Published in final edited form as:

Transfusion. 2016 August ; 56(8): 1951–1959. doi:10.1111/trf.13594.

Platelet transfusion therapy in sub-Saharan Africa: bacterial contamination, recipient characteristics and acute transfusion reactions

Heather A. Hume¹, Henry Ddungu², Racheal Angom², Hannington Baluku³, Henry Kajumbula³, Dorothy Kyeyune-Byabazaire⁴, Jackson Orem², Sandra Ramirez-Arcos⁵, and Aaron A.R. Tobian⁶

¹CHU Ste Justine, University of Montreal, Montreal, QC, Canada ²Uganda Cancer Institute Kampala, Uganda ³College of Health Sciences, Makerere University, Kampala, Uganda ⁴Uganda Blood Transfusion Service, Kampala, Uganda ⁵Canadian Blood Services, Ottawa ON, Canada ⁶The Johns Hopkins University, Baltimore MD, USA

Abstract

Background—Little data are available on bacterial contamination (BC) of platelet units or acute transfusion reactions to platelet transfusions (PT) in sub-Saharan Africa (SSA).

Methods—This prospective observational study evaluated the rate of BC of whole blood derived platelet units (WB-PU), the utility of performing Gram stains (GS) to prevent septic reactions, characteristics of patients receiving PT and the rate of acute reactions associated with PT at the Uganda Cancer Institute in Kampala, Uganda. An aliquot of each WB-PU studied was taken to perform GS and culture using the Bactec™ 9120 instrument. Study participants were monitored for reactions.

Results—337 WB-PU were evaluated for BC, of which 323 units were transfused in 151 transfusion episodes to 50 patients. The frequency of BC ranged from 0.3%–2.1% (according to criteria used to define BC). The GS had high specificity (99.1%), but low sensitivity to detect units with BC. The median platelet count prior to PT was 10,900 (IQR 6,000–18,900) cells/μL. 78% of PT were given to patients with no bleeding. Acute reactions occurred in 11 transfusion episodes, involving 13 WB-PU, for a rate of 7.3% (95%CI=3.7–12.7%) per transfusion episode. All recipients of units with positive bacterial cultures were receiving antibiotics at the time of transfusion; none experienced a reaction.

Conclusions—The rate of BC observed in this study is lower than previously reported in SSA, but still remains a safety issue. As GS appears to be an ineffective screening tool, alternate methods should be explored to prevent transfusing bacterially-contaminated platelets in SSA.

Corresponding Author: Heather A. Hume MD, FRCP, Service d'Hématologie/Oncologie, CHU Sainte-Justine, 3175, Côte-Sainte-Catherine, Montréal, QC, Canada, H3T 1C5, Tél: 514-345-4639 Fax: 514-345-4884, heather.hume@umontreal.ca.

Reprints: Reprints will not be available.

Disclosures: The authors declare no conflicts of interest.

Introduction

In most settings in sub-Saharan Africa (SSA), outside South Africa, blood transfusions are limited to the transfusion of whole blood. However, in the larger cities, blood components, including platelet concentrates are becoming available.¹ In Kampala, Uganda, the Uganda Blood Transfusion Service (UBTS) has been routinely preparing whole-blood derived platelet concentrates for more than 5 years.

As platelet product availability is still relatively recent in SSA, very limited data about platelet transfusion therapy in SSA, including its safety, are available. Blood product safety with respect to transfusion transmitted infection in SSA has focused primarily on HIV, hepatitis B virus (HBV) and hepatitis C virus (HCV). However, in high-income countries, bacterial contamination of platelet units is now the most common transfusion transmitted infection, with reports of bacterial contamination of platelet units ranging from 0.01 to 0.07%.²⁻⁵ In Africa, seven studies have evaluated the frequency of bacterial contamination, primarily in whole blood units and/or red cell concentrates with only three of the seven publications including platelet components. In these three studies combined, only 63 platelet units were tested.⁶⁻⁸ All studies found alarmingly high rates of bacterial contamination - an average of 8.8% of units tested with a range of 3.1% (Zimbabwe) to 17.5% (Ghana) (summarized in Table 1).⁶⁻¹² The rate of bacterial contamination of red cell concentrates in high income countries is lower than the rate in platelet units.¹³ It therefore seemed possible that the rate of bacterial contamination of platelet units in SSA could be even higher than the 8.8% observed in whole blood/red cell units.

Similarly, to our knowledge, only two publications have addressed the characteristics of patients receiving platelet transfusions and only one has assessed the rate of acute transfusion reactions associated with platelet transfusion.¹⁴⁻¹⁶ These three studies were performed in South Africa and Namibia; none have addressed the situation in SSA, outside these two countries.

