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Original Article

The impact of autocancellation of uncollected *Clostridioides difficile* specimens after 24 hours on reported healthcare-associated infections: A quality improvement intervention

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Abstract

Objective: To assess the impact of a 24-hour autocancellation of uncollected *Clostridioides difficile* samples in reducing reported healthcare-associated infections (HAIs).

Design: Quality-improvement, before-and-after implementation study.

Setting: The study was conducted in 17 hospitals in Pennsylvania.

Interventions: *Clostridioides difficile* tests that are not collected within 24 hours are automatically canceled ("autocancel") through the electronic health record. The intervention took place at 2 facilities (intervention period November 2021–July 2022) and subsequently at 15 additional facilities (April 2022–July 2022). Quality measures included percentage of orders canceled, *C. difficile* HAI rate, percent positivity of completed tests, and potential adverse outcomes of canceled or delayed testing.

Results: Of 6,101 orders, 1,090 (17.9%) were automatically canceled after not being collected for 24 hours during the intervention periods. The reported *C. difficile* HAI rates per 10,000 patient days did not significantly change. These rates were 8.07 in the 6-month preintervention period and 8.77 in the intervention period for facilities A and B combined (incidence rate ratio [IRR], 1.09; 95% CI, 0.88–1.34; $P = .43$), and were 5.23 HAIs per 10,000 patient days in the 6-month preintervention period and 5.33 in the intervention period for facilities C–Q combined (IRR, 1.02; 95% CI, 0.79–1.32; $P = .87$). From the preintervention to the intervention periods, the percent positivity rates of completed *C. difficile* tests increased by 1.1% for facilities A and B and by 1.4% for facilities C–Q. No adverse outcomes were observed.

Conclusions: The 24-hour autocancellation of uncollected *C. difficile* orders reduced testing but did not result in reported HAI reduction.

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Clostridioides difficile is a priority healthcare-associated pathogen, but testing for *C. difficile* poorly distinguishes colonized patients from those with an active infection.[1] As many as 4%–15% of hospitalized patients may be asymptomatically colonized with *C. difficile*, and it is estimated that *C. difficile* colonization is 5–10 times more common than symptomatic *C. difficile* colitis.[2] Any positive *C. difficile* test that is collected on hospital day three or later, whether the test result correlates clinically with colonization or infection, is reported to the Centers for Disease Control and Prevention National Healthcare Safety Network (NHSN) as a healthcare-associated infection (HAI).[3] Overestimating disease due to *C. difficile* HAIs adversely affects a facility's ability to provide care, primarily through financial penalties and reputational scores.[4] Furthermore, overdiagnosis of *C. difficile* infection (CDI) can result in the clinically nonindicated treatment of colonized patients with *C. difficile*-effective antimicrobials, which can lead to increased risk for developing a symptomatic CDI, promotion of multidrug-resistant organisms through inappropriate use of antibiotics, increased healthcare costs and length of stay, and altered diversity of the patient microbiome.[2,5,6] Diagnostic stewardship of *C. difficile* testing is therefore important in preventing poor patient outcomes and reducing reported HAIs.

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The electronic health record (EHR) can facilitate diagnostic stewardship via "soft stops" that provide guidance on testing but do not prevent ordering, such as alerts, or "hard stops" that prevent ordering if predetermined criteria are not met, such as automated cancellation of orders.[2] Various studies have shown soft stops in the form of alerts to be effective in decreasing *C. difficile* testing, with some having an effect on CDI rates, but "alert fatigue" can be an unintended consequence.[7] Studies with "hard stops" more often find success in decreasing clinically nonindicated testing than those that employed "soft stops."[2] In this quality improvement study, we implemented a "hard stop" CDI diagnostic stewardship intervention, an automated cancellation of the EHR order after *C. difficile* stool specimens remained uncollected for 24 hours. This intervention was designed to prevent testing on patients who do not have symptomatic CDI. By reducing testing, this intervention could reduce laboratory costs, prevent unnecessary treatment for *C. difficile*, and decrease reported HAIs for patients who are asymptomatically colonized with *C. difficile*.

