A Comparative Analysis of MRSA and C. difficile Trends in Relation to National HAI Patterns in the United States

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Received December 15, 2025
Accepted July 5, 2026
Electronic access July 31, 2026

Hospital-acquired infections (HAIs), specifically Methicillin-resistant Staphylococcus aureus (MRSA) and Clostridioides difficile (C. difficile), are a major challenge in U.S. healthcare due to high death rates, financial strains, and antibiotic resistance. Despite prevention measures such as hand hygiene, environmental cleaning, and antibiotic stewardship, the challenge of HAIs continues. This study examines national trends in MRSA and C. difficile, compares infection patterns across hospital types and regions, and evaluates whether state reporting mandates correlate with changes in HAI rates. CDC data from 2013–2022 were used. Average MRSA and C. difficile cases per reporting hospital were calculated and compared across states, U.S. regions, and hospital types to identify possible patterns. Analysis included trend assessments, geographic mapping, and comparisons of state mandates and infection rates. Results showed that MRSA prevalence remained relatively stable over the 10-year period, while C. difficile rates declined across many states. Both infections showed similar geographic patterns, with higher rates in eastern states and lower rates in western/central states. Differences by hospital type were observed, but no association was found between state reporting mandates and infection trends. These findings suggest that regional healthcare practices and variations in policy implementation may cause differences in HAI rates among states. Continued efforts are needed to address persistent MRSA rates while sustaining progress in reducing C. difficile.

Keywords: nosocomial infections, hospital-acquired infections, rates, MRSA, C. difficile, practices/policies, state mandates, handwashing procedures.

Introduction

Hospital Acquired Infections

Hospital Acquired Infections (HAIs) are one of the largest challenges faced in healthcare today, as about 99,000 deaths in the U.S. are associated with them every year. Nosocomial Infections is another word used to describe HAIs. These are infections that are developed by patients in hospital settings through contact with other patients, healthcare workers, or surfaces that are infected. There are multiple types of infections including bacterial, fungal, viral, and multidrug resistant. These contribute to the most common cases of HAIs[1]. In the U.S., many measures have been taken in hopes of reducing HAIs, but they still pose a high threat. One study found that they are still quite prevalent and their high rates show that there is still much needed effort to reduce and control them[2]. Another major problem is that in not just the U.S., but many other countries, there is a large financial strain caused by high rates of HAIs[3]. According to the CDC there are an estimated 2.8 million cases of anti-microbial resistant infections in hospitals yearly. About 35,000 people out of the infected pass away from the infection[4]. Due to these high infection rates, financial strains, and mortality rates, nosocomial infections are thought to be one of the largest challenges in healthcare that needs to be overcome. They are also a problem because they put healthcare workers and hospital visitors at high risk[5]. MRSA and C. difficile are two predominant nosocomial infections in healthcare. They are both antimicrobial resistant infections and are the focus of this paper. The CDC is one database that tracks information on HAIs yearly and reports them online. Specifically, the CDC reports on MRSA and C. difficile.

MRSA

According to the CDC, MRSA (Methicillin-resistant Staphylococcus Aureus) is a type of staphylococcal bacteria that is resistant to multiple antibiotics. MRSA is considered to be a serious threat level antimicrobial resistant bacterium. It is most commonly associated with skin infections. Common symptoms of MRSA include skin that is red, swollen, painful, warm to touch, or full of pus. In addition, it is usually spread by direct contact with people who are infected. This includes the hands of healthcare workers and shared personal items like

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towels or razors. MRSA comes with many serious complications including but not limited to pneumonia, bloodstream and surgical site infections, sepsis, and even death if not properly treated. MRSA can affect anyone, but groups of people that are at a higher risk of getting infected include athletes, daycare students, military personnel in barracks, people who receive inpatient medical care, people with medical devices inserted in their body, and people who inject drugs. To diagnose if a person has MRSA, a healthcare provider sends in a clinical specimen to determine if MRSA is the cause of the infection. To treat MRSA, healthcare providers often prescribe antibiotics and in some cases surgery could be needed to drain the infected area[6]. MRSA is a very predominant and serious antibiotic-resistant infection, and it is important for research to be conducted in that area as it does not yet have many treatments with high accuracy rates. According to the CDC, MRSA has a high threat level as it had an estimated 323,700 cases in 2023, about 10,600 of which died from it. It also costs healthcare an estimated 1.7 billion dollars to keep controlled[7]. Although MRSA colonization is often asymptomatic and does not cause invasive disease, MRSA infection can become invasive and lead to serious complications like death. There have been multiple reports of fatality amongst healthy patients with MRSA[8]. MRSA should be considered important because there are cases of fatality caused by MRSA and many U.S. funds go towards MRSA yearly. This puts MRSA at a high level of importance when concerning hospital acquired infections. Part of the reason MRSA is a high threat is its resistance to many antibiotics. According to the CDC, MRSA is resistant to many commonly used antibiotics including Vancomycin-resistant MRSA, Daptomycin-resistant MRSA, Fluoroquinolone-resistant MRSA, and Linezolid-resistant MRSA[9]. This resistance develops through picking up resistance genes from other organisms. Antibiotic resistance also occurs during altered drug targets, enzymatic drug inactivation, and increased efflux of antimicrobial compounds[10]. These statistics show the extent to which MRSA can affect people because it causes resistance to many common antibiotics. This can cause many problems for people in need of these antibiotics for ongoing medical needs. MRSA resistance is important to study as it can tremendously affect the daily lives and medical intakes of patients.

