin-resistant *Enterococcus* and hospital-onset carbapenem-resistant Enterobacterales and *Acinetobacter*.[5] An important next step with these data is to assess the appropriateness of AU based on infection type and patient clinical characteristics.

There are several limitations to this study. First, the small HAI sample size makes it difficult to draw meaningful conclusions about changes in specific HAI infection types between years. Second, NHSN guidelines for identifying HAIs were updated between survey years, raising the possibility that an HAI identified in 2015 would not be identified in 2023 and vice versa. Finally, only patients receiving antimicrobials were evaluated for HAIs in 2015, while all patients were evaluated in 2023, which could have led to an underestimation of HAI prevalence in 2015. However, underestimation would likely have been negligible considering only one additional HAI out of a total of 1,620 patients was identified in 2023 when all patients were evaluated for HAIs, regardless of AU.

The CDC HAI and AU Point Prevalence Surveys are powerful tools to assess longitudinal changes in antimicrobial prescribing practices and HAI prevalence both locally and nationally. Data from these surveys not only elucidate successes in antibiotic stewardship and HAI prevention over time but also highlight potential targets for future public health interventions.

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Table 1. Demographic and clinical characteristics of patients by survey year

	2015 Survey (N=1,050)	2023 Survey (N=1,620)	Chi-square *P* value
Age (in years)			
0–17	138 (13.1)	95 (5.9)	< .001*
18–49	209 (19.9)	295 (18.2)	
50–64	226 (21.5)	350 (21.6)	
≥65	477 (45.4)	880 (54.3)	
Sex			
Male	505 (48.1)	754 (46.5)	.433
Female	545 (51.0)	866 (53.5)	
Race/Ethnicity			
White	768 (73.1)	1,088 (67.2)	.004*
Black	124 (11.8)	187 (11.5)	
Hispanic	88 (8.4)	203 (12.5)	
Asian	15 (1.4)	26 (1.6)	
Other	1 (0.1)	4 (0.3)	
Missing	54 (5.1)	112 (6.9)	
Urinary Catheter			
Yes	160 (15.2)	258 (15.9)	.693
No	882 (84.0)	1,362 (84.1)	
Missing	8 (0.8)	0 (0.0)	
Central Venous Catheter			
Yes	165 (15.7)	221 (13.6)	.130
No	881 (83.9)	1,397 (86.2)	
Missing	4 (0.4)	2 (0.1)	
Mechanical Ventilation			
Yes	59 (5.6)	57 (3.5)	.009*
No	990 (94.3)	1,563 (96.5)	
Missing	1 (0.1)	0 (0.0)	
Antimicrobials on survey date or day before			
Yes	485 (46.2)	755 (46.6)	.834
No	565 (53.8)	865 (53.4)	
Healthcare-Associated Infection			
Yes	42 (4.0)	34 (2.1)	.004*
No	1,008 (96.0)	1,586 (97.9)	

Notes: Column percentages may not total 100 due to rounding. Comparisons exclude patients with missing data. An asterisk (*) indicates a statistically significant difference ($P < .05$), determined by chi-square test.