Methods

Study setting

University of Pittsburgh Medical Center (UPMC) is an integrated healthcare delivery and finance system that provides care ranging from rural communities to urban academic quaternary care. In total, 17 hospitals (facilities A–Q) implemented the intervention and self-selected for participation. These 17 facilities had a median number of 195 inpatient beds (range, 20–758 beds). This study underwent formal review and was granted approval as a quality improvement project by the UPMC Quality Improvement Review Committee (project no. 3817).

C. difficile test-ordering criteria included at least 3 loose stools (not explained by laxatives, tube feeds, enemas, or bowel preparation) in a 24-hour period and at least 1 other indication for testing: antibiotic exposure within the last 60 days, fever >38°C, abdominal tenderness, cramping, or distention, peripheral blood total white blood cell count >10,000 cells/μL within 24 hours of unformed stools, recent chemotherapy or immunosuppression, or history of CDI. *C. difficile* testing was performed at all study facilities using a 2-step testing algorithm. This 2-step test included an enzyme immunoassay to detect glutamate dehydrogenase and the *C. difficile* toxin (TECHLAB, Blacksburg, VA) followed by polymerase chain reaction for toxin gene (Cepheid, Sunnyvale, CA) in case of a discordant result.[8–11] *C. difficile* tests were only performed on stool that conformed to the shape of the sample container.

Study intervention

The intervention was an automated cancelation of *C. difficile* orders that had not been documented as collected within 24 hours of order ("autocancel"), implemented within the EHR. Practitioners did not receive an alert that the order was canceled; however, prescribers and inpatient nursing teams were educated about the intervention before implementation through announcements and emails from physician and nursing leadership describing the intervention.

After a hospital-initiated pilot at 2 hospitals (facilities A and B) beginning October 27, 2021, the intervention was offered to all health-system hospitals, with voluntary adoption by participating hospitals on March 30, 2022. The preintervention period was defined as the 6 calendar months preceding implementation (May 1, 2021, through October 31, 2021, for facilities A and B, and October 1, 2021, through March 31, 2022, for facilities C–Q). The intervention period included observations through July 31, 2022, including 9 months for facilities A and B (November 1, 2021–July 31, 2022) and 4 months for facilities C–Q (April 1, 2022–July 31, 2022).

Outcomes and data sources

Data collected from the EHR included ordering, nursing, and laboratory data as well as ordering unit, patient name, medical record number, admit date, order date, *C. difficile* test result (if order was completed), and whether the order was canceled by a practitioner, rejected by the laboratory, or autocanceled. Microsoft Excel software (Microsoft, Redmond, WA) was used for data collection.

The primary outcome of the study was the rate of reported *C. difficile* HAI.[3] Outcome data were obtained from organizational NHSN reporting. The secondary outcome was percent positivity of *C. difficile* testing, calculated before and after the intervention. Additional outcomes included *C. difficile* ordering rate and completed test rate.

The EHR for patients who had an autocanceled *C. difficile* testing order was reviewed 30 days after the order was placed to assess for patient harm (CDI-related intensive care unit admission, surgical intervention, or death) due to a delay in diagnosis or potential missed diagnosis of CDI. We summarized the number of autocanceled orders that had a test reordered within 30 days from initial order date and the result of the repeated testing. Diagnoses of CDI after having an autocanceled order—with or without a subsequent positive test—and whether they were started on treatment were documented.

For patients with autocanceled orders that did not have a test reordered, chart reviews were performed to document the reason for *C. difficile* testing as no longer indicated. The primary reason for not having a test reordered based on provider documentation specific to the patient's *C. difficile* testing order or diarrheal state were categorized by the local infection preventionist at each facility in the following mutually exclusive categories: the patient had alternative diagnosis as a cause of diarrhea, the patient was receiving medical therapy for constipation, the patient was receiving enteral nutrition at the time of testing, the patient's diarrhea resolved, the patient was discharged within the 24-hour period after the order before the sample was collected, the patient had a recent positive or negative *C. difficile* test within a few days of the autocanceled order, the patient received treatment for *C. difficile* without testing, or other reason.

Statistical methods

The number of autocanceled orders, orders canceled by practitioner, orders rejected by the laboratory, and completed orders were counted in aggregate and by facility. Percentages were calculated in each of these categories as a percentage of total orders.