C. difficile

According to the CDC, C. difficile (Clostridioides difficile) is a nosocomial infection that causes diarrhea and colitis, which is the inflammation of the colon. Symptoms of C. difficile include watery diarrhea, fever, appetite loss, nausea, and abdominal pain. C. difficile spreads through materials contaminated by feces, including commodes, bathtubs, and electronic rectal thermometers. Complications caused by C. difficile include dehydration and colitis at a common level, but in rare cases patients may experience serious intestinal conditions like toxic megacolon, sepsis, and even death. People who are taking an antibiotic, or are within 3 months after taking one, are 10 times more susceptible to getting C. difficile. Other groups at higher risk of C. difficile include people 65 and older, recent patients at a hospital or nursing home, people with a weakened immune system such as those with organ transplants, and previous patients who suffered from C. difficile. One of the main prevention techniques for spreading C. difficile is proper handwashing techniques[11]. Some other common current treatments for C. difficile are the use of medications like Fidaxomicin, Vancomycin, and Metronidazole. Another emerging treatment includes Biotherapeutics[12]. C. difficile is a commonly acquired infection that can inhibit the daily lives of patients and hinder the recovery process of patients healing from other diseases. It hinders the healing process as it is resistant to many antibiotics including vancomycin, metronidazole, moxifloxacin, and clindamycin. C. difficile cases have a higher rate of being resistant to moxifloxacin and clindamycin[12]. These are all common antibiotics that are used to treat various infections. This makes C. difficile important because it can emerge after antibiotic use and lead to severe illnesses in the colon. In addition, C. difficile is one of the most common HAIs and affects many patients. According to the CDC, C. difficile causes about half a million cases per year, out of which an estimated 29,300 people die[13]. C. difficile costs many hospitals tons of money yearly. One study showed that in a hospital that tested a new theory, CHG (chlorhexidine gluconate) wipes to reduce HAIs similar to C. difficile, a 32% decrease of HAIs saved that hospital about 815,000 dollars that year[14]. These statistics show that C. difficile is a high risk that affects healthcare through its high mortality rates and high cost rates. This makes C. difficile an important hospital acquired infection that needs to be addressed.

Current Precautions

Some of the current precautions in place to limit the spread of HAIs include handwashing techniques, hospital policies and practices implemented, and changes in the hospital's environment. According to the National Library of Medicine, one of the leading causes of higher spreading rates of hospital acquired infections is hand washing hygiene. It is said that healthcare workers only follow the recommended hand hygiene procedures 40% of the time[15]. By following specific guidelines when using ABHRs, hospital infection rates are affected positively as they decrease[16]. This can be shown in MRSA infection rates in hospitals. It is known that there is a direct correlation between the spread of MRSA in hospitals and usage of proper hand hygiene[17]. It does not just matter the amount of time healthcare workers perform hand hygiene, it is also the technique they use. Using a specific technique when performing hand hygiene is important in order to kill as much bacteria as possible[18]. When using hand sanitizers instead of hand washing, it is good to use hand sanitizers with Ethanol in order to kill viruses and hand sanitizers with propanol to kill bacteria[19]. There is a specific study that showed the results of using AGT-1, a type of sanitizer. This sanitizer was found to be able to kill both bacteria and viruses, which caused a reduction in HAIs in that hospital[20]. In addition to hand hygiene, one study found that there was a significant reduction in the spread of HAIs when using long-sleeved hospital gowns versus short-sleeved hospital gowns with a hand washing technique. When healthcare workers used short-sleeved gowns along with a specific hand washing technique, it was found that the spread of HAIs was reduced[21]. In addition to handwashing practices implemented, many other policies started in hopes of reducing HAIs. According to the CDC, there are 7 core elements in hospital antibiotic stewardship that affect the spread of HAIs. These elements include hospital leadership commitment, accountability, pharmacy expertise, action, tracking, reporting, and education. None of these 7 elements have a 100% performance rate in hospitals[22]. There is a direct correlation between higher implementation rates of antibiotic stewardship and reduced HAIs[23]. Alongside antibiotic stewardship, it is important for healthcare workers to be able to properly collaborate with each other. It was found that when professionals in hospitals collaborate to prevent transmissions, the spread of HAIs reduces[24]. The compliance of healthcare professionals with MRSA guidelines was found to be very poor. It is important for these healthcare workers to follow the guidelines because it is stated that more compliance with policies decreases the rates of HAIs like MRSA[25]. Different research implemented the usage of admission screening in both ICUs and non-ICUs. It was determined that the addition of admission screenings actually helped reduce the amount of MRSA in the hospitals[26]. When trying to reduce the amount of hospital acquired infections in a hospital, one important factor is the environment of the hospital. When a patient is diagnosed with C. difficile, it is crucial that they are placed in private rooms, and anyone who sees them should perform proper hand hygiene and washing of all surfaces touched afterwards[27]. A hospital's environment and hygiene has a large effect on the spread of MRSA. It was determined through an experiment that 35% of the samples taken from the surfaces of hospitals contained MRSA[28].

