Deficits in knowledge, attitude, and practice towards blood culture sampling: results of a nationwide mixed-methods study among inpatient care physicians in Germany

Heike Raupach-Rosin*[a]	heike.rosin@helmholtz-hzi.de
Arne Duddeck*[a]	duddeck.arne@gmail.com
Maike Gehrlich[a]	m.gehrlich@gmx.de
Charlotte Helmke[a]	charlotte.helmke@online.de
Johannes Huebner[c]	johannes.huebner@med.uni-muenchen.de
Mathias W. Pletz[d]	Mathias.Pletz@med.uni-jena.de
Rafael Mikolajczyk[a, b, e]	rafael.mikolajczyk@helmholtz-hzi.de
André Karch[a, b]	andre.karch@helmholtz-hzi.de

*contributed equally

[a] ESME - Epidemiological and Statistical Methods Research Group, Department of Epidemiology, Helmholtz Centre for Infection Research, 38124 Braunschweig, Germany

[b] German Center for Infection Research (DZIF), Hannover-Braunschweig site, 30625 Hannover Germany

[c] Division of Pediatric Infectious Diseases, Dr. Von Hauner Children's Hospital, Ludwig Maximilian University Munich, Munich, Germany.

[d] Center for Infectious Diseases and Infection Control, Jena University Hospital, Erlanger Allee 101, 07747, Jena, Germany.

[e] Institute for Medical Epidemiology, Biometry, and Informatics (IMEBI), Medical Faculty of the Martin Luther University Halle-Wittenberg, Germany

Corresponding author:

Dr. André Karch

Department of Epidemiology

Helmholtz Centre for Infection Research

Inhoffenstr. 7

38124 Braunschweig, Germany

Tel.: +49 531 6181 3113

Email: andre.karch@helmholtz-hzi.de

Acknowledgments

We thank all study participants for their valuable time and the department directors for their support of our study. Furthermore, we would like to thank in particular the three hospitals which allowed us to perform focus groups with their staff and provided rooms free of charge. Finally, we thank Philipp Krajewski and his team at the “Centre for Quality and Management in Healthcare” at the Medical Association of Lower Saxony for their support of our study.

Internal funding of the Helmholtz Centre for Infection Research.

MWP was supported by the German Ministry of Education and Research (BMBF), Grant number 01KI1501.

Abstract

Purpose: Blood culture (BC) sampling rates in Germany are considerably lower than recommended. Aim of our study was to assess knowledge, attitudes, and practice of physicians in Germany regarding BC diagnostics.

Methods: We conducted a cross-sectional mixed-methods study among physicians working in inpatient care in Germany. Based on the results of qualitative focus groups, a questionnaire-based quantitative study was conducted in 2015-2016. In total, 706 medical doctors and final year medical students from 11 out of 16 federal states in Germany participated.

Results: BC sampling was considered an important diagnostic tool by 95 % of the participants. However, only 23 % of them would collect BCs in three scenarios for which BC ordering is recommended by present guidelines in Germany; almost one out of ten physicians wouldn't have taken blood cultures in any of the three scenarios. The majority of participants (74 %) reported not to adhere to the guideline recommendation that blood culture sampling should include at least two blood culture sets from two different injection sites. High routine in blood culture sampling, perceived importance of blood culture diagnostics, the availability of an inhouse microbiological lab, and the department the physician worked in were identified as predictors for good blood culture practice.

Conclusion: Our study suggests that there are substantial deficits in BC ordering and the application of guidelines for good BC practice in Germany. Based on these findings, multimodal interventions appear necessary for improving BC diagnostics.

Keywords**:** Blood culture, sepsis, bloodstream infection, focus groups, KAP survey

Background

Bloodstream infections (BSI) and their clinical correlates (sepsis and septic shock) are a major cause of morbidity and mortality worldwide [1]. For Germany, Fleischmann et al. [2] estimated the annual incidence of sepsis as 335 cases per 100,000 persons per year. Sepsis incidence rates are rising in many countries due to aging population structures and an associated increase in predisposing comorbidities (e.g. by immunosuppressive medication) [3]. As in-hospital case fatality rates for patients with sepsis (36.5 %) and severe sepsis (60.3 %) remain high in Germany [3], early diagnosis of BSI is essential in order to decrease the overall burden of disase [4]. Blood culture (BC) sampling is still the key diagnostic tool for BSI; it allows not only pathogen identification but is also necessary for targeted antibiotic therapy based on susceptibility testing [5]. There are several guidelines available for Germany describing when and how BC sampling should be performed in patients with suspected BSI, (both from a microbiological [6] and a clinical perspective [7]).