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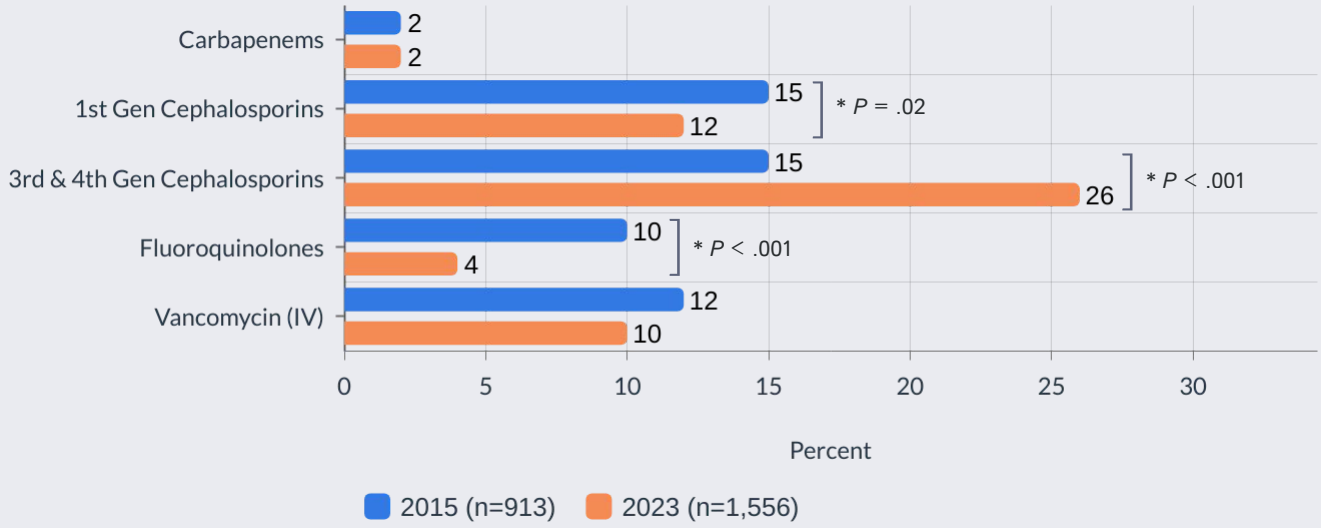
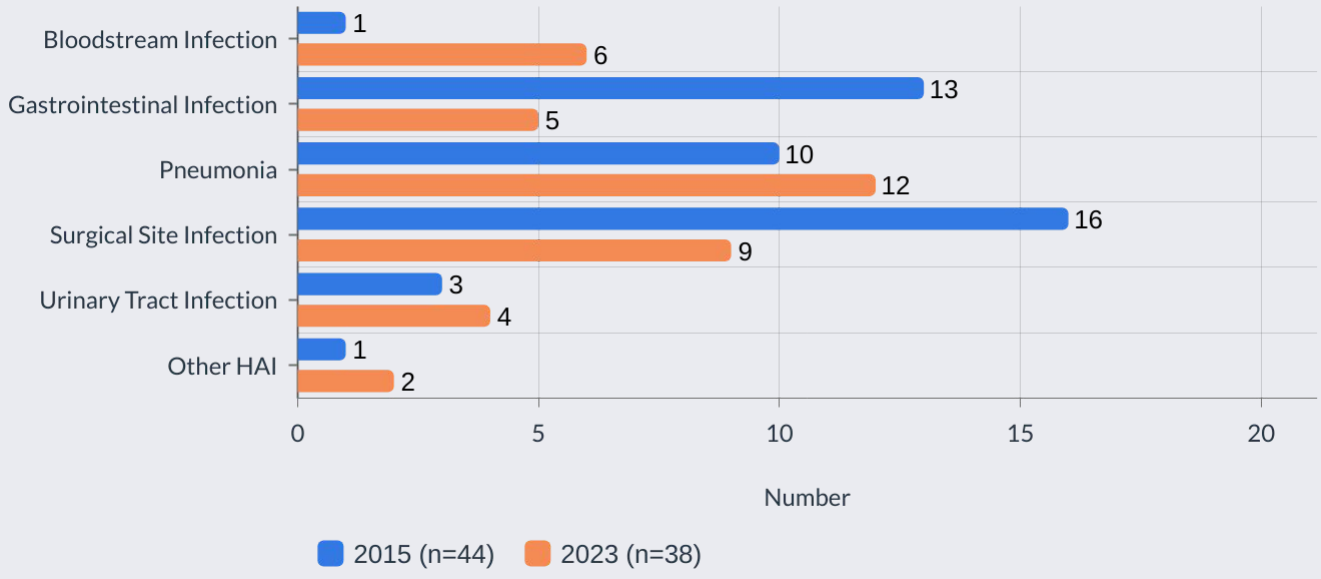
Figure 1: Proportion of antimicrobials administered to patients by antimicrobial class and survey year



Note: An asterisk (*) denotes a statistically significant difference at $P < .05$, determined by chi-square test.

Figure 2: Proportion of HAIs by types and survey year



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