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ORIGINAL ARTICLE

The Impact of Performance Improvement Interventions and Phlebotomy Staff Counseling on Blood Culture Contamination Rates: Experience of Security Forces Hospital, Makkah, Saudi Arabia

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ABSTRACT

Background: *Blood culture contamination is a global problem that heeds all healthcare settings and has many negative impacts.* ***Objectives:*** *to compare the effectiveness of the two implemented interventions on blood culture contamination rates.* ***Methodology:*** *The blood culture reports of specimens received by the microbiology laboratory during the study period were grouped into 3 groups; pre-intervention group, post-intervention I group after educational lectures and practical workshops, post-intervention II group after implementation of the same intervention I together with individual counseling for staff identified as having obtained contaminated specimens. The contamination rates were evaluated and compared to the target and as regards departments and organisms.* ***Results:*** *After intervention I, there was a 31.56% reduction rate while after post-intervention II there was a 56.8% reduction from the pre-intervention rate. The total number of contaminants showed a highly significant difference between pre-intervention and post-intervention I & between post-interventions I and II (p=0.001) and an extremely highly significant difference between pre-intervention and post-intervention II (p=0.0001). The highest rate of contamination was found in the emergency department followed by ICUs. The contaminants were coagulase-negative staphylococci (CoNS) (82.8%, 92.6%, 93.3%) micrococci (9.7%, 5.5% 6.7%), anthracoid (4.9%,1.2%, 0%) and Corynebacterium spp. (2.6%, 0.6%, 0%) in the three groups pre or post interventions respectively.* ***Conclusion:*** *Intervention II proved to be more effective in reducing blood culture contamination rate. So, it is recommended to continuously track the contamination rate and train the staff on the best practice together with disciplinary counseling for those who frequently withdraw contaminated blood culture specimens.*

INTRODUCTION

Bloodstream infections (BSIs) are serious infections that have a significant influence on the morbidity and mortality of hospitalized patients worldwide. Accurate and timely identification of the causative organism are imperative for patient survival [1,2].

Blood culture is considered a currently critical and gold standard diagnostic test for BSIs. It controls the appropriate management of patients by identifying the causative pathogen and selecting effective antimicrobial[3]. Consequently, blood culture contamination constitutes a problematic cause of false-positive results, with misdiagnosis and misuse of antimicrobials. This may adversely affect the quality of health care services with a great impact on patient safety and length of hospital stay [4].

Other significant negative impacts of blood culture contamination include an economic burden on hospital resources, by performing further laboratory testing and prescribing unnecessary antibiotics. Additionally, false-positive blood culture results could breach antibiotic

stewardship programs and overcome hospital infection and prevention control policies [2,5].

An internationally acceptable standard rate of ≤3% blood culture contamination could serve as a key performance indicator (KPI)[6]. To limit blood culture contamination rates within the acceptable international range, many measures have been reported as contributing factors. These measures include proper antiseptic measures during venipuncture together with dedicated professionals and qualified phlebotomy team members well-trained for blood collection [7, 8].

In previous studies, measures considered in quality improvement interventions to reduce blood culture contamination rates included education and training, suitable kits, sterile gloves, and phlebotomy teams [9,10,11].

Based on the data from our hospital, blood culture contamination in 2018 was ranging from 3.53% to 6.18 % %, per month which is not acceptable according to the internationally accepted standard rate. So, measures were introduced in a multimodal performance improvement project aiming to reach a percentage within the standard rate.

The aim of this study was to evaluate and compare the effectiveness of the two implemented interventions to reduce the blood culture contamination rates during the study period (from September 2018 to August 2021).

METHODOLOGY

This cross-sectional study was carried out at our hospital, in Saudi Arabia including all blood culture reports of specimens received by the Microbiology laboratory during the study period from September 2018 to August 2021. The contamination rate was determined by the detection of contaminant organisms *that were detected in a single blood culture bottle and not detected in the repeated specimens from the same patient.* These organisms include coagulase-negative *staphylococci* (CoNS), *Corynebacterium* species, *Bacillus* species other than *Bacillus anthracis*, *Propionibacterium acnes*, and *Micrococcus* species; viridans group *streptococci*[12]. Repeated isolated strain with the same antibiogram from another blood culture specimen collected under perfect sterile precautions from the same clinically manifested patient was considered a pathogen and excluded from the study.