Nevertheless, BC sampling rates in Germany seem to be considerably lower than recommended [8-10], indicating deficits in the practice of BC sampling. The reasons for that are, however, unclear. Previous studies on deficits in BC sampling and in the application of guidelines into clinical practice are scarce. She et al. [11] analysed attitude and practice of German and US physicians towards different diagnostic tests for sepsis in 2015; in this study, German physicians reported lower BC ordering rates than their US colleagues. However, the authors did neither investigate reasons for this difference, nor did they assess knowledge about the correct indication and performance of BC diagnostics. In a single center US study, Parada et al. [12] showed deficiencies in BC-related knowledge among physicians; more experienced physicians and those with self-reported training on BC sampling showed better knowledge. Two studies from developing countries showed as well deficits in blood culture related knowledge [13, 14], but due to structural differences in the health care systems, these results are not easily transferable to Germany. No study has yet evaluated, how deficits in knowledge and attitudes towards BC sampling affect physicians' practice in ordering BC and in performing them correctly. The aims of our study were to identify potential problems in BC sampling practices of physicians in Germany and to assess their modifiability.

Methods

Study design

We conducted this study in a mixed-methods design [15]. In a first step, we performed a qualitative analysis based on three focus groups in three different German hospitals including all professional groups involved in pre-analytic BC diagnostics (inpatient care physicians, final year medical students, and intensive care nurses); this part of the study aimed to identify potential problems in the process of BC ordering and sampling and to prepare the quantitative survey in a second step. Focus groups were carried out according to the standards suggested by Krueger [16], were transcribed and were then analysed using qualitative content analysis by two independent readers [17]. As a result of the focus group analyses, we identified three main problem categories (institutional, individual, and procedure-related) in which eleven potential problems of the BC sampling process could be classified (Table 1).

Based on these potential problems, we developed a KAP (knowledge, attitude, practice)- survey which was piloted with 29 physicians in two different hospitals; the survey was then adapted according to the results and to the qualitative feedback of the pilot study; the translated version of the questionannaire is made available as Online Resource 1. The final survey included 52 questions about the correct initiation and the practical application of BC sampling, about the knowledge of the relevant BC guidelines as well as about attitudes towards these guidelines. Furthermore, we asked for the demographic characteristics of the participants as well as for the characteristics of their hospitals. The survey was implemented using the software LimeSurvey® and delivered online.

We identified all registered hospitals in 11 of 16 federal states of Germany and sent an invitation to participate in the survey to all clinical directors (n=3,087) in November 2015. We asked them to forward the invitation to all physicians working in their departments. Moreover, all final year medical students in the Federal State of Lower Saxony were invited using centralised mailing lists. We sent two reminders in December 2015 and January 2016.

Since case numbers for neurologists and dermatologists were rather small, we decided to group them together with internal medicine physicians into “non-surgical disciplines” which might have masked department-specific effects. However, we did not find any differences between internal medicine physicians and neurologists when analysing them seperately in a sensitivity analysis.

Statistical analyses

Survey results were analysed descriptively using relative frequencies and means and their 95 % confidence intervals or medians and interquartile ranges; groups were compared by chi-squared tests and t-tests or Wilcoxon rank-sum tests as appropriate. A composite good practice score was constructed for the analysis of individual and institutional predictors for good practice in BC diagnostics. The score included points for three case studies about the correct initiation, a question about the correct blood volume for BC bottles, implementation of sampling of BC sets from two different injection sites, and a question about waiting time after skin disinfection (in total 0-24 points possible). Potential predictors were first tested univariably for their association with score values in mixed effects linear regression models, allowing for heterogeneity in scores across federal states. In case predictors showed an association with the outcome ($p<0.25$), they were included in a multivariable linear regression model in order to estimate their effect when adjusted for other potential predictors. Beta coefficients and corresponding 95% confidence intervalls are reported as effect measures; a beta of “zero” corresponds to no effect while a beta of “one” indicates a one point increase in score values per one point increase in the predictor variable. All statistical analyses were carried out using Stata 12 (StataCorp, US).

Results

A total of 706 medical professionals (636 physicians representing all levels of medical training and a variety of specialties and 70 final year medical students) were included in our study (Table 2). Participating medical staff represents 11 of the 16 federal states in Germany; the majority of study participants worked in academic teaching hospitals (54.4%).

Attitude towards blood culture diagnostics

Nearly all (97.6 %) of the study participants considered BC sampling to be a very important or an important diagnostic tool; the vast majority (96.3 %) considered BC sampling their responsibility. Most (81.3 %) of the participants indicated, that there was a need for improvement concerning BC sampling practices in Germany. Two thirds (66.7 %) of the participants reported that guidelines for BC ordering and sampling exist in their hospital on some administrative level (for 49.2 % of participants hospitalwide; for 58.1 % on department or ward level). Half of the participants (50.6 %) stated to follow existing guidelines in at least 75 % of the cases, whereas 13.3 % of all participants indicated not to know the guidelines in detail.