We therefore undertook this study to address these issues. Our primary objectives were to determine the rate of bacterial contamination of platelet units transfused at the Uganda Cancer Institute (UCI) in Kampala, Uganda and the usefulness of performing Gram stains to prevent the transfusion of bacterially-contaminated platelet units. Our secondary objectives were to determine characteristics of patients at UCI receiving platelet transfusions and the rate and nature of acute transfusion reactions associated with platelet transfusions.

Methods

Study setting and platelet units

This prospective, observational study was conducted between March and September 2014 at Uganda Cancer Institute (UCI) and the Makerere University Microbiology Laboratory (MUML), both located within the Mulago National Referral Hospital Complex in Kampala, Uganda. All platelet units were supplied by the UBTS. All donors were healthy, anonymous, volunteer donors. As per UBTS protocols, donors were questioned about their general health, recent dental treatment and possible wounds; donor temperatures were not taken;

donor skin was cleansed with povidone-iodine skin swabs. In-line diversion pouches were not used. All donations were serologically screened for HIV, HCV, HBV and syphilis. Each platelet unit was prepared from a single whole blood donation using the platelet-rich plasma method; units were not leukoreduced (neither prestorage nor at the bedside) and not irradiated; no bacterial testing (or any other form of potential bacterial detection such as pH measurement) was performed by UBTS prior to issuing the platelet unit to UCI.

All patients (both pediatric and adult) thought likely to require platelet transfusions during their treatment at UCI were approached to request consent for participation in the study. For consenting patients, platelet units were included in the study if the platelet unit was transfused at a time when the bacterial testing could be conducted (in general from Monday to Friday between 9am and 5pm) and when transfusion reaction monitoring could be performed (up until 10 PM). In addition, for each platelet transfusion, physician agreement that the patient's platelet transfusion could be delayed for the time necessary to perform a Gram stain (approximately one hour) was required.

Bacterial detection of platelet units

Removal of the aliquot for bacterial testing was performed in the UCI laboratory by trained study staff. For each platelet unit studied, immediately prior to transfusion, a side sample coupler was inserted into one of the platelet ports and a 4 mL aliquot was aseptically removed. For the first 42 units, chlorhexidine was used to clean the side sample coupler; the couplers of the remaining platelet units were cleaned with 70% isopropanol. Three mL of the aliquot was inoculated into a Becton Dickinson Bactec™ Peds Plus™ Aerobic/F culture vial (which contain media specialized to accommodate samples with volumes $\leq$ 3 mL) and immediately taken to the MUML where the culture bottle was placed for incubation in a Bactec™ 9120 instrument. An aliquot from the other 1 mL was used for Gram staining, performed in the MUML, with the remainder (approximately 0.5 mL) refrigerated for follow-up investigation of positive cultures. The Gram stain was deemed positive if more than 1 bacterial organism was observed by two MUML technologists. Culture bottles were incubated for a maximum of 7 days or until they became positive. For initial positive cultures, a second culture bottle was inoculated with the remaining aliquot (approximately 0.5 mL) from the platelet unit and incubated for up to 7 days in the Bactec™ 9120 instrument.

Results of bacterial testing were categorized as follows:

- negative if both the Gram stain and culture were negative,
- true positive if initial and repeat cultures were positive for the same bacterium,
- unconfirmed positive if the initial culture was positive but the second culture was negative,
- possible bacterial contamination if the Gram stain was positive but the blood culture was negative.

All laboratory procedures and equipment in the MUML are internally quality controlled, including daily positive and negative controls for Gram staining and the laboratory performs

regular College of American Pathologists (CAP) proficiency testing. In addition, for this study, positive controls for the bacterial cultures were performed after approximately every 100 study platelet units tested. For the latter, 0.4 ml of 10^{-5} dilutions of *Staphylococcus epidermidis* and *Escherichia coli*, were inoculated into Becton Dickinson Bactec™ Peds Plus™ Aerobic/F culture vials. A 1.5 mL aliquot of whole blood removed from expired whole blood units (as no expired platelet units were available) in exactly the same manner as that used for study platelet units was then added to each culture bottle. After incubation, all positive culture controls gave appropriate positive results.

Platelet transfusions

Only platelet units with a negative Gram stain were transfused. As per UCI protocols, platelet units were transfused singly (i.e. not pooled prior to transfusion); when more than one unit per transfusion episode was given there was minimal delay between the transfusion of units. Patients were not given pretransfusion medications for the purpose of reducing transfusion reactions. All units were transfused within 4 hours of breach of the closed system.