To test the hypothesis that the autocancel intervention would reduce the reported *C. difficile* HAI rate, we compared the rate of *C. difficile* HAIs in the preintervention period to the intervention period in aggregate and separately by facility by calculating an incidence rate ratio (IRR, HAIs per 10,000 patient days of admission). Because this was a quality-improvement intervention, sample sizes were not calculated, and execution of the intervention was a continuous assessment with a planned complete analysis as part of the quality-improvement timeline occurring after 4 months

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of implementation. The percent positivity of testing was summarized in the preintervention and intervention periods. For test of proportions (reported HAI and percent positivity outcomes), 2-sided *P* values were calculated using median unbiased estimation and a standard normal distribution. *C. difficile* test-order rate and completed test rate were calculated as an IRR per 10,0000 patient days and were summarized for the preintervention and intervention periods.

We counted 30-day retesting outcomes for autocanceled orders, as well as reasons autocanceled orders did not have a test reordered in aggregate and by facility in the preintervention and intervention periods. Descriptive analyses were performed to assess reasons that *C. difficile* autocanceled test orders did not have a test reordered.

Statistical calculations were performed using STATA version 16.1 software (StataCorp, College Station, TX).

Results

During the intervention periods, 6,101 orders were placed for *C. difficile* at facilities A–Q. Of 6,101 orders, 1, 090 (17.9%) orders were automatically canceled after not being collected for 24 hours (Table 1). The percentage of orders autocanceled due to the intervention at individual facilities ranged from 8.6% to 41.7%, with a median of 22.5% (Supplementary Table S1 online).

Outcomes

The reported *C. difficile* HAI rate per 10,000 patient days did not significantly change. The rates were 8.07 in the preintervention period and 8.77 HAI per 10,000 patient days in the intervention period for facilities A and B combined (IRR, 1.09; 95% CI, 0.88–1.34; $P = .43$). The rates were and 5.23 in the preintervention period and 5.33 HAI per 10,000 patient days in the intervention period for facilities C–Q combined (IRR, 1.02; 95% CI, 0.79–1.32; $P = .87$) (Fig. 1). The reported *C. difficile* HAI counts, patient days, and rates by facility in the preintervention and intervention periods are summarized in Table 2.

In the preintervention period, 3,099 orders were placed at facilities A and B, with 1,754 (56.6%) negative results, 283 (9.1%) positive results, and 1,062 (34.3%) not collected. For facilities C–Q, 3,726 orders were placed in the preintervention period, with 1,869 (50.2%) negative results, 400 (10.7%) positive results, and 1,457 (39.1%) not collected. Of the 2,037 completed orders (positive or negative results) at facilities A and B, 283 (13.9%) were positive in the preintervention period; in the postintervention period, percent positivity increased by 1.1%, with 338 (15.0%) of 2,253 completed orders had positive results (95% CI, −1.0 to 3.2; $P = .30$). For facilities C–Q, the percent positivity increased by 1.4% from 17.6% (400 of 2,269) of completed orders with positive results in the preintervention period to 19.0% (235 of 1,236) in the intervention period (95% CI, −1.3 to 4.1; $P = .31$) (Table 1). Data regarding *C. difficile* test orders, HAI, and percent positivity stratified by facility are available in Supplementary Tables S1–S4 (online).

For facilities A and B, the *C. difficile* order rate per 10,000 patient days decreased from 164.5 in the preintervention period to 159.9 in the intervention period. For facilities C–Q, this order rate decreased from 118.1 per 10,000 patient days in the preintervention to 107.5 in the intervention period (Supplementary Table S5 online). For facilities A and B, the *C. difficile* completed test rate per 10,000 patient days decreased from 108.1 in the preintervention period to 88.2 in the intervention period. For facilities C–Q, *C. difficile* completed test rate decreased from 71.9 per 10,000 patient days in the preintervention period to 65.9 in the intervention period (Supplementary Table S6 online).