Blood culture ordering practice

Only 22.6 % of the respondents would have initiated BC sampling in all of the three constructed case studies for which BC testing is recommended by German guidelines (Figure 1). A majority (66.1 %) of the respondents reported that they would have taken BCs in case of an elderly lady with hypothermia and suspicion of pneumonia; the same was true for a patient with a central line accompanied by a rise in CRP (67.7 %). Less than half (46.2 %) of the participants would have initiated BC sampling in case of a young woman presenting with symptoms of a urinary tract infection and chills (Figure 1). When asked to indicate which three clinical criteria for BC sampling they apply most often in their own clinical practice, study participants mentioned most often fever above 38.5 °C (81.2 %), chills (45.6 %), and clinical suspicion of infection (41.4 %) (Figure 2).

A majority of participants (60.8 %) acknowlegded that despite an existing indication for BC sampling, antibiotic therapy is often initiated first. As reasons for this, participants mentioned lack of time as most important (56.2 %) followed by “calculated antibiotic therapy in the presence of a known focus made BC sampling dispensible” (30.5 %, Figure 2). There was no difference in the perceived and reported

importance of the item “Lack of time” betweenthose institutions in which BC sampling is mainly performed by nurses and those in which doctors are in charge (chi²-test, p=0.790).

Blood culture sampling practice

While the majority of participants (78.0 %) reported to take more than one BC set at a time (in more than 75 % of the cases), only a quarter (26.0 %) followed (in more than 75 % of the cases) guideline recommendation to obtain at least two BC sets from at least two separate injection sites. Most (82.7 %) of the participants stated that they fill each BC bottle with at least 8-10 ml of blood as recommended by guidelines and manufacturers. Hygiene measures aiming at a reduction of contamination risks were implemented well by the participants (89.4 % performed hand disinfection before BC sampling, 84.0 % used disposable gloves, 98.0 % conducted skin disinfection, and 72.0 % disinfection of the diaphragma of BC bottles in more than 75 % of the cases). However, only 31.7 % reported to wait always for 60 seconds after skin disinfection as suggested by German guidelines.

Predictors of good blood culture practice

Having a microbiological laboratory at the institution (β-coefficient (β)=1.13; 95 % confidence interval (95 % CI) 0.31-1.94), the number of BC sets taken in the last 30 days (β=0.51 per set; 95 % CI 0.18-0.84) as well as the importance attached to BC sampling (β=1.62; 95 % CI 0.82-2.42) were all associated with good BC practice in our multivariable regression model. Participants working in non-surgical departments (internal medicine / neurology / dermatology) (β=2.57; 95 % CI 1.65-3.50) or anaesthesia (β=3.36; 95 % CI 2.36-4.35) reported better BC practice than participants from surgical departments (Table 3). There was no interaction between perceived importance of BC sampling and the number of BCs ordered or drawn in the linear regression model (p=0.7664).

While hospital size and the participants’ professional role had no systematic effect on good BC sampling practice, there was some evidence that physicians working in university hospitals and in hospitals with BC guidelines in place report a better BC practice. There was no evidence for regional differences (indicated by a lack of effect of federal state on the score in the empty model (p=0.097) and in the final multivariable model (p=0.378) in multilevel mixed-effects linear regression)

Potential for improvement

The majority of the surveyed physicians (71.3 %) stated to be aware of the fact that not enough BCs are taken in Germany. As most important reasons why BC sampling is not performed according to the guidelines, 80.5 % of the participants indicated that the guidelines are not known sufficiently; 68.8 % reported, that there is not enough time in clinical practice to perform BC sampling according to the guidelines. Only 6.9 % doubted the scientific basis behind the guidelines; 7.5 % suggested that economic reasons are important for not performing BC diagnostics according to the guidelines.

A vast majority (90.4 %) considered more time in the daily routine as helpful; the same was true for regular training (88.9 %) and improved communication of the value of BC sampling (88.5%). Measures aiming at a structural change were mentioned less frequently (e.g. improved extraction systems (66.7 %) and faster diagnostic procedures (like e.g. polymerase chain reactin (PCR)) (78.7%)).

Discussion

We showed in our study considerable deficits in the implementation of BC sampling and ordering recommendations in Germany which might partly explain low BC sampling rates observed in surveillance studies.

Although most study participants reported to be aware of the importance of BC sampling, less than a quarter of the participants would take BC sets in all three constructed scenarios representing German guideline recommendations. The same was true for the recommendation to take at least two BC sets from two different injection sites, which is crucial for reducing both the false-negative and false-positive rates. Unspecific reasons like lack of knowledge of existing guidelines and lack of time were ranked highest as potential causes for the gap between attitude and practice. Good BC practice was associated with the importance attached to BC sampling, the availability of a microbiological lab, the number of BCs taken in the last 30 days, and the department the physician worked in.

Only few of our participants would have ordered BC in all three scenarios ; this is in line with previous studies suggesting that BC sampling rates in Germany are lower than in the US [11] and then recommended [8]. The majority of our participants indicated lack of time as a reason for not taking BCs, and 90% would consider more time as helpful. On the one hand this could point to the actual work density in German hospitals and might indicate the wish to change work distribution. On the other hand, “lack of time” represents the low priority attributed to BC diagnostics since time is relative. This is supported by the observation, that there was no statistically significant difference in the reported importance of the item “Lack of time” betweenthose institutions in which BC sampling is mainly performed by nurses and those in which doctors are in charge.

