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## **Effectiveness of a multimodal intervention to improve blood culture collection in an adult emergency department**

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1 Effectiveness of a multimodal intervention to Improve Blood Culture  
2 Collection in an Adult Emergency Department

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19 **Abstract**  
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21 We investigated the impact of a multimodal intervention to improve the compliance of BC  
22 collections as a composite outcome, taking into account both blood volume collected and  
23 absence of solitary BC. We performed a quasi-experimental study using a before-after design  
24 (5 months for pre and post intervention evaluation) in an adult emergency department at a  
25 tertiary care hospital that showed that a multimodal intervention was associated with a dramatic  
26 increase in the proportion of blood cultures that were collected as recommended per national  
27 guidelines, from 17.3% (328/1896), to 68.9% (744/1080),  $P < 0.0001$ . The implementation of  
28 such intervention in other settings could improve the diagnosis of bloodstream infections and  
29 reduce irrelevant costs.

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## 35 INTRODUCTION

36  
37 Sepsis is a life-threatening multiorgan dysfunction affecting up to 49 million patients/year  
38 worldwide, with in-hospital mortality rates around 20% [1]. Identification of the pathogen  
39 involved through blood cultures (BC), combined with drug-susceptibility testing, are  
40 paramount to get the right diagnosis [2], optimize antimicrobial treatment [3] and reduced  
41 mortality [4].

42 Current sepsis guidelines recommend to obtain at least two sets with 35-40 mL of blood,  
43 directly inoculated on aerobic and anaerobic bottles, ensuring > 90% sensitivity [5,6]. However,  
44 despite the importance of blood volume collected to reliably detect pathogens, recent studies  
45 have shown that 20-97 % of BC bottles contain less than the recommended volume, and that  
46 for 10-33 % of patients only one pair of BC is collected during the first 24-hour period, this  
47 detrimental situation being referred to as ‘solitary BC’ [7].

48 Although several studies reported a positive impact of educational interventions to optimize the  
49 volume of blood collected for BC [8–10], and reduce the proportion of solitary BC [7,11], no  
50 study has investigated the simultaneous impact of interventions on these outcomes, which is  
51 key to attain the recommended target of 35-40 mL blood collected.

52 Here, we aim to investigate the impact of a multimodal intervention to improve the compliance  
53 of BC collections as a composite outcome, taking into account both blood volume collected in  
54 each bottle, and absence of solitary BC.

## 55 METHODS

### 56 Study population

57 We conducted a quasi-experimental study using a before-after design in the adult emergency  
58 department (AED) of the Rennes University Hospital, a 1,500-bed tertiary care center in  
59 western France. We selected this department for the intervention as a baseline assessment of  
60 BC use in our hospital revealed that AED was the largest user of BC, with the highest proportion  
61 of non-compliance with guidelines.

62 The pre-intervention evaluation was carried out from April 1<sup>st</sup> to August 31<sup>st</sup> 2020, before any  
63 educational intervention focused on appropriate use of BC in the hospital. The intervention was  
64 implemented from March 1<sup>st</sup> to March 31<sup>st</sup> 2021. The post-intervention evaluation was  
65 conducted from April 1<sup>st</sup> to August 31<sup>st</sup> 2021.

## 66 **Intervention**

67 The intervention relied on a new local protocol based on the concept of a BC train (BCT),  
68 defined by the concomitant collection of 35-40 mL blood through two pairs of BC obtained on  
69 a single venipuncture with the following sequence: i) aerobic bottle; ii) anaerobic bottle; iii)  
70 aerobic bottle; iv) anaerobic bottle. The protocol was designed according to the medical  
71 literature [12], by a local multidisciplinary committee including infectious diseases physicians,  
72 intensivist, microbiologist, and methodologist.

73 This protocol consisted of two educational tools. The first one targeted nurses (Supplemental  
74 Material I), who are in charge of BC sampling in France, specifying optimal procedures to  
75 collect BCT. The second one targeted BC prescribers (physicians) (Supplemental Material II)  
76 explaining the concept of BCT with a medical decision support listing the indications, and non-  
77 indications, of ordering BC.