Blood culture laboratory' reports were classified according to the dates into 3 groups:

- Pre-intervention group: blood culture laboratory reports from September 2018-to August 2019
- Intervention I group blood culture laboratory reports from September 2019 -to August 2020
- Intervention II group: blood culture laboratory reports from September 2020 -to August 2021

In group I intervention, a 12-month strategic approach; including educational lectures and practical workshops on preprocedural and procedural measures; by training personnel in the proper technique for collecting blood cultures with mock performance simulation using Phlebotomy Practice Kit Blood Drawing Model to acquire clinical skills. The training was achieved for all hospital nurses with competency assessment.

In group II intervention, a 12-month cumulative strategic approach; including the measures involved in group I in addition to wall mounting of posters for the standard procedures at each nurse station, and an educational video available on the hospital -intranet. Postprocedural measures were also implemented by continuous monthly monitoring of blood culture contamination rates and providing feedback to personnel who collect blood cultures. As well as following -up with one-on-one training for staff identified as having obtained contaminated specimens (disciplinary counseling). Additionally, individual contamination rates also became part of the collector's annual performance review.

The contamination rates were compared between the pre-intervention group and each of interventions I and II groups to assess its impact on the reduction of blood culture contamination. Also, a comparison was made of the rate of contamination reduction between group I and II interventions.

Statistical Analysis:

Numeric data were presented as numbers and percentages according to the type of distribution of each variable using Statistical Package for Social Science (SPSS) software. One-way ANOVA was used to compare the reduction in contamination rate after each intervention stage. A pairwise comparison was done to compare the three study groups regarding the total number of contaminants, contaminating organisms, and the hospital departments.

RESULTS

The monthly number of blood culture contaminants out of the total number of blood-culture specimens received in the three groups is shown in Table 1. Categorization of contaminants according to the organism revealed that the highest number of contaminants in the three study groups was CoNS while the least was Corynebacterium spp.

Table 1: Numbers of monthly contaminants in the three study groups according to the organism

Month	Study group	Total no. of blood cultures	No. of contaminants	CNS	Micrococcus	Anthracoid spp	Corynebacterium spp.
September	Pre	421	22	20		1	1
	Post I	400	18	18			
	Post II	286	7	7			
October	Pre	403	20	16	2	2	
	Post I	468	10	8		2	
	Post II	287	6	5	1		
November	Pre	520	31	25	1	3	2
	Post I	489	12	12			
	Post II	281	10	9	1		
December	Pre	585	31	25	3	3	
	Post I	289	20	20			
	Post II	289	2	2			
January	Pre	550	34	27	3	2	2
	Post I	380	16	14	2		
	Post II	249	10	10			
February	Pre	482	17	11	5		1
	Post I	359	9	8	1		
	Post II	238	5	5			
March	Pre	454	20	18	2		
	Post I	367	4	4			
	Post II	281	5	5			
April	Pre	533	22	18	2	1	1
	Post I	267	4	4			
	Post II	289	5	5			
May	Pre	351	21	19	2		
	Post I	234	11	9	2		
	Post II	303	6	5	1		
June	Pre	316	17	14	2	1	
	Post I	268	13	12	1		
	Post II	343	12	11	1		
July	Pre	334	17	14	3		
	Post I	331	23	20	2		1
	Post II	333	4	3	1		
August	Pre	341	16	15	1		
	Post I	378	23	22	1		
	Post II	258	3	3			
Total	Pre	5290	268	222	26	13	7
	Post I	4230	163	151	9	2	1
	Post II	3437	75	70	5	0	0

Pre = pre-intervention group, Post I= post- intervention I group, Post II = post- intervention II group

Figure 1 shows that the percentage of monthly blood culture contamination was higher than the target in the preintervention group (5.07 %), slightly higher in post-intervention I group (3.47%) while it was lower than the target in post-intervention II group (2.19%).