Types of Hospitals

There are many different types of hospitals that each have a different environment. Some of the most important types focused on in this paper include Acute Care Hospitals, Long-Term Acute Care Hospitals, Critical Access Hospitals, and Inpatient Rehabilitation Facilities. Acute Care Hospitals are considered the normal type of hospital that a person would go to in the event of an injury. Patients go to Acute Care hospitals for surgeries, acute illnesses, monitoring of medical devices, and more. An Acute Care hospital can be defined as the most time-sensitive and individually oriented type of hospital that takes curative actions to improve health. It is also said that in these types of hospitals, many sudden cases resulting in death can occur[29]. Long-term Acute Care hospitals are for patients that still have an illness that needs to be monitored with a high level of care, but they are in a stable enough position where they don't need to be kept in an intensive care unit[29]. Critical Access hospitals are small healthcare facilities located in rural areas and receive special federal designation in order to be maintained. A Critical Access hospital must meet certain criteria to be considered one officially. This includes being located in a rural area in a state that has a Flex Program, providing 24-hour emergency care, having no more than 25 inpatient beds, and maintaining an average patient stay of 96 hours or less[30]. An Inpatient Rehabilitation Facility is a hospital where patients go for intensive rehab if they are able to tolerate at least 3 hours of therapy a day. If the hospital is certified under Medicare or Medicaid, then it is exempt from the standard Hospital Prospective Payment System and will instead receive reimbursement through the IRF Prospective Payment System, which was implemented in 2002. These facilities are regularly checked to make sure they are complying with federal regulations and are using established protocols/guidelines to ensure quality care[31].

Mandate

Another step taken by the U.S. in hopes of reducing HAIs was the implementation of state-level reporting mandates. When nosocomial infections became too much of a burden in the U.S., some states were mandated to release a public report of these infections. These mandates are legal requirements that are established through state legislation or administrative regulations and require healthcare providers to report infections to state health departments. Rather than being uniform across the country, the reporting requirements vary by state in terms of which infections must be reported and under what circumstances. This new rule was put in place in hopes of reducing HAIs. To release a public report on HAIs means that whenever a case of an HAI is identified in the state, they are mandated to report this information to the state health department. Then, this information is released to the public yearly[32].

Scope of Paper

Objectives.

The objective of this paper is to analyze data about MRSA and C. difficile given by the CDC and compare the HAIs to see what commonalities and differences they may have. In addition, this paper will explore the patterns that are possibly present when looking at these two antibiotic-resistant infections. These patterns could then give insights into how to reduce overall HAI rates in the U.S.

Limitations.

This paper will mainly be limited to the study of MRSA and C. difficile. However, the findings in this paper can be applicable to many other types of HAIs. This limitation is due to the large scope of HAIs, making it easier to go deeper when focusing on two specific types. MRSA and C. difficile were chosen because they are both predominant HAIs seen in hospitals and are both specifically antibiotic-resistant infections, making them better for connections. This paper will also be limited to the scope of the U.S., although other countries may be mentioned in comparison. In addition, the CDC does not provide a data set on the year 2015 and does not give data sets after 2022, which further limits what patterns and changes may have occurred in the missing years. Many states also do not provide information or only give limited information. This restricts the scope that this paper can reach, as the information given by some states is scarce. The CDC only provides information on reporting hospitals, which is why the main metric of the paper is cases per reporting hospital. Information in this paper may be biased because there is no information on non-reporting hospitals.