Table 1. *Clostridioides difficile* Order Metrics During Implementation of a 24-Hour Electronic Health Record Autocancellation for Uncollected Specimens

Metric	Frequency, No. (%)[a]	
Order outcome (N=6,101)		
Autocanceled	1,090	(17.9)
Provider canceled	1,433	(23.5)
Rejected by lab	89	(1.5)
Completed	3,489	(57.2)
Percent positivity		
Facilities A and B[b]		
Preintervention (May 1, 2021–October 31, 2021)	283 of 2,037	(13.9)
Intervention (November 1, 2021–July 31, 2022)	338 of 2,253	(15.0)
Change in positivity (95% CI)		1.1% (−1.0 to 3.2)
P value		.30
Facilities C–Q[c]		
Preintervention (October 1, 2021–March 31, 2022)	400 of 2,269	(17.6)
Intervention (April 1, 2022–July 31, 2022)	235 of 1,236	(19.0)
Change in positivity (95% CI)		1.4% (−1.3 to 4.1)
P value		.31
30-day retesting outcomes following canceled orders (N=1,090)		
Retested positive	43	(3.9)
Reordered, not collected	70	(6.4)
Retested negative	204	(18.7)
Not retested	697	(63.9)
Duplicate order	76	(7.0)
Reasons autocanceled orders were not retested (N=697)		
Alternative diagnosis	113	(16.2)
Diarrhea resolved/improved	490	(70.3)
Discharged before collection	22	(3.2)
Laxative use	10	(1.4)
On tube feeds	9	(1.3)
Other	29	(4.2)
Recent *C. diff* test	13	(1.9)
Treated without collection	11	(1.6)

Note: CI, confidence interval.
[a]No. (%) unless otherwise indicated.
[b]The intervention period for facilities A and B was November 1, 2021–July 31, 2022.
[c]The intervention period for facilities C–Q was April 1, 2022–July 31, 2022.

Quality improvement measures

In total, 697 patients (63.9%) were not retested within 30 days; 204 patients (18.7%) were retested and were negative, 70 patients (6.4%) had a test reordered that was not collected, and 76 patients (7.0%) had duplicate tests (ie, autocanceled orders placed at the same time as a test that either resulted positive or negative, was not

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Table 2. *Clostridioides difficile* Reported Healthcare-Associated Infections (HAIs) Before and During Implementation of a 24-Hour Order Autocancellation

	Preintervention May 1, 2021–October 31, 2021			Intervention November 1, 2021–July 31, 2022			IRR	95% CI	*P* Value
Facility	HAIs	Patient Days	Rate per 10,000 PD	HAIs	Patient Days	Rate per 10,000 PD			
A	82	114,578	7.16	125	153,575	8.14	1.14	(0.85–1.52)	.37
B	70	73,812	9.48	99	101,855	9.72	1.02	(0.75–1.41)	.88
Total	152	188,390	8.07	224	255,430	8.77	1.09	(0.88–1.34)	.43
	Preintervention October 1, 2021–March 31, 2022			Intervention April 1, 2022–July 31, 2022			IRR	95% CI	*P* Value
Facility	HAIs	Patient Days	Rate per 10,000 PD	HAIs	Patient Days	Rate per 10,000 PD			
C	28	43,854	6.38	19	28,183	6.74	1.06	(0.56–1.96)	.85
D	31	49,523	6.26	17	28,155	6.04	0.96	(0.50–1.80)	.92
E	19	23,175	8.20	15	14,866	10.09	1.23	(0.58–2.56)	.55
F	16	26,907	5.95	11	14,117	7.79	1.31	(0.55–3.01)	.49
G	9	32,609	2.76	8	20,578	3.89	1.41	(0.47–4.11)	.49
H	11	18,882	5.83	10	12,904	7.75	1.33	(0.51–3.45)	.52
I	12	32,916	3.65	6	20,369	2.95	0.81	(0.25–2.33)	.69
J	15	13,080	11.47	6	8,111	7.40	0.65	(0.21–1.76)	.37
K	4	4,037	9.91	1	1,810	5.52	0.56	(0.01–5.63)	.67
L	13	17,802	7.30	4	8,351	4.79	0.66	(0.16–2.12)	.48
M	3	7,352	4.08	2	4,188	4.78	1.17	(0.10–10.22)	.85
N	2	4,760	4.20	1	2,547	3.93	0.93	(0.02–17.95)	1.00
O	0	2,332	0.00	0	977	0.00	. . .	. . .	. . .
P	2	2,300	8.70	0	1,143	0.00	0.00	(0–10.71)	.45
Q	0	36,089	0.00	0	21,258	0.00	. . .	. . .	. . .
Total	165	315,618	5.23	100	187,557	5.33	1.02	(0.79–1.32)	.87

Note. CI, confidence interval; IRR, incidence rate ratio; PD, patient days.