It is further supported by the results of the multivariable analyses in which the importance attached to BC diagnostics was a strong predictor for good BC practice. Thus, more attention towards the value of BC sampling could lead to a priorization of BC in the clinical work.

Studies about BC-related knowledge, attitude, and practice are mainly from non-Western countries. Chew et al. [14] showed, that Malaysian emergency department staff had a lack of knowledge concerning good BC sampling practice. Ojide et al. [13] analysed BC-related knowledge, attitude, and

practice in a Nigerian hospital and showed that 39.8 % did not always order BCs if required, although the majority of the medical doctors had good BC-related knowledge. Reasons for this included “cost consideration for the patients” and “BC bottles not readily available”, which suggests, that these results are not transferable to the German health care system.

In a European study, semi-structured telephone interviews with microbiological laboratories and staff from ICU were used to assess problems concerning BC sampling [18]. This study concluded, that transportation time in Germany was longer than in other countries probably due to a higher proportion of off-site microbiological labs and that deficits in communication between hospital and lab staff are more common in Germany than in other European countries. A majority of our participants considered a better communication with the lab to be an important step for improvement. Moreover, having a microbiological lab onsite was a predictor for better blood culture practice in our study.

Not only the frequency of BC sampling, but also the quality of the procedure is of importance[19], [20] [21]. According to Schmitz et al. [18], German laboratories report a high rate of false positive results due to preanalytic contamination. Chew et al. [14] described preanalytic quality problems in a small study in Malaysia and showed, that the majority of the participants did not know the correct time required for the skin disinfection. However, they did not analyse reasons for these deficits on the physicians’ side. Two thirds of our participants reported not to wait for 60 seconds skin disinfection. The problem of preanalytical contamination of BC sets is further aggravated if BC sets are only taken from one injection site, since a differentiation between contamination and true infection is more difficult. On the basis of five studies Snyder et al. [22] showed in a systematic review that phlebotomy teams substantially reduce BC contaminaion rates in hospitals. While the majority of our study participants reported to fill BC bottles with the recommended volume, only about a quarter of our respondents take more than one BC set from two different injection sites.

A regular feedback about the actual and the target rate of BC sampling per ward or department was shown to increase awareness about BC diagnostics [23]. Parada et al. [12] showed, that physicians with self-reported subject-related education had better knowledge regarding BC-related knowledge; however, this was only a single center study in the US.

For the improvement of hand hygiene, a multimodal campaign was implemented in Germany since 2008 and led to an increase of hand hygiene compliance as well as alcohol-based hand-rub

consumption in the participating hospitals [24]. A comparable programme to improve **the quality of BC sampling** in Germany could be successful, given that the problems identified in our study appear to be modifiable on the level of the physician.

Since good BC practice was less likely in surgical departments, it might be effective to implement department-specific interventions. The bundle of measures for surgical departments could include the establishment of phlebotomy teams, the increased availability of infecions diseases consultants and subject-related education.

Intervention programmes for improving **BC sampling rates** at German hospitals seem less straight forward given that the recommendations from medical professional associations are not necessarily concordant. Although our three constructed scenarios included at least two triggers for BC sampling according to both guidelines, they must be discussed critically. A young woman in outpatient care with suspected urosepsis might be managed with empirical antibiotic treatment given the low probability that the BC will be positive [25]. Furthermore, one could argue that an increased CRP value in combination with a risk factor (like central lines) should not automatically trigger BC sampling. Moreover, in our study clinicians focused on the presence of fever as the most important (or maybe even single) trigger for BC sampling which corresponds with the clinical experience of the authors. Since a growing number of patients (eldery, immunosuppressed, treated with antipyretics) do not develop fever, a large number of BSIs can be missed. Moreover it has been shown that the level of bacteremia decreases shortly after the onset of fever and that BC sampling during fever did not show higher positivity rates, so that early clinical symptoms preceding fever might be a better trigger [26, 27]. One problem might be that guidelines for BC sampling are not consice enough for clinical routine so that a large number of patients qualify for BC sampling [28].This has been taken into account in the 2016 revision of the international sepsis criteria [29], but was not implemented in guidelines on BC sampling yet.

Strengths and limitations

Major strengths of our study are the mixed-methods design allowing a better interpretation of the results and the broad coverage of German hospitals. While we had to restrict our study to 11 of the 16 federal states in Germany due to technical reasons, there was no evidence for regional differences in any of our analyses, suggesting that the restriction did not cause selection bias.