Methods

In this research many databases were used, including PubMed and The National Library of Medicine. When searching through these databases, keywords used include nosocomial infections, hospital acquired infections, rates, MRSA, C. difficile, practices/policies, state mandates, and handwashing procedures. These keywords helped find lots of information on the topic of Hospital Acquired Infections. When looking for helpful articles, some things that were searched for were a setting in the U.S., articles about changes from the last decade, and articles that show how a new factor/policy changed HAI rates in hospitals. Then, information from the CDC was analyzed in order to find new insights on HAIs, specifically MRSA and C. difficile, over the years. The CDC has a report on HAIs for every year from 2013 to 2022. These reports can be found on their website under NHSN reports in a section named HAI Progress Reports. This study specifically used SIR data on Acute Care Hospitals from 2013–2022 and SIR data on Long-term Acute Care hospitals, Critical Access Hospitals, and Inpatient Rehabilitation Facilities from 2022. All files were downloaded in July of 2025. An analysis of these data sets helped find the effect of mandates, number of hospitals, and types of hospitals on HAIs. Alongside this, the reports gave insights into differences between the evolution of MRSA vs. C. difficile in hospitals. All of this data was derived from the CDC's information by compiling information from Excel charts to easily compare and create new charts/graphs that help show how HAIs are changing. Rates presented in this paper were found through specific calculations that took place in the Excel sheet. The formula used to find the average cases per reporting hospital, which is the main metric used in this paper, is the amount of observed cases per year in a state divided by the amount of reporting hospitals in the state. These two pieces of information are given by the CDC. Also using spreadsheets, most of the graphs found in the paper were made in Excel. In addition, data was extracted from the CDC's data on MRSA and C. difficile over the years and organized by different types of healthcare settings to make accurate comparisons that would reveal more about C. difficile and MRSA.

Results and Analysis

MRSA

A

	Top 10 highest cases	Amount of reporting hospitals	Top 10 lowest cases	Amount of reporting hospitals
	MRSA		**MRSA**	
1	D.C.	8	Wyoming	11
2	New York	170	Puerto Rico	8
3	Delaware	9	Kansas	62
4	West Virginia	28	Montana	12
5	New Jersey	71	Utah	38
6	Florida	221	Idaho	17
7	North Carolina	102	Wisconsin	86
8	Nevada	28	South Dakota	19
9	Georgia	111	Vermont	6
10	South Carolina	63	Nebraska	28

B

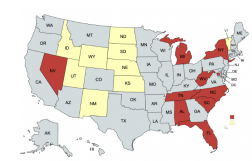

Figure. 1 These figures shows different aspects of MRSA rates in the U.S. over time. (A) The top 10 states highest in MRSA in 2022 and the top 10 states lowest in MRSA in 2022, along with the number of reporting hospitals in each state depicted. (B) Geographic location of the top 10 states highest in MRSA cases in 2022 (red) versus the geographic location of the top 10 states lowest in MRSA cases in 2022 (yellow), with the exception of Nevada and Vermont.

Overall Trends.

The overall trends for MRSA appear relatively stable over time (Supplementary Figure 1), but a very slight decline can be observed. Through linear regression, it was found that the trends over the last decade have a slope of -0.3896 (95% CI of -0.7568 to -0.02), which shows the gradual decrease of MRSA rates over the last decade. In addition, the p-value is 0.0405, which makes the slight change statistically significant. It is important to keep in mind that regional variation does exist. For example, D.C. (the darkest row) reduced from about 10.22 cases per reporting hospital in 2013 to about 5.5 cases per reporting hospital in 2022, a large reduction in comparison to the overall slight decline. Despite statistical significance, the relatively small magnitude of the slope suggests that the decline may not be substantial in practical terms.

Top Ten Highest vs. Lowest States.

The states with the top 10 highest cases per reporting hospital in 2022 and the top 10 states with the lowest cases per reporting hospital in 2022 (Figure 1A) are represented in a table. They are also mapped, with the 10 highest depicted in red and the 10 lowest in yellow (Figure 1B). When looking at the map, it can be seen that, with the exception of Nevada and Vermont, the states lower in MRSA are more concentrated in central/west America, while most of the states higher in MRSA are located in eastern America. It is important to keep in mind that Puerto Rico, while in the chart, is not depicted on the map. The number of reporting hospitals per state was included to show that this was not the reason for which states have higher or lower case counts.

C. difficile

A

	Top 10 highest cases in 2013	Top 10 highest cases in 2022
	C.diff	**C.diff**
1	D.C.	D.C
2	North Dakota	Massachusetts
3	Rhode Island	Maryland
4	Delaware	New York
5	New Mexico	Connecticut
6	Connecticut	West Virginia
7	Maryland	Missouri
8	North Carolina	New Jersey
9	Florida	Minnesota
10	Maine	Vermont

B

	Top 10 highest cases	Amount of reporting hospitals	Top 10 lowest cases	Amount of reporting hospitals
	C.diff		**C.diff**	
1	D.C.	8	Alaska	8
2	Massachusetts	69	Wyoming	11
3	Maryland	47	Puerto Rico	8
4	New york	170	Oklahoma	85
5	Connecticut	32	Mississippi	63
6	West Virginia	28	Louisiana	102
7	Missouri	75	Arkansas	50
8	New Jersey	71	Rhode Island	10
9	Minnesota	51	South Dakota	19
10	Vermont	6	Kansas	62

C

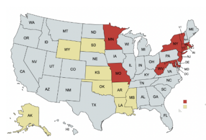

Figure. 2 These figures shows different aspects of C. difficile rates in the U.S. over time. (A) Chart showing the top 10 states highest in C. difficile in 2013 versus 2022. (B) The top 10 states highest in C. difficile in 2022 and the top 10 states lowest in C. difficile in 2022. (C) Geographic location of the top 10 states highest in C. difficile cases in 2022 (red) versus the top 10 states lowest in C. difficile cases in 2022 (yellow).