78 During the intervention period, we conducted 15 to 30-minute training sessions involving  
79 nurses and physicians. During each session, one voluntary nurse and one physician from the  
80 AED who received a specific training instructed other members of the team. These trainings  
81 included oral presentation of the new BCT protocol, an educative video of BC collection that  
82 remained available at any time on the AED computers, and a questions/answers session  
83 (Supplemental Material III and IV). A pocket memo was provided to each physician. Briefings  
84 and feedbacks were scheduled before and after each session. The AED medical files and  
85 prescription software (Résurgence® Berger-Levrault) were adapted to facilitate the application  
86 of the BCT protocol, and cancel pre-existing systematic rules for BC collection by nurses  
87 without medical prescription (eg, collect BC when patients present with body temperature  
88  $>38.5$  °C).

## 89 **Pertinence of BC prescription**

90 For a random sample of 50 patients admitted during the pre-intervention period, and a random  
91 sample of 50 patients admitted during the post-intervention period, the pertinence of BC  
92 prescription was evaluated by a physician (AM), through retrospective review of medical  
93 records.

## 94 **Data collected for BC**

95 All BCs sampled in the AED are carried to the microbiology laboratory within 2 hours of  
96 collection, 24/7. Bottles are placed in an automated BC system (Bactec FX 480, Becton  
97 Dickinson), at 37°C, that detects microorganism growth by fluorescence. When a signal is  
98 detected by the automated system, a laboratory technician performs microscopic examination

99 after Gram staining, and a BC sample is inoculated on aerobic and anaerobic Agar plates for  
100 culture.

101 During the study period, the number of BC received and the volume of blood collected in each  
102 bottle assessed by visual inspection were routinely recorded in the TD Synergy (nexlabs  
103 technidata) software.

#### 104 **Statistical analysis**

105 Comparisons of categorical variables were made using the chi-square test or Fisher's exact test  
106 according to the usual conditions of validity. Comparisons of means were made using the  
107 Student's t test or Wilcoxon tests if the conditions of validity were not met. Knowledge of  
108 physicians and nurses before and after the training session was compared. The primary outcome  
109 criteria was compliance to BC sampling guidelines, defined as blood volume collected  $\geq 8$  mL  
110 per bottle, with at least two sets (4 bottles) collected within the first 24 h. Secondary outcome  
111 criteria included: i) knowledge of training participants, evaluated through a short questionnaire  
112 on the concept of BCT, indications for BC sampling, optimal sampling rules (ie, number of  
113 bottles and volume), and risk factors for contamination; ii) pertinence of BC prescription.  
114 Primary and secondary outcomes were compared before and after the intervention. We  
115 conducted two sensitivity analysis with different pre-intervention period to take into account  
116 potential effect of COVID-19 waves : one before the COVID-19 pandemic (April 1<sup>st</sup> to August  
117 31<sup>st</sup> 2019) and one just before the intervention (January 1<sup>st</sup> to February 30<sup>st</sup> 2021). A value  
118 of  $P < 0.005$  was considered as significant. SAS 9.5 software was used to perform the statistical  
119 analyses.

120

#### 121 **RESULTS**

122 We found a dramatic increase in the proportion of appropriate BC sampling, defined as  
123 appropriate volume for each bottle and no solitary BC, from 17.3% (328/1896) before the  
124 intervention, to 68.9% (744/1080) after the intervention ( $P < 0.0001$ ). The proportion of AED  
125 patients with BC sampling decreased from 8.7% (1896/21771) to 4.2% (1080/25977),  
126  $P < 0.0001$  (Table 1). Sensitivity analysis conducted with two different pre-intervention period  
127 found similar results on the primary outcome (Supplemental Material V and VI).

128 During the intervention period, 48 nurses (67.6% of all AED nurses), and 28 physicians (50.9%  
129 of all AED physicians) participated jointly to training sessions. Pertaining to BCs sampling,  
130 training sessions led to a significant improvement of nurses knowledge on the BCT concept  
131 (67.4% before vs 95.8% after,  $P = 0.0004$ ), BC qualitative criteria (55.8% to 79.2%  $P = 0.02$ ),

132 contamination factors (23.3% to 87.5%  $P<0.0001$ ) and material required for sampling (48.8%  
133 to 91.7%  $P<0.0001$ ). Pertaining to BCs prescription training sessions increased physicians  
134 knowledge about non-indications of prescription (55.6% to 89.3%,  $P=0.005$ ), the BCT rules  
135 (40.7% to 96.4%,  $P<0.0001$ ), and variables that improve BC sensitivity (11.1% to 67.8%,  
136  $P<0.0001$ ). Physicians knowledge about BC indications did not significantly improve (60.7%  
137 to 67.6%,  $P=0.51$ ).