The overall response rate was low on the physician level, under the assumption that all physicians working in the respective hospitals were invited to participate; However, it is not clear to what extent loss of participants occurred already at the level of the primarily contacted department heads, who may not have forward the invitation to their employees. One can assume, that heads of departments attaching importance to the topic of sepsis and BC sampling were more likely to forward our invitation. Thus, the proportion of hospitals or wards with BC guidelines might be overestimated. Furthermore, physicians and final year medical students with interest in the field might have been more likely to participate in our study, so that the quality of BC ordering and sampling might be overestimated. While study participants estimated BC sampling as very important, the low overall participation rate might indicate, that BC diagnostic is not of high priority for most physicians in Germany.

Conclusion

Although the majority of physicians in our study felt responsible for BC diagnostics, and attached high importance to it, there are substantial deficits in the quality of BC ordering and sampling in Germany. Factors associated with good BC practice were the importance attached to BC sampling, the presence of an in-house microbiological lab, the department the physician worked in, and the number of BC sets taken by the participants in the past 30 days. Multimodal intervention strategies targeting the main predictors of good BC practice might be helpful in improving the quality of BC diagnostics in Germany.

Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

1. Engel C, Brunkhorst FM, Bone HG, Brunkhorst R, Gerlach H, Grond S et al. Epidemiology of sepsis in Germany: results from a national prospective multicenter study. Intensive care medicine. 2007;33(4):606-18. doi:10.1007/s00134-006-0517-7.
2. Fleischmann C, Thomas-Rueddel DO, Hartmann M, Hartog CS, Welte T, Heublein S et al. Hospital Incidence and Mortality Rates of Sepsis. Deutsches Arzteblatt international. 2016;113(10):159-66. doi:10.3238/arztebl.2016.0159.
3. Fleischmann C, Thomas-Rueddel DO, Hartmann M, Hartog CS, Welte T, Heublein S et al. Hospital Incidence and Mortality Rates of Sepsis. Deutsches Arzteblatt international. 2016;113(10):159-66. doi:10.3238/arztebl.2016.0159.
4. Kumar A, Roberts D, Wood KE, Light B, Parrillo JE, Sharma S et al. Duration of hypotension before initiation of effective antimicrobial therapy is the critical determinant of survival in human septic shock. Critical care medicine. 2006;34(6):1589-96. doi:10.1097/01.CCM.0000217961.75225.E9.
5. Opota O, Croxatto A, Prod'hom G, Greub G. Blood culture-based diagnosis of bacteraemia: state of the art. Clinical microbiology and infection : the official publication of the European Society of Clinical Microbiology and Infectious Diseases. 2015;21(4):313-22. doi:10.1016/j.cmi.2015.01.003.
6. Seifert H, Abele-Horn M, Fätkenheuer G, Glück T, Jansen B, Kern WV et al. Blutkulturdiagnostik. Sepsis, Endokarditis, Katheterinfektionen, Teil I. München: Urban & Fischer Verlag; 2007.
7. Leitlinien der Deutschen Sepsis-Gesellschaft und der Deutschen Interdiszplinären Vereinigung für Intensiv- und Notfallmedizin. Prävention, Diagnose, Therapie und Nachsorge der Sepsis. 2010. http://www.awmf.org/uploads/tx_szleitlinien/079-001l_S2k_Sepsis_2010-abgelaufen.pdf. Accessed 04.08.2016.
8. Karch A, Castell S, Schwab F, Geffers C, Bongartz H, Brunkhorst FM et al. Proposing an empirically justified reference threshold for blood culture sampling rates in intensive care units. Journal of clinical microbiology. 2015;53(2):648-52. doi:10.1128/JCM.02944-14.
9. Gastmeier P, Schwab F, Behnke M, Geffers C. [Less blood culture samples: less infections?]. Der Anaesthesist. 2011;60(10):902-7. doi:10.1007/s00101-011-1889-9.
10. Antimicrobial resistance surveillance in Europe http://ecdc.europa.eu/en/publications/Publications/antimicrobial-resistance-europe-2014.pdf. 2014. Accessed 2017.01.23 2017.
11. She RC, Alrabaa S, Lee SH, Norvell M, Wilson A, Petti CA. Survey of physicians' perspectives and knowledge about diagnostic tests for bloodstream infections. PloS one. 2015;10(3):e0121493. doi:10.1371/journal.pone.0121493.
12. Parada JP, Schwartz DN, Schiff GD, Weiss KB. Effects of type and level of training on variation in physician knowledge in the use and acquisition of blood cultures: a cross sectional survey. BMC infectious diseases. 2005;5:71. doi:10.1186/1471-2334-5-71.
13. Ojide C, Onwuezobe IA, Asuquo EE, Obiagwu CS. Knowledge, attitude and practice of blood culture: A cross sectional study among medical doctors in a Nigerian tertiary hospital. African Journal of clinical and experimental microbiology 2013;14(3):6.
14. Chew KS, Mohd Hashairi F, Jusoh AF, Aziz AA, Nik Hisamuddin NA, Siti Asma H. Knowledge of Good Blood Culture Sampling Practice among Healthcare Staffs in An Emergency Department - Are We Getting It Right? The Medical journal of Malaysia. 2013;68(4):323-5.
15. Creswell JW, Plano Clark VL, Gutmann ML, Hanson WE. Advanced mixed methods research designs. Handbook of mixed methods in social and behavioral research Thousands Oaks, CA: Sage; 2003.
16. Krueger RA, Casyey MA. Focus Groups. A practical guide for Applied Research. 4th Edition. Thousands Oaks: Sage: 2009.
17. Mayring P. Qualitative Inhaltsanalyse. Grundlagen und Techniken. 11., aktualisierte und überarbeitete Auflage. Weinheim und Basel: Beltz; 2010.