Fig. 1: The percentages of monthly blood cultures contamination in comparison to the target in different study groups

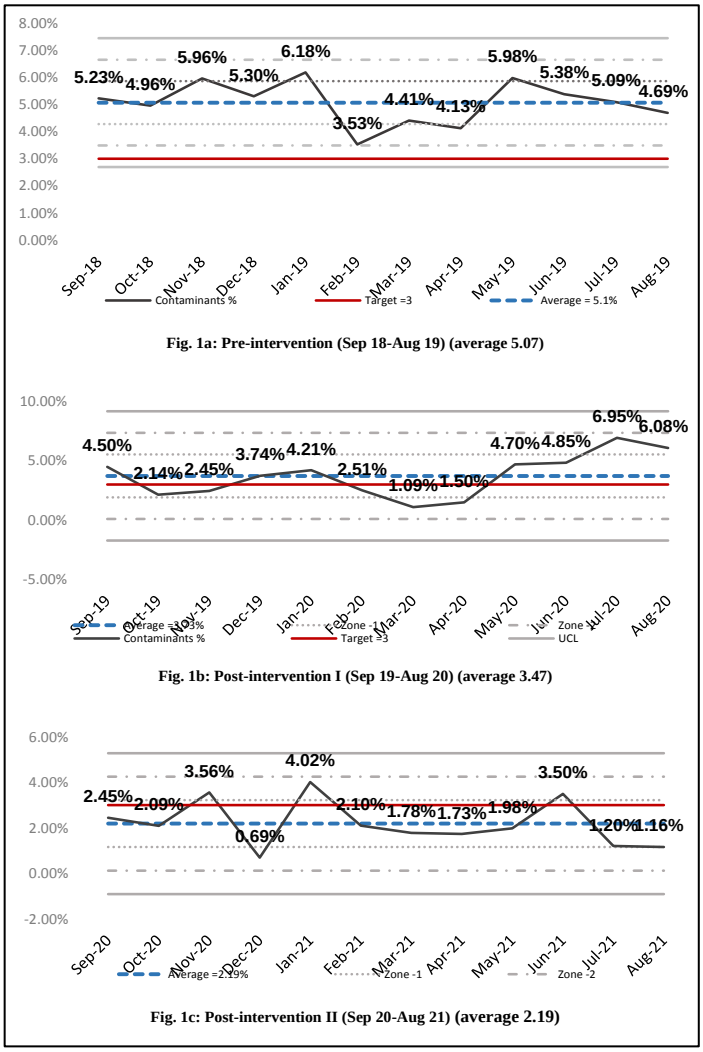

Fig. 1a: Pre-intervention (Sep 18-Aug 19) (average 5.07)

Fig. 1b: Post-intervention I (Sep 19-Aug 20) (average 3.47)

Fig. 1c: Post-intervention II (Sep 20-Aug 21) (average 2.19)

The reduction of contamination shows the highest rate (56.8%) when the pre-intervention group was compared with the post-intervention II group while it shows the lowest rate (31.56 %) when comparing the percentages of the pre-intervention with post-intervention I (Figure 2).

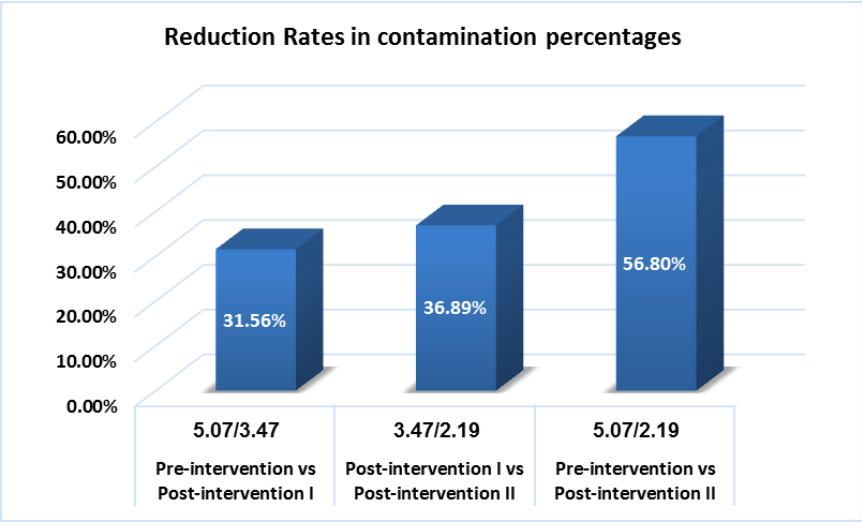

Fig. 2: Comparison between reduction rates of contamination percentages in the three study groups

The contaminants isolated from blood culture cases received from all departments showed the highest number of blood culture cases received from the emergency department and the least number from outpatient clinics (Table 2).