Overall Trends.

When viewing the overall trends of C. difficile, it can be seen that in most states C. difficile is usually decreasing (Supplementary Figure 2). This is with the exception of some states like Massachusetts, which increased from about 6.5 cases per reporting hospital in 2013 to about 20.6 cases per reporting hospital in 2022. Linear regression analysis shows that C. difficile trends over the last decade have a slope of -4.786 (95% CI of -7.237 to -2.33), which indicates a pronounced decrease over the last decade. In addition, the p-value is 0.0024, making the decrease in C. difficile statistically significant. In addition, the relatively high R^2 of 0.7528 shows that 75% of the variation in C. difficile rates is explained by the model.

In the top 10 states with the highest cases of C. difficile per reporting hospital in 2013 vs. 2022 (Figure 2A), it can be seen that D.C. stayed the highest throughout the years, but this does not mean there have not been changes. D.C.'s cases per reporting hospital drastically decreased since 2013, going from about 61.7 cases per reporting hospital to 29.25 cases per reporting hospital. Many of the other states seen as having high case counts in 2013 dropped largely enough that they were lower than Vermont in 2022. In 2022, Vermont had 15 cases per reporting hospital, meaning that the states now lower than Vermont dropped below 15 cases per reporting hospital.

Top Ten Highest vs. Lowest States.

The top 10 highest states in amount of C. difficile cases and the top 10 lowest states in amounts of C. difficile in 2022 are represented in a chart (Figure 2C). On the map, the 10 highest are depicted in red and the 10 lowest are in yellow (Figure 2D). When looking at the map, it can be seen that all the states with lower cases of C. difficile are in central to west America, while the states higher in C. difficile cases are located in east to central America. It can also be seen that Missouri, which has a high rate of C. difficile, is surrounded by states with low rates of C. difficile, which is quite interesting. While Puerto Rico is on the chart, it is not depicted on the map.

C. difficile vs. MRSA

Overall Trends.

Since MRSA and C. difficile are both common HAIs and are antibiotic resistant, we compared the cases across the U.S. to see if there were any differences or similarities in their prevalence. The graphs shown previously portrayed every state's amount of MRSA and C. difficile per hospital over the years of 2013 to 2022 (Figures 1A and 2B). These graphs show that overall, MRSA has stayed relatively the same over the years, but C. difficile has reduced, with some state reductions being much more significant than others. It can also be seen that the line representing D.C. is prominent and higher than the other states in both graphs.

Top Ten Lowest and Highest for MRSA vs. C. difficile.

A comparison of the top 10 highest and lowest states for MRSA to the top 10 highest and lowest states for C. difficile is depicted in a chart (Figure 3A). There are many patterns seen when comparing these two charts, including that D.C. is the highest in both infections and Wyoming is the lowest in MRSA and second-lowest in C. difficile. New York is also seen as the second-highest in MRSA and third-highest in C. difficile. Some interesting differences are that Vermont is the

	Top 10 highest cases				Top 10 lowest cases	
	MRSA	C.diff			MRSA	C.diff
1	D.C.	D.C.		1	Wyoming	Alaska
2	New York	Massachusetts		2	Puerto Rico	Wyoming
3	Delaware	Maryland		3	Kansas	Puerto Rico
4	West Virginia	New york		4	Montana	Oklahoma
5	New Jersey	Connecticut		5	Utah	Mississippi
6	Florida	West Virginia		6	Idaho	Louisiana
7	North Carolina	Missouri		7	Wisconsin	Arkansas
8	Nevada	New Jersey		8	South Dakota	Rhode Island
9	Georgia	Minnesota		9	Vermont	South Dakota
10	South Carolina	Vermont		10	Nebraska	Kansas

Highest reduction rates:	MRSA	C.diff
1	D.C	Rhode island
2	North Dakota	North Dakota
3	New Mexico	New Mexico
4	Nebraska	Delaware
5	Vermont	D.C
6	Delaware	Connecticut
7	Connecticut	Arkansas
8	Florida	North Carolina
9	Pennsylvania	Florida
10	Wisconsin	Maine

Figure. 3 These figures compare aspects of MRSA to aspects of C. difficile. (A) Chart comparing the top 10 states highest and lowest in MRSA in 2022 to the top 10 highest and lowest in C. difficile in 2022. (B) Specific graph comparison of the rates of C. difficile and MRSA in D.C. over the years 2013–2022. (C) Specific graph comparison of the rates of C. difficile and MRSA in Wyoming over the years 2013–2022. (D) Chart comparing the states that had the highest reduction of MRSA rates to C. difficile rates from 2013–2022.