18. Schmitz RP, Keller PM, Baier M, Hagel S, Pletz MW, Brunkhorst FM. Quality of blood culture testing - a survey in intensive care units and microbiological laboratories across four European countries. Critical care. 2013;17(5):R248. doi:10.1186/cc13074.
19. Kim NH, Kim M, Lee S, Yun NR, Kim KH, Park SW et al. Effect of routine sterile gloving on contamination rates in blood culture: a cluster randomized trial. Annals of internal medicine. 2011;154(3):145-51. doi:10.7326/0003-4819-154-3-201102010-00003.
20. Bouza E, Sousa D, Rodriguez-Creixems M, Lechuz JG, Munoz P. Is the volume of blood cultured still a significant factor in the diagnosis of bloodstream infections? Journal of clinical microbiology. 2007;45(9):2765-9. doi:10.1128/JCM.00140-07.
21. Patel R, Vetter EA, Harmsen WS, Schleck CD, Fadel HJ, Cockerill FR, 3rd. Optimized pathogen detection with 30- compared to 20-milliliter blood culture draws. Journal of clinical microbiology. 2011;49(12):4047-51. doi:10.1128/JCM.01314-11.
22. Snyder SR, Favoretto AM, Baetz RA, Derzon JH, Madison BM, Mass D et al. Effectiveness of practices to reduce blood culture contamination: a Laboratory Medicine Best Practices systematic review and meta-analysis. Clinical biochemistry. 2012;45(13-14):999-1011. doi:10.1016/j.clinbiochem.2012.06.007.
23. Karch A, Schmitz RP, Rissner F, Castell S, Topel S, Jakob M et al. Bloodstream infections, antibiotic resistance and the practice of blood culture sampling in Germany: study design of a Thuringia-wide prospective population-based study (AlertsNet). BMJ open. 2015;5(12):e009095. doi:10.1136/bmjopen-2015-009095.
24. Reichardt C, Koniger D, Bunte-Schonberger K, van der Linden P, Monch N, Schwab F et al. Three years of national hand hygiene campaign in Germany: what are the key conclusions for clinical practice? The Journal of hospital infection. 2013;83 Suppl 1:S11-6. doi:10.1016/S0195-6701(13)60004-3.
25. Laupland KB, Church DL, Gregson DB. Blood cultures in ambulatory outpatients. BMC infectious diseases. 2005;5:35. doi:10.1186/1471-2334-5-35.
26. Kee PP, Chinnappan M, Nair A, Yeak D, Chen A, Starr M et al. Diagnostic Yield of Timing Blood Culture Collection Relative to Fever. The Pediatric infectious disease journal. 2016;35(8):846-50. doi:10.1097/INF.0000000000001189.
27. Riedel S, Bourbeau P, Swartz B, Brecher S, Carroll KC, Stamper PD et al. Timing of specimen collection for blood cultures from febrile patients with bacteremia. Journal of clinical microbiology. 2008;46(4):1381-5. doi:10.1128/JCM.02033-07.
28. Vincent JL, Opal SM, Marshall JC, Tracey KJ. Sepsis definitions: time for change. Lancet. 2013;381(9868):774-5. doi:10.1016/S0140-6736(12)61815-7.
29. Seymour CW, Liu VX, Iwashyna TJ, Brunkhorst FM, Rea TD, Scherag A et al. Assessment of Clinical Criteria for Sepsis: For the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA : the journal of the American Medical Association. 2016;315(8):762-74. doi:10.1001/jama.2016.0288.

Table 1: Problems identified by focus groups among physicians, final year medical students, and intensive care nurses with respect appropriate blood culture sampling

Institutional problems
➢ Lack of standardization ➢ Technical difficulties ➢ Transport modalities ➢ Economic pressure ➢ Lack of time
Individual problems
➢ Lack of knowledge about procedure and indication ➢ Low motivation for taking blood cultures o Blood culture diagnostics is not treated with priority o Advantage of blood culture diagnostics is hardly known o Little trust in blood culture results o Low intrinsic motivation ➢ Lack of routine[1] ➢ Sterile performance is difficult[1] ➢ Lack of perceived responsibility[1]
Microbiological procedures
➢ Long latency period before result reduces therapeutic relevance
[1] Only mentioned by medical students in their final year.