138 The analysis of BC prescription on two random samples of 50 medical records before and after  
139 the intervention found a trend towards increased proportion of compliance to guidelines, from  
140 44.0% to 60.0% ( $P=0.07$ ).

141

## 142 **DISCUSSION**

143 This quasi-experimental study showed that a multimodal educational intervention improved the  
144 knowledge of nurses and physicians on good practices for BC prescription and sampling. This  
145 intervention was followed by better compliance in terms of BC sampling and decreased  
146 proportion of stays with BC sampling.

147 These results are in line with previous studies [7,9–11,13] : Three of them [8–10] reported a  
148 positive impact of educational programs, followed by significant improvement in the volume  
149 of blood collected in each BC bottle. Two others [7,11,13] reported educational programs that  
150 were followed by decreased proportion of solitary BC. To our knowledge, our study is the first  
151 that observed an improvement in both outcomes, using a composite criterion to define  
152 appropriate BC sampling, in terms of volume collected in each bottle, and number of bottles  
153 sampled (ie, no solitary BC). In addition, our study is the first to document that a multimodal  
154 educational intervention focusing on physicians and nurses was followed by a reduction in the  
155 proportion of AED patients with BC sampling. This reduction of BC collection was not  
156 unexpected, given that the educational program included a special focus on appropriate  
157 prescription of BCs by physicians, and emphasized that nurses should not collect BC in the  
158 absence of medical prescription.

159 Our study carries limitations. First, as a quasi-experimental study the improvement of practices  
160 for BC sampling after the intervention may be due to other factors. This is especially relevant  
161 given that the study took place during the first 2 years of the Covid-19 pandemic, which had a  
162 dramatic impact on health care in general. However, additional sensitivity analysis with another  
163 pre-intervention period before Covid-19 showed similar results . Second, as the intervention  
164 was multimodal, we are unable to analyze the separate effects of each intervention. Finally, the

165 evaluation occurred within the first 6 months following the intervention, so that we cannot  
166 extrapolate on its long-term impact. Strengths of the study were its location in an AED, where  
167 the early management of most sepsis cases occur [14], the sample size, and the standardization  
168 of data collection during the study period.

169 This study demonstrates that a multimodal educational intervention on BC in an AED was  
170 followed by significant improvement in BC compliance. The implementation of such  
171 intervention in other settings could improve the diagnosis of bloodstream infections and reduce  
172 irrelevant costs.

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176 **Table 1.** Patient characteristics and appropriateness of blood cultures before and after the  
 177 intervention  
 178

	<b>Pre-intervention period</b>	<b>Post-intervention period</b>	<b>P-value</b>
<b>Number of AED patients</b>	21 771	25 977	
<b>Sex</b>			
- Male	1011 (53.3%)	624 (57.8%)	0.02
- Female	885 (46.7%)	456 (42.2%)	
<b>Age, years</b>	61.8 (± 22.6)	61.1 (± 2.9)	0.42
<b>Number of AED patients with at least one pair of blood cultures sampled</b>	1 896 (8.7%)	1 080 (4.2%)	<0.0001
<b>Appropriateness of blood cultures sampling per hospital stay</b>			
Solitary blood culture *	1431 (75.5%)	102 (9.4%)	<0.0001
<b>Appropriate volume for each bottle §</b>	1906 (79.0%)	1718 (82.4%)	0.004

179

180 \* only one pair of blood cultures collected during the first 24-hour period

181 § 8-10 mL per blood cultures bottle

182 Qualitative variables are reported as numbers (%), quantitative variables as mean ± standard  
 183 deviation

184

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241 **Declaration of interest**

242 The authors reported no potential conflict of interest.

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245 **Code availability** : Not available.

246 **Ethics approval Ethical committee**: Validated by the local ethical committee.

247 **Author contribution statement**

248 RG and YM designed the study. YM, PT, CP, VC, AB were in charge of the implementation  
249 of the local protocol. AM, DB, LS were in charge of the staff training and of data collection.  
250 CP and VC were in charge of microbiological data collection. RG analysed the data. AB, AM,  
251 DB, RG, PT and YM wrote the initial manuscript. All authors contributed to the revision of the  
252 manuscript and approved the final version.

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