10th highest state in C. difficile, but the 7th lowest state in MRSA.

A specific comparison of MRSA and C. difficile rates in D.C. from 2013 to 2022 can be viewed (Figure 3B). It can be seen that C. difficile decreased by a lot, but MRSA stayed the same throughout the years.

A specific comparison of MRSA and C. difficile rates in Wyoming from 2013 to 2022 can be viewed (Figure 3C). This graph is on a different scale than the D.C. graph because Wyoming's rates are much lower. Throughout the years, it can be seen that C. difficile cases fluctuated, showing changes, but MRSA cases stayed about the same.

MRSA vs. C. difficile Reduction Rates.

The states are ordered by their reduction rate from highest to lowest from 2013–2022 in a chart (Figure 3D). It shows the top 10 states for both MRSA and C. difficile in reduction over the years. The chart is color coded to show similar states for both infections. This includes states like D.C., North Dakota, New Mexico, Delaware, Connecticut, and Florida, which have high rates of reduction in both diseases.

Mandates

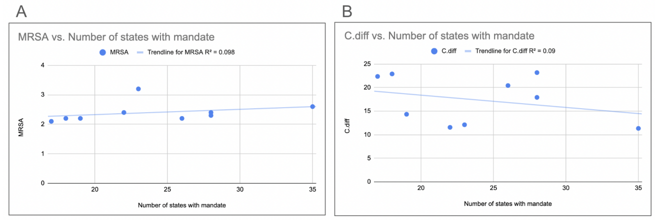

Figure. 4 These figures compares the average cases of an infection over the years to the number of hospitals mandated to give information that year. (A) MRSA rates. (B) C. difficile rates.

MRSA.

To investigate whether implementing a mandate would affect the amount of HAIs, we compared data on the presence of mandates to the rates of HAIs. The number of states per year that had a mandate on hospital reporting of MRSA can be viewed in the first graph (Figure 4A). When visually inspecting the data, it can be seen that there is no clear relationship between the number of mandates and the MRSA rates. This is directly supported by linear regression analysis, which shows a very small positive slope of 0.018 (95% CI of −0.0308 to 0.0668) that is not statistically significant because the p-value is 0.4119. In addition, this graph had an R^2 of 0.098, meaning only 9.8% of the variance is due to mandates. When there are fewer mandates, sometimes the case counts are higher and other times they are lower. An example of this is 2021 and 2019: in 2021, 18 states were mandated to release MRSA data, and in 2018, 19 states were mandated to release MRSA data. However, when looking at the average number of cases per reporting hospital yearly, 2019 had fewer cases per reporting hospital compared to the average, while 2021 had more cases per reporting hospital compared to the average. This shows that there is visually no relationship between mandates and case counts.

C. difficile.

The number of states per year that were mandated to report their information on C. difficile can be viewed in the second graph (Figure 4B). These numbers are similar to those for MRSA, but there are acute differences, with C. difficile having more reporting hospitals in some years. Also, the average cases per reporting hospital for C. difficile yearly can be seen in the graph. When comparing the information on average cases per year and the presence of mandates, there is visually no relation once again seen between the two. While C. difficile is on a gradual, steady decrease, the mandates fluctuate throughout the years, showing that whether the mandates were there or not, it did not affect the amount of C. difficile cases. This is supported by linear regression analysis, which shows a very small negative slope of -0.2607 (95% CI of -1.003 to 0.4813) that is not statistically significant because the p-value is 0.4334. In addition, this graph had an R^2 value of 0.09, meaning only 9% of any variance would be due to the presence of mandates.

Other Hospital Types

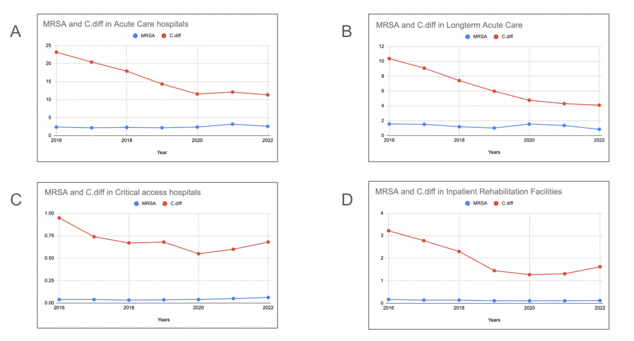

Figure. 5 These figures show the average rates of MRSA (blue) and C. difficile (red) from 2016–2022 in various healthcare settings: (A) Acute Care hospitals, (B) Long-term Acute Care hospitals, (C) Critical Access hospitals, (D) Inpatient Rehabilitation Facilities.