Table 2: Characteristics of participants (n=706)

	Study population (n=706)
Sex	
Female	260 (36.8%)
Male	446 (63.2%)
Current function	
Head of department	130 (18.4%)
Consultant	226 (32.0%)
Resident	280 (39.7%)
Final year student	70 (9.9%)
Duration of job	
<12 months	22 (3.1%)
1-5 years	131 (18.6%)
5-10 years	127 (18.0%)
>10 years	356 (50.4%)
Final year student	70 (9.9%)
Speciality	
Surgical disciplines	157 (22.2%)
Internal Medicine / Neurology / Dermatology	259 (36.7%)
Anaesthesia	177 (25.1%)
Paediatrics	52 (7.4%)
Other	61 (8.6%)
Unit	
Normal ward	380 (53.8%)
Intensive care unit	194 (27.5%)
Emergency room	21 (3.0%)
Outpatient clinic	28 (4.0%)
Operation theatre	83 (11.8%)
Number of beds	
<200	114 (16.1%)
201-400	175 (24.8%)
401-600	135 (19.1%)
>600	249 (35.3%)
I don't know	33 (4.7%)
Type of hospital	
University hospital	171 (24.2%)
Academic teaching hospital	384 (54.4%)
Other	147 (20.8%)
I don't know	4 (0.5%)
Federal state	
Baden-Württemberg	114 (16.2%)
Bavaria	93 (13.2%)
Berlin	53 (7.5%)
Brandenburg	33 (4.7%)
Hamburg	20 (2.8%)
Hessen	56 (7.9%)
Mecklenburg-West Pomerania	36 (5.1%)
Lower Saxony	217 (30.7%)
North Rhine-Westphalia	43 (6.1%)
Rhineland-Palatinate	36 (5.1%)
Saarland	5 (0.7%)

Table 3: Predictors for good blood culture practice (n=706, linear regression analysis).

	Univariable			**Multivariable**		
	β-Coefficient	**95% CI**	**p value**	**β-Coefficient**	**95% CI**	**p value**
Female	-0,27	[-0.98; 0.44]	0.451			
Male	reference					
Current function			0.450			
Head of department	reference					
Consultant	0,82	[-0.19; 1.82]				
Resident	0,55	[-0.42; 1.52]				
Final year student	0,71	[-0.65; 2.06]				
Speciality			<0.001			<0.001
Surgical discplines	reference			reference		
Internal Medicine / Neurology / Dermatology	3.00	[2.12; 3.90]		2.57	[1.65; 3.50]	
Anaesthesia	3.66	[2.71; 4.62]		3.36	[2.36; 4.35]	
Paediatrics	1.66	[0.27; 3.06]		0.96	[-0.5; 2.42]	
Other	1.61	[0.29; 2.93]		1.45	[0.09; 2.80]	
Hospital size						
Number of beds (per 100 beds increase)	0.10	[-0.06; 0.26]	0.212	-0.16	[-0.36; 0.04]	0.122
SOP in place	0.82	[0.09; 1.55]	0.027	0.68	[-0.03; 1.39]	0.061
Number of blood cultures taken in last 30 days	0.91	[0.58; 1.24]		0.51	[0.18; 0.84]	0.002
Importance attached to blood culture (Very important vs. rest)	2.11	[1,30; 2,92]	<0.001	1.62	[0.82;2.42]	<0.001
Academic hospital	1.04	[0.19; 1.88]	0.016	0.90	[-0.46; 1.85]	0.062
Microbiological laboratory at the institution	0.81	[0.13; 1.50]	0.020	1.13	[0.31; 1.94]	0.007

Fig. 1 Three scenarios for blood culture ordering

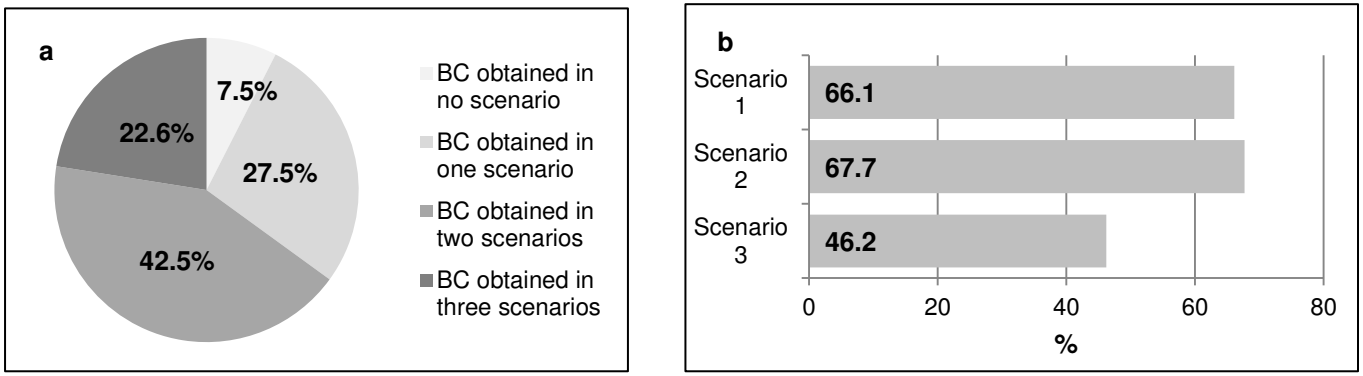

Figure 1 Three scenarios for blood culture ordering

a Percentages of participants who would order blood culture samples in 0, 1, 2, or 3 of the scenarios (n=708)

b Percentages of participants who would have ordered blood cultures for each scenario (n=708)

Scenario 1: Bedridden, elderly woman with suspicion of pneumonia and hypothermia.