Table 2: Numbers of monthly contaminants in the three study groups according to the department

Month	Study group	No. of contaminants	ER	ICUs	In patients departments	OPD clinics
September	Pre	22	15	2	5	
	Post I	18	14	3	1	
	Post II	7	7	0	0	
October	Pre	20	16	1	4	
	Post I	10	7	1	2	
	Post II	6	5	1	0	
November	Pre	31	25	0	6	
	Post I	12	12	0	0	
	Post II	10	7	2	1	
December	Pre	31	19	5	7	1
	Post I	20	18	2	1	
	Post II	2	2	2	0	
January	Pre	34	23	0	9	2
	Post I	16	10	1	5	
	Post II	10	4	1	5	
February	Pre	17	16	0	0	1
	Post I	9	6	2	1	
	Post II	5	2	2	1	
March	Pre	20	12	5	2	1
	Post I	4	2	1	1	
	Post II	5	1	3	3	
April	Pre	22	11	4	8	
	Post I	4	1	2	2	
	Post II	5	1	1	3	
May	Pre	21	13	5	3	
	Post I	11	8	1	2	
	Post II	6	3	0	3	
June	Pre	17	9	3	5	
	Post I	13	8	2	3	
	Post II	12	7	2	3	
July	Pre	17	13	2	2	
	Post I	23	18	2	3	
	Post II	4	2	2	2	
August	Pre	16	9	0	7	
	Post I	23	20	3	0	
	Post II	3	3	0	0	
Total	Pre	268	181	28	54	5
	Post I	163	124	21	18	0
	Post II	75	42	15	18	0

ER= Emergency, ICUs= Intensive care units, OPD clinics= Outpatient department clinics.

Table 3 shows that the difference between the total number of blood culture contaminants in the three study groups was extremely highly significant (X^2 =20.812/ p=0.0001). While the difference was significant between the three groups regarding the organisms isolated.

Pair-wise comparison among study groups shows that in the total number of contaminants, there is a

highly significant difference between pre-intervention and post-intervention I as well as between post-intervention I and post-intervention II (p=0.001) and an extremely highly significant difference between pre-intervention and post-intervention II (p=0.0001). As regards contaminant organisms, coagulase-negative staphylococci show a significant difference between pre-intervention and post-intervention II (p=0.01) as well as between post-intervention I and post-intervention II (p=0.05). Micrococci shows no significant difference between post-intervention I and post-intervention II (p=0.072) while the difference was highly significant between pre-intervention and post-intervention II (p=0.001) and only significant between pre-intervention and post-intervention I. Anthracoid spp. and Corynebacterium spp show significant differences between pre-intervention and post-intervention I (p=0.05, 0.01) respectively (Table 3).

Table 3: Chi-square and pairwise comparison of contaminants isolated from blood culture in the 3 study groups

Study groups	Total blood culture cases	Total no. of contaminants	CoNS	Micrococci	Anthracoid spp	Corynebacterium spp.
Pre	5290	268 [ab]	222 [b]	26 [ab]	13 [a]	7 [a]
Post I	4230	163 [ac]	151 [c]	9 [a]	2 [a]	1 [a]
Post II	3437	75 [bc]	70 [bc]	5 [b]	0	0
Chi-square (p value)		20.812 (0.0001)	9.231 (0.01)	9.728 (0.01)	6.314 (0.05)	6.421 (0.05)

a= the significant difference between pre with the post I , b =the significant difference between pre with post II, c =significant difference between Post I with post II

Among the departments, the difference was highly significant in the ER and inpatient departments (p=0.001) while it was only significant in ICUs (p=0.01). Pair-wise comparison among study groups shows that the number of contaminants in different departments showed a highly significant difference between preintervention and post-intervention II in the emergency department and between preintervention and post-intervention I as well as between post-I and post-II interventions in inpatients departments(p=0.001). On the other hand, the difference is only significant between post-I and post-II interventions in both emergency and ICU departments (Table 4).