In order to find more insights into what may cause higher rates of HAIs, we compared MRSA and C. difficile in different environments. Trends in MRSA and C. difficile over the years in different types of hospitals can be viewed (Figures 5A–5D). The trends show that all types of hospitals seem to have been reducing C. difficile cases. In Critical Access hospitals (Figure 5C) and Inpatient Rehabilitation Facilities (Figure 5D), the end of the graphs shows that recently these have started to increase in C. difficile cases. However, Long-term Acute Care hospitals are still reducing in C. difficile cases. Long-term Acute Care hospitals also had the highest rates of MRSA, while Critical Access and Inpatient Rehabilitation both had around less than one case per reporting hospital on average. It is important to keep in mind that each of these graphs is on a different scale, showing how drastic the difference between each actually is. The data shown here is from 4 different hospital types across all 50 states, which leads to large variability between data sets. Therefore, direct comparisons between hospital types is impossible, so only overall trends are visually analyzed.

Discussion

MRSA

The data provided on MRSA reveals information on geographical and numerical patterns. MRSA in general has always had lower infection rates when compared to other hospital acquired infections, but most reporting hospitals still have at least 1 case per year. The overall trend of MRSA, which can be seen as a very slight reduction over the last decade, shows that there has possibly not been much new development in that field of research. This is with the exception of Washington D.C., which was able to reduce cases by a total of about 5 per reporting hospital over the years 2013–2022. Although D.C. had a significant reduction, when viewing its cases per reporting hospital throughout the years, there is not one year where the rates immediately dropped. The rates fluctuated throughout the years, showing there was no singular development that helped reduce MRSA rates. Although the general amount of MRSA seems lower, MRSA management in hospitals can be challenging if it breaks out. In the case of MRSA, it is important to identify it in a timely manner in order to implement the appropriate treatment. One further development that could help in early identification is molecular and immunochromatographic tests, which could dramatically lessen the amount of days it takes to identify MRSA[33]. Some possible policies that should be enacted in order to help reduce MRSA rates include: screening of healthcare workers for dangerous pathogens, setting up a surveillance system for healthcare workers to identify possible pathogens like MRSA these workers may acquire in hospitals, establishment of a plan for economic safety for workers who are infected by pathogens, evaluating the effectiveness of policies and practices placed to prevent the spread of pathogens like MRSA, and further research in the field of MRSA[34].

There are also geographical patterns present when comparing states with high MRSA rates to states with low MRSA rates. The color-coded map depicts that most states lower in MRSA (with the exception of Nevada and Vermont) are located in the west/central U.S. The states with higher rates of MRSA are located in the eastern U.S. This regional clustering shows that there may be differences in healthcare practices/protocols and economic situations between regions. These differences could be what is impacting MRSA rates. One of these differences could be the varying integrity in the application of important policies in hospitals throughout the U.S. Some hospitals give excuses to cover up their poor adherence to healthcare guidelines. This is a primary cause of how some hospitals may have higher cases than others[35]. There is also additional evidence that even small breaks in basic infection control practices, especially hand hygiene, can lead to higher MRSA transmission and added healthcare costs. A study on hand hygiene noncompliance found that small failures in following these guidelines were directly linked to increased MRSA infections[36].

C. difficile

The data provided on C. difficile reveals both numerical and geographical patterns in the information. Generally, C. difficile's overall pattern shows a large reduction in most states. This pattern has exceptions in some states, like Massachusetts, which rose in numbers throughout the years. However, the larger number of states that follow the pattern of decrease provides evidence that there may have been significant developments in the field of research on C. difficile that led to this reduction. Although no definitive conclusions can be drawn regarding causation, a recent significant development in C. difficile treatment is the implementation of fecal microbiota transplantation (FMT). It was found that FMTs are highly effective in reducing rates of C. difficile. There are still many challenges in the safety and standardization of them, but they are one significant start toward reducing C. difficile rates[37]. This study does not directly measure the impact of FMTs on C. difficile rates, meaning FMTs should be treated as a possible contributor rather than a confirmed cause.

There are also geographical patterns present when comparing states with high C. difficile rates to states with low C. difficile rates. The states lower in C. difficile are located in central/west America, while the states higher in C. difficile are located in central/east America. Regional differences in healthcare practices/policies and economic conditions may be the reason for this large geographic difference in C. difficile rates. One significant difference between hospitals is that the organizations that assess hospital protocols affect how hospitals implement these protocols. Research from Canada shows that some hospitals use the Public Health Agency of Canada (PHAC), while others use the Canadian Agency for Drugs and Technologies in Health (CADTH), which causes differences in the implementation of healthcare guidelines[38]. This idea can also be applied to the U.S., considering there are multiple agencies including the U.S. Department of Health and Human Services (HHS), the Centers for Medicare & Medicaid Services (CMS), the Health Resources and Services Administration (HRSA), the Department of Veterans Affairs (VA), and more. These contrasts in agencies do not just affect C. difficile, but can affect all types of HAI case numbers and regulation.