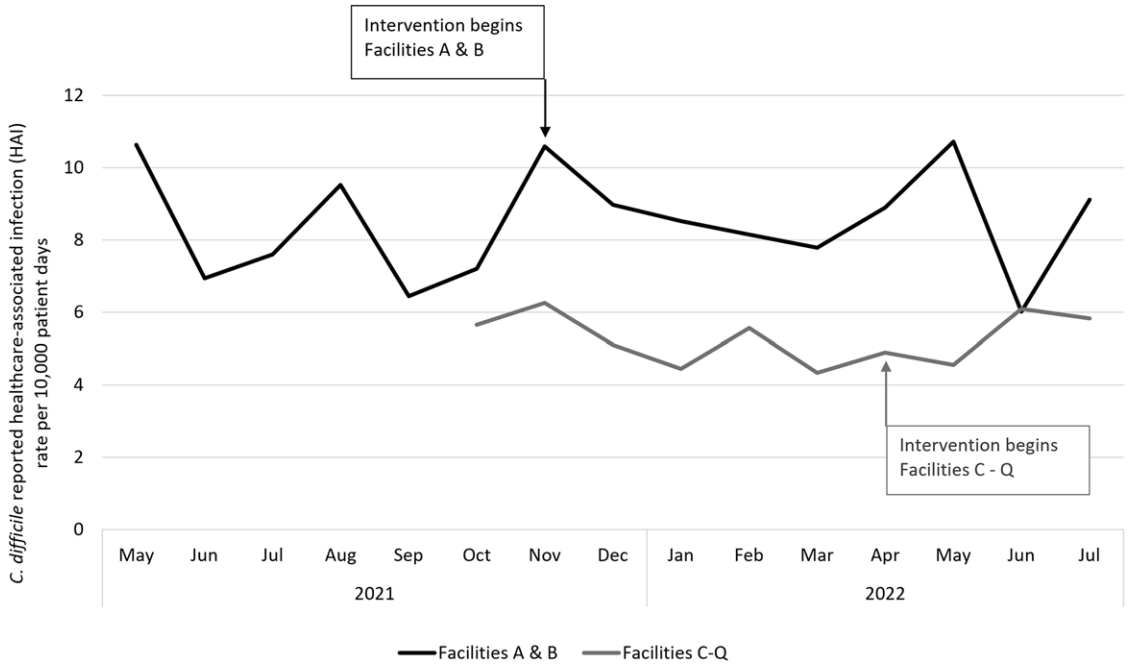

Figure 1. *Clostridioides difficile* reported healthcare-associated infection rate per 10,000 patient days, University of Pittsburgh Medical Center facilities, 2021–2022.

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collected, or was autocanceled) (Table 1). Supplementary Figure S1 (online) shows the timing of retesting; 166 of 247 retests occurred within 3 days of the autocanceled order. Only 43 patients (3.9%) with a reordered test had a collected specimen that resulted positive. Of the 43 patients with a positive test, 8 had asymptomatic colonization and might have been tested despite not meeting ordering criteria or had resolving symptoms after being tested. In the remaining 35 infections, 13 patients had resolution of loose stools between tests. No adverse outcomes were observed in the remaining 22 patients. Of these 22 cases of true infections, 20 patients were started on treatment. One patient was discharged, and another patient died before the test result came back positive, and the cause of death was not likely related to *C. difficile*.

Of the 697 autocanceled orders for which a test was not reordered, the most common reason was resolution of the patient's diarrhea (n = 490, 70.3%); 11 patients (1.6%) were treated empirically (Table 1). One patient was started on *C. difficile* treatment 4 days after an autocanceled order without a positive retest. We did not observe any potential undiagnosed cases of *C. difficile* due to the order being autocanceled.