Table 4: Chi-square and pairwise comparison of departments in the 3 study groups

Study groups	Total blood culture cases	Total no. of contaminants	ER	ICUs	Inpatient departments	OPD clinics
Pre	5290	268 [ab]	181[b]	28[c]	54[ac]	5
Post I	4230	163 [ac]	122[c]	21	18[a]	0
Post II	3437	75 [bc]	42 [bc]	15[c]	18[c]	0
Chi-square (p value)		20.812 (0.0001)	31.715 (0.001)	11.439 (0.01)	19.476 (0.001)	----------

a= the significant difference between pre with the post I , b= the significant difference between pre with post II, c=significant difference between Post I with post II

DISCUSSION

Blood culture contamination is a global significant problem that could compromise the quality of care and lead to unnecessary antibiotic exposure and prolonged length of hospitalization. In the present study, the estimated mean blood culture contamination rate in the pre-intervention group was 5.07%, which is higher than the internationally accepted percentage. So, a task force team was established by the Microbiology laboratory and quality department members in collaboration with the antimicrobial stewardship committee at our hospital. The mission of the team was to track the blood culture contamination rates in the hospital and provide data that would optimize multidisciplinary quality improvement by designing and implementing interventions to decrease contamination rates.

In the pre-intervention group, the team could not determine the exact root causes of high contamination rates at our hospital, as it might be due to multiple frequent causes. Theoretically, contamination may be caused by poor collection techniques; an inappropriate approach in taking the sample from an inappropriate sample site, unprofessional intravascular access, or poor compliance in the application of skin antisepsis [13]. Additional possible causes would be the transfer of microorganisms from the surrounding environment of the patient, or from the unclean hands of the nurses who draw blood for culture [14].

So, it was required to initiate performance improvement interventions that could cover all proposed causes using the potential means of reduction of such contamination. These means included the use of collection methods that increase the chances for sterility, the choice of more effective antiseptic preparations with adequate contact time, and well training of phlebotomists and blood drawing nurses. The hospital team designed the suggested interventions to cover most of these factors starting with intervention I for one year, then, intervention II for another year. Post-procedural measures were also implemented by continuous monthly monitoring of contamination rates and providing feedback to personnel who collect blood cultures. As well as one-on-one training for staff who obtained contaminated specimens to achieve the target of reducing the contamination rate.

After the first intervention stage, the mean contamination rate was reduced to 3.7% (31.56% reduction rate) which is slightly higher than the acceptable percentage with a highly significant difference between pre-intervention and post-intervention I groups (p=0.001). Similarly, educational interventions were proven to be effective in the reduction of contamination rates in an earlier study done by Gel et al.,[15] where the implementation of educational training courses resulted in a 30% decrease in BCC rate [from (5.9%) to (4.1%)] in the study department. The implementation of closely similar interventions in a study from three hospital systems in the United States showed a reduction of contamination rates in the emergency department and inpatient of the first hospital from 6.0–7.0% in 2007 to below 1.6% in 2011. In the second hospital, the contamination rate also decreased following the educational interventions from 3.92% to 1%. A similar reduction in contamination rate from 7.4% to < 3% between 2007 and 2012 was recorded in the third hospital [5].

One important observation in the present study is that July 2020 and August 2020 showed an increase in the number of contaminants after their initial reduction following the first intervention. Controversially, in Poland where no variation in blood culture contamination rate was observed during a 2-years study period [16]. But, similarly, previous studies in Korea in 2014 [13] and in Pakistan on blood culture records in 2019 [8,] revealed higher contamination rates during the summer months that were later on explained by the possibility of staff shortage during summer vacation with involvement of temporary staff for nursing and blood culture specimen collection [16]. While the increased contamination rate during these months in the present study could be due to the fact that months were corresponding to the peak COVID-19 pandemic in Saudi Arabia where our hospital strategic policy was half-manpower attendance every other week to overcome the expected lack of staff if any of them acquired infection as well as staff relocation during the ongoing COVID-19 pandemic. Additionally, these months were the Hajj season that was restricted to selected categories due to COVID-19 which required an increased number of the Ministry of Interior staff in the Makkah region to serve pilgrims. Their increased number in Makkah was reflected in an increased number of patients in our hospital because this hospital was mainly established to provide health care to the Ministry of Interior staff and their families.