All patients receiving study platelet units were monitored by a study nurse or doctor. Recipient information including diagnosis, treatment with chemotherapy within the previous 2 weeks, treatment with antibiotics within the previous 2 days, and the most recent platelet count prior to transfusion were recorded; bleeding status was reported using a recently published bleeding tool.¹⁷ Patient vital signs were recorded immediately before, at the end, and at 2 hours after the end, of the transfusion of each study platelet unit. All study report forms were reviewed by at least one study physician (HH or HD) to determine the presence (or absence) of an adverse transfusion event. All adverse transfusion event reports were then reviewed by the 2 transfusion medicine study physicians (HH, AT), using United States Center for Disease Control hemovigilance definitions, to determine the presence or absence of an acute transfusion reaction and if present, its classification, severity and imputability.¹⁸

Statistical analysis

Median and interquartile ranges were determined for the platelet age at time of transfusion. Sensitivity and specificity of the Gram stain were calculated comparing the Gram stain to bacterial culture. For bacterial contamination and acute transfusion reaction rates, 95% confidence intervals were calculated. Analyses were performed using the STATA version 11 computer program (StataCorp LP, College Station, TX).

The study was powered assuming the bacterial contamination rate would be approximately 10% (similar to Ghana and Kenya).^{7,10} With this assumption, if we evaluated 300 platelet transfusion units, we estimated we would detect 30 units with bacteria. For whole blood derived platelets, the prevalence of bacterial contamination in high income countries is approximately 1:1500 units.¹⁹ Thus, we would have >95% power with a two-sided alpha of 0.05 to detect a difference between the prevalence in Uganda and that in high income countries.

Ethical approvals

Approval to conduct the study was obtained from the School of Medicine Research Ethics Board, Makerere University, Kampala, Uganda and the Uganda National Council for Science and Technology as well as the research ethics committees of the Centre Hospitalier Universitaire Sainte-Justine, Montreal, QC, Canada and The Johns Hopkins University School of Medicine, Baltimore, MD, USA.

Results

During the study period, approximately 890 platelet units were issued to UCI from UBTS. Of these, 337 platelet units (approximately 38%) were included in this study. Platelet units not included in the study were mainly excluded for logistical reasons (e.g. arrival at UCI outside study hours, including weekends, or during intermittent shortages of study materials); a smaller number were not included as the treating physician did not wish to delay the transfusion for the time required for the bacterial testing or the units were to be transfused to a patient who did not consent to participate in the study. We did not record the exact number of platelet units that fell into each of these categories. Of the 337 platelets evaluated, the median age at time of bacterial testing was 2 days (IQR 2 – 3 days). Only 34 (10.1%) units had been stored for four days and 17 (5.0%) units stored for five days.

Bacterial testing

Results of the bacterial testing are summarized in Table 2. Of the 337 units studied, 330 had both negative Gram staining and negative bacterial culture results. One (0.3%) yielded a true positive culture identified as *Streptococcus viridans*; three (0.9%) cultures yielded unconfirmed positive results (*Bacillus* spp-2, coagulase-negative *Staphylococcus* -1); these 4 platelet units all had negative Gram stains. Three platelet units were considered to have possible bacterial contamination as they had positive Gram stains (Gram-negative rods-1, Gram-positive rods-1, Gram-positive cocci-1) with negative culture results (2 of the 3 units were among the 42 units for which chlorhexidine cleansing of the platelet port had been used). Since none of the positive bacterial cultures also had a positive Gram stain, the sensitivity of the Gram stain for detecting culture positive platelet units was 0%. However, the specificity of the Gram stain was 99.1%.

The frequency of bacterial contamination of the tested platelet units depends on whether one considers only the confirmed positive unit giving a rate of 1/337 (0.3%, 95%CI=0.008–1.6%), or the confirmed and unconfirmed positives, giving a frequency of 4/337 (1.2%, 95%CI=0.3–3.0%), or the confirmed and unconfirmed positives plus the possible positives giving a frequency of 7/337 (2.1%, 95%CI=0.8–4.2%).

Patient and platelet transfusion characteristics

Of the 337 platelet units for which bacterial testing was performed, 323 units were transfused in 151 transfusion episodes to 50 patients. Of the 14 units not transfused, 5 were not transfused because of a possible positive Gram stain result (3 confirmed and 2 not confirmed on reading by a second technologist), 5 because the patient left the UCI prior to

being transfused, 3 because of the inability to complete the transfusion within 4 hours of entering the platelet unit, and 1 because of miscommunication.

Patient characteristics are shown in Table 3 and the platelet transfusion characteristics are shown in Table 4. The median platelet count prior to transfusion was 10,900 (IQR 6,000–18,900) cells/ μ L. In 20% of the 151 transfusion episodes, the recipients had mild bleeding and in 2% of the transfusion episodes the recipients had serious bleeding immediately prior to the platelet transfusion. In 53.6% of the 151 transfusion episodes, the recipients had received chemotherapy within the previous two weeks and in 96.0% of the transfusion episodes the recipients had received antibiotic treatment within the previous two days.