MRSA vs. C. difficile

When comparing the overall patterns of MRSA and C. difficile, it can be seen that MRSA has shown relatively little change over time, while C. difficile has reduced largely over the years. This provides further evidence of possible differences in the amount of development between MRSA and C. difficile research, but it cannot be fully confirmed without further analysis of interventions and treatment changes. Although MRSA and C. difficile have differing overall patterns, they have similar geographical patterns. This includes the prominent feature of D.C. being the highest in both MRSA and C. difficile. This could mean that D.C. may have higher rates because of different healthcare policies/practices or a different economic status. Additionally, in both maps showcasing where states higher and lower in MRSA or C. difficile are located, the states with higher rates are generally located in the east and the states with lower rates are generally located in the west/central U.S. Possible explanations for the observed regional differences include population density, economic differences, hospital mix, patient case mix, and severity of illness. One study found that the west coast uses hospitals 40% less than the east coast, attributing this difference partly to population density and partly to different characteristics of the healthcare system. When looking closely at differences between New York and Los Angeles, it was seen that New York had a large backlog of patients waiting to be placed in long-term healthcare facilities. This is believed to possibly be because New York has more medical specialists and advanced supplies, causing more people to go to hospitals. However, having more specialists and more people going to hospitals does not necessarily mean better outcomes, and this example is not directly linked to the MRSA or C. difficile rates measured in this study[39]. Future research could focus on finding more explanations for these regional differences by using census data to examine how population density may affect case counts on the east versus west coast.

Mandates

When looking at the data on state mandates compared to C. difficile and MRSA rates, both show that there is no correlation present. According to one source, these mandates were implemented in hopes of reducing the amount of HAIs in the U.S., as they were becoming a high burden[40]. Another study had similar results to those discovered when looking at the CDC data. In this study, the prevalence of MRSA in Chicago, Illinois was examined when there was a mandate versus when there was not. They found similar results, with no pattern between an increase or decrease in cases and the presence of a mandate[41]. These results show that although many may have thought that putting in place or removing a mandate would change the number of cases, there seems to be no correlation or change.

Different Types of Hospitals

When looking at the data on how C. difficile and MRSA rates change in different healthcare settings, it can be seen that they are all on different scales. This means that while some graphs go up by tens, another may only go up by ones. This contrast in scaling shows how drastic the difference in rates is. Specifically, Acute Care Hospitals can be seen to have the highest rates out of the four types investigated. One study tested the prevalence of nosocomial infections in Acute Care hospitals and found a higher infection rate of 10.1% prevalence. This large infection rate is most probably due to Acute Care hospitals' large size and unfavorable mix of patients[42].

Data Availability

MRSA vs C.difficile cleaned

MRSA vs. C. difficile cleaned data and Supplementary Figures 1 and 2 can be found in the Google Sheets file referenced below. Raw CDC data was found in the NHSN reports section labeled HAI Progress Reports. Specifically, only SIR data was used.

Conclusion

It is important to remember that this study also came with limitations. CDC infection data only extends to 2022, meaning recent changes cannot be fully evaluated. In addition, only reporting hospitals were included, so trends may differ due to a lack of data from additional non-reporting hospitals. Despite these restrictions, the CDC dataset still provides one of the most reliable and complete views of national HAI patterns, and it helps form an understanding of how infections like MRSA and C. difficile differ across states and hospital systems.

This study highlighted several important patterns in MRSA and C. difficile infections across the United States. Using CDC data, which provided standardized national reporting from a wide range of hospitals, it was possible to compare states, regions, hospital types, and long-term trends in HAIs from 2013–2022. These findings show that while C. difficile infections have decreased in most states, MRSA has remained relatively steady, with only a few areas showing noticeable improvement. The repeated pattern of higher infection rates in eastern states and lower rates in western/central states suggests that regional differences in healthcare practices, resources, and economic conditions may play an important role. Differences in how hospitals actually follow infection-control policies also appear to influence these infection rates.

Although progress has been made, especially with approaches like fecal microbiota transplantation for C. difficile, there is still room for development in both fields. MRSA would benefit from stronger screening programs, more consistent policy enforcement, and improved early-identification methods. For C. difficile, more research into the long-term safety and standardization of treatments such as FMTs could help support the continued decline in infection rates. Future research should also explore explanations for why geographical patterns exist, because understanding these regional differences could help states adopt more effective practices used in lower-rate areas. Additionally, since this study found no connection between mandates and infection rates, efforts spent trying to find a use for mandates can instead be better spent focusing on ways to ensure policies are actually implemented. Overall, these findings suggest that continued research, stronger adherence to infection-control practices, and attention to regional differences could help reduce MRSA and C. difficile infections in the future.

Acknowledgements

I would like to thank Rachel Erickson for her mentorship and guidance during the writing of this paper.

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Supplementary information

The online version contains supplementary material available at https://nhsjs.com/?p=47085