Post-intervention II group in the present study revealed a reduction in contamination rate to 2.19% which is considered a success of the plan implemented to reduce the contamination rate lowering it below the internationally accepted level. This success is statistically confirmed by the extremely highly significant difference between the total number of contaminants in pre-intervention and post-intervention II groups (p=0.0001). This could be explained by the approach taken in a timely manner reporting the name of the nurse who withdraw the contaminated specimen and individual counseling with a reinforcement training session and follow-up to take the required corrective action. Similarly, an earlier study in Taiwan, 12 weeks 2 phases (6 weeks for each phase), from February 2009 to April 2009, revealed a reduction from 3.4% in the pre-intervention period to 2.67% in the first phase (i.e., educational intervention only) then to 2% in the second phase (i.e. educational intervention plus one-on-one feedback) [17].

The higher reduction rate of blood culture contamination in the post-intervention II group in the present study could be attributed to the fact that counseling and one on one training focus on the individual needs of the trained nurse. Another possible factor is the involvement of individual contamination rates in the collector's annual performance review. This assumption emphasizes the results of the previous study by Halstead et al., [5] where the contamination rate in their hospital rate was reduced from 10 % by the newly hired staff in 2015 to 2.6% in 2019 after individual contamination rates became part of the collector's annual performance review.

With respect to the blood culture contamination rates in the different hospital departments in the present

study, high-rate contamination was found in the ER and ICU departments, and the least rate was determined in outpatient clinics only in the pre-intervention group. The ER department showed higher contamination rates even after the first and second interventions. This result goes in line with that of Alshamrani, and Al-Surimi [18] and emphasizes the previous assumptions that the emergency department always shows overcrowding, high staff and patients' turnover, medical staff workload with urgent need of collecting cultures in critically ill patients prior to resuscitation and obtaining cultures before the first dose of antibiotics as well as lack of staff continuous training and all resulted in inadequate skin preparation [19, 20, 21].

On the other hand, the high rate of blood culture contamination in ICUs may be attributed to the postulation that a high percentage of their patients rely on indwelling central venous catheters and invasive devices. Consequently, there is a high risk of developing sepsis that necessitates more frequent ordering of blood cultures [22]. Controversially, in a study in Madina, Saudi Arabia 2017, the highest contamination rate was reported in the medical wards followed by the Emergency Unit over one year [3].

The contaminants isolated in the present study were CoNS (82.8%, 92.6%, 93.3%) micrococci (9.7%, 5.5% 6.7%), anthracoid spp (4.9%,1.2%, 0%) and Corynebacterium spp. (2.6%, 0.6%, 0%) in the three groups either pre or post interventions respectively. Similarly, the same organisms were reported as blood culture contaminants in New York [4], Pakistan [8], and Poland [16].

On the other hand, CoNS was the most predominant contaminant, followed by Corynebacterium species and Micrococcus species with no anthracoid reported in a study at a university hospital in Riyadh, [23]. Micrococcus spp. and CoNS constitute together 25.5 % of total contaminants in a study carried out in India [6]. The predominance of these organisms is explained by the fact that CoNS is reported as a normal flora on human skin and mucous membranes that could be transmitted from the hands of medical staff [24], and Corynebacterium species and Micrococcus species was previously identified to be among the top ten bacterial species found on human skin [25].

The contribution of CoNS as blood culture contaminants was also previously explained by the defective use of skin antiseptics before blood withdrawal as about one-fifth of this organism is protected by lipids and superficial cornified epithelia in hair follicles, sebaceous glands, and deeper layers of the epidermis, and could not be reached in case of inefficient use of antiseptics [14,22]. These observations significantly promote and support the adoption of proper antisepsis to achieve best practices to reduce blood culture contamination.

CONCLUSION

The experience of our hospital to reduce blood culture contamination rates shows that disciplinary counseling with one-on-one training to phlebotomy staff together with continuous training on standards of practice for blood sampling as well as for using the suitable kit for blood collection could significantly reduce contamination rates better than training alone. So, continuous education with close observation and follow-up is highly recommended to maintain the internationally accepted blood culture contamination rate.

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Conflict of interest

The authors have no conflicts of interest to declare.
All authors have read and approved the final submitted version of the manuscript.
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