Data on autocanceled orders stratified by facility are available in Supplementary Tables S7 and S8 (online).

Discussion

We implemented a 24-hour autocancellation of uncollected *C. difficile* specimens as a diagnostic stewardship intervention that reduced testing for *C. difficile*; 18% of orders were autocanceled during the intervention period but reported HAI rates were not affected. Percent positivity of completed tests did not significantly change. The ordering and testing rates decreased, and very few autocanceled orders (4%) had a subsequent positive test within 30 days. In 70% of patients for whom an order was autocanceled, diarrhea improved or resolved without *C. difficile* treatment. We did not identify any adverse outcomes, such as CDI-related intensive care unit admission, surgical intervention, or death, as a result of the intervention. This "hard stop" diagnostic stewardship EHR intervention reduced orders without measurable harm but did not decrease reported *C. difficile* HAI rates.

Karlovich et al[12] studied canceling uncollected *C. difficile* orders after 24 hours as part of a diagnostic stewardship bundle intervention. They observed a decrease in testing when implemented alongside other interventions yet detected increases in their reported *C. difficile* HAI rate after implementation of the autocancel rule.[12] Yen et al[13] also implemented a 24-hour autocancel rule and found a reduction in both testing and reported CDI rates. However, in this study, the rule was coupled with other diagnostic stewardship interventions and was implemented at only 1 facility.[13] Although individual facilities may have had other CDI reduction initiatives underway during this intervention, this is the first study, to our knowledge, in which an order-autocancel rule was implemented in isolation and at multiple facilities.

We may have not seen reductions in reported *C. difficile* HAI rates due to multiple reasons. In post hoc analyses, we identified 431 autocanceled orders (61.8%) placed on hospital day 1 or 2. If these samples had been collected on those days and with a positive result, they would not have been reported as HAIs. The intervention could have preferentially canceled orders that would have had a negative result if they had been collected; however, no significant change in the percent positivity suggests that canceled orders were a mix of samples that would have had positive and negative results. Additionally, analyses conducted when considering this quality improvement intervention revealed that 10.7% of patients who had a stool specimen collected after 24 hours had positive results reported as HAIs. This finding justified the initiative and infers that some reported HAIs may have been prevented during the intervention. Another possibility is that these tests were canceled manually anyway, resulting in no HAIs being reported. Also, we may have prevented reporting of HAIs with the autocancel intervention, and the increase in reported HAIs may have been due to other factors, such as increased antibiotic exposure or an increase in transmission.

Most patients (70.3%) who had an autocanceled order that did not have a test reordered had resolution of loose stools. Moreover, in those who had a test reordered after an autocanceled test, most were either negative or not collected (86.4%), and, of the 43 patients who tested positive, 8 had asymptomatic colonization. These outcomes support clinical practice guidelines for *C. difficile*: when a patient is not having clinically significant loose stools in a 24-hour period, *C. difficile* testing is not recommended.[8]

This study had several limitations. We did not correct for temporal trends in this before-and-after study. We may not have accounted for all concomitant, facility-specific *C. difficile* HAI reduction interventions. Although not a limitation, the education of staff regarding the intervention may have influenced *C. difficile* testing practices, as demonstrated by a modest decrease in overall testing rates. An autocancel rule could have caused some reported HAIs via delays in diagnoses; 3.9% of patients with autocanceled orders had a test reordered that was positive and autocanceled orders occurred frequently during the present-on-admission window, although we would expect this to happen infrequently. A major strength of our study is its generalizability; we included 17 hospitals ranging from academic medical centers to small community hospitals.

Our 24-hour autocancel intervention of uncollected *C. difficile* orders reduced testing across a hospital system with diverse facilities but did not affect reported *C. difficile* HAIs. By demonstrating a substantial reduction in clinically nonindicated testing, this intervention would affect laboratory cost savings, prevent unnecessary treatment for *C. difficile*, and affect length of stay. With no adverse outcomes observed, this low-cost and operationally straightforward intervention should be considered at other facilities as a diagnostic stewardship intervention for *C. difficile*.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2023.117

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