Scenario 2: Patient with central-venous catheter and increase in CRP.

Scenario 3: 32-years old female outpatient with dysuria and shivering.

Fig. 2 Reasons for (a) and against (b) blood culture sampling.

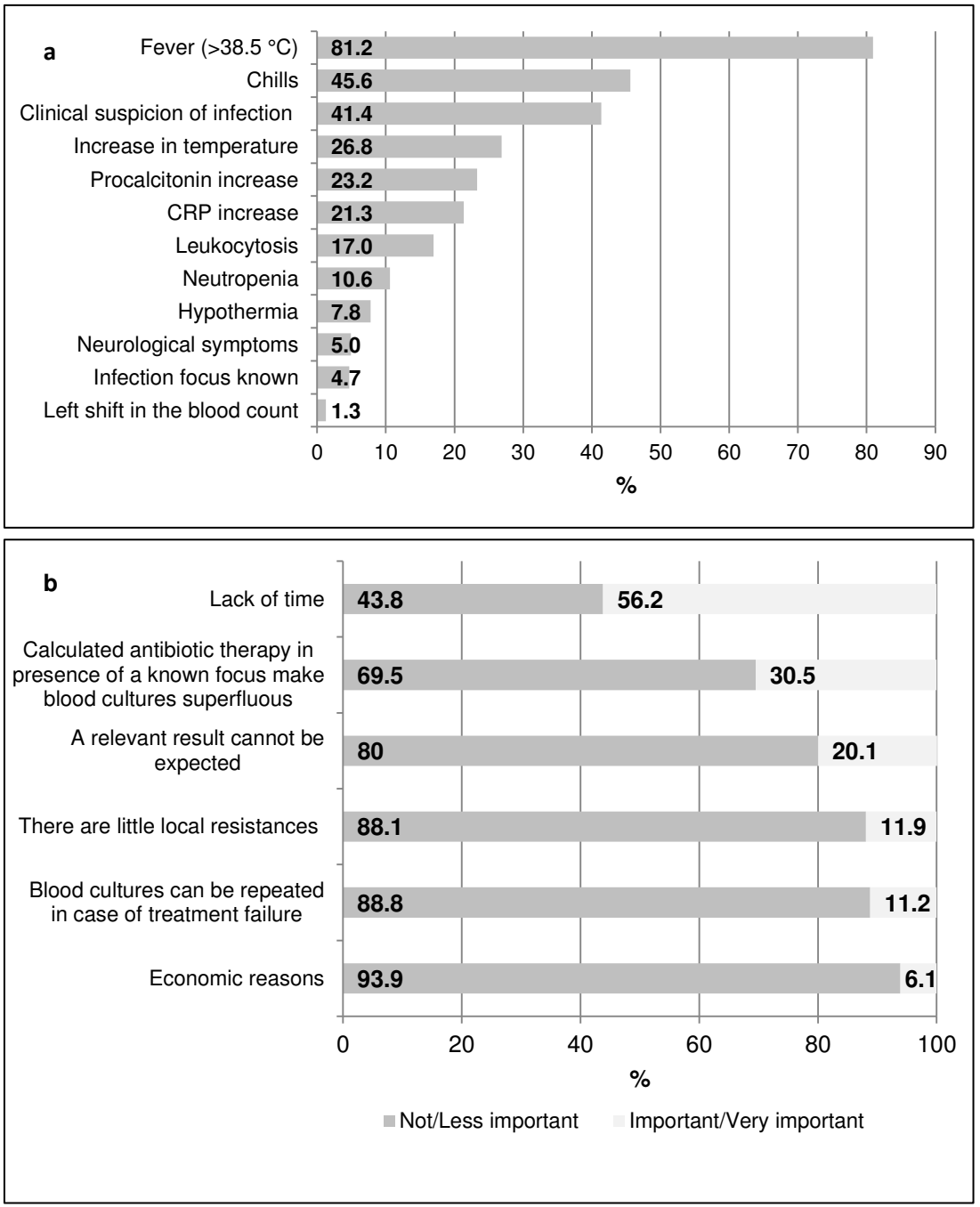

Figure 2 Reasons for (a) and against (b) blood culture samling.
a Most common indications for BC sampling in the clinical practice of the participants (every participant could choose up to three indications).
b Reasons reported by the participants why they do not perform BC sampling according to the guidelines.