Acute transfusion reactions

Details of the acute transfusion reactions are shown in Table 5. Acute transfusion reactions occurred in 11 transfusion episodes in 8 different patients, involving 13 platelet units, for an overall rate of 4.0% (13/323, 95%CI=2.1–6.8%) per platelet unit or 7.3% (11/151, 95%CI=3.7–12.7%) per transfusion episode. All of the recipients of the four platelet units with confirmed or unconfirmed bacterial testing were receiving antibiotic therapy at the time of the transfusion and no acute transfusion reactions were observed. The majority of the reactions were febrile non-hemolytic transfusion reactions.

Discussion

Limited data are available on platelet transfusion therapy in low-resource settings such as SSA. As far as we are aware, this is the first study in SSA to evaluate the rate of bacterial contamination using a substantial number of platelet units, and also the first to report on platelet transfusion therapy and prospectively study acute transfusion reactions to platelet transfusions in SSA, outside Namibia or South Africa. This study demonstrates that bacterial contamination of platelet units remains a significant issue in SSA, although the rate is not as high as might have been predicted based on previously published reports of contamination of whole blood and RBC units in SSA.^{6–12} However, Gram staining did not prove to be an effective tool to prevent the transfusion of bacterially contaminated platelet units. In addition, this study shows that the majority of platelet transfusions are given for appropriate indications and febrile nonhemolytic transfusion reactions are the most common adverse event.

Although only 0.3% (1/337) of the platelet units tested had confirmed bacterial contamination, this may underestimate the true rate of bacterial contamination in this setting. For 2 of the 3 platelet units with possible bacterial contamination (Gram stain positive but culture negative) the side sample couplers placed in the platelet port for aliquot removal was disinfected with chlorhexidine. Both chlorhexidine and isopropanol have a broad spectrum of action and act mainly by disrupting cell membrane and precipitating proteins.²⁰ Disinfection of the side sample couplers with chlorhexidine may have affected the bacterial recovery from contaminated platelet units since this disinfectant remains effective on surfaces for up to 48 hours. In contrast, isopropanol evaporates quickly once in contact with a surface.²¹ It is also possible (albeit unlikely) that the bacteria observed in Gram stain were not viable or able to grow in the Bactec media. The 3 platelet units with unconfirmed

positive cultures (second cultures performed with a platelet unit aliquot of only 0.5 mL) may also in fact have been bacterially contaminated units. A recently published study has reported data suggesting that unconfirmed bacterial cultures, particularly those with organisms other than *Bacillus* spp. (the case of 1 of our 3 unconfirmed cultures) likely reflect the contamination of platelet units with a low-concentration of bacteria.² Hence, the true rate of bacterial contamination of platelet units in Uganda could be as high as 2.1% (95% CI 0.8%–4.2%). Bacteria isolated in this study from positive cultures included *Streptococcus viridans*, *Bacillus* sp and coagulase negative *Staphylococcus*. *Bacillus* is an environmental contaminant, coagulase negative staphylococci are part of the normal skin flora and streptococci are part of the mucosal flora that can be transitorily present in the human skin. Although these bacterial species are not considered to be highly pathogenic, all have been involved in severe or fatal transfusion events.¹³

The bacterial contamination rate in this study, at either the lower or higher ends of the possible spectrum, is lower than that previously reported in studies from SSA, including a study done in Uganda, and this in spite of the fact that most of the units tested in previous reports were whole blood or RBC units.^{6–12} Overall the lower rate observed in the present study could be due to differences in donor selection and/or blood collection techniques between countries, the careful attention in this study to aseptic sample collection techniques (including the use of a side sampler couplers which were not used in previous studies), and/or possible repetitive periods of leaving the whole blood/RBCs outside of refrigerated storage. In addition in the Kenyan study, a major source of bacterial contamination was the repetitive, non-sterile entry into the blood units over several days to remove small aliquots for pediatric transfusions.⁹ However, the precise reasons for the high bacterial contamination rate of whole blood and RBC units observed in the previous studies and the possibility that bacterial contamination of whole blood and RBC units represents a bigger problem than the bacterial contamination of platelet units in SSA requires further study. Interestingly, recent studies have shown that bacteria present in whole blood distributes into different blood components with preferential segregation into RBCs and plasma. Furthermore, up to a 2-log reduction in bacteria concentration has been obtained for certain species in platelet concentrates prepared from experimentally inoculated whole blood subjected to the buffy coat platelet production method.^{1,22} It is important to notice that bacterial titers in whole blood cannot be directly compared to bacterial loads in platelet concentrates prepared from whole blood as it has recently been shown that blood processing can result in bacterial reduction for certain species in the final product due to bacterial segregation to other fractions such as RBCs and plasma.

Although the bacterial contamination rate in this study is lower than that previously reported in studies from SSA, it is higher than reports from high income countries where the incidence of confirmed positive bacterial cultures of platelet units ranges from 0.01 to 0.1%.^{23,24} The higher rate of bacterial contamination observed in this study occurred despite the fact that the platelet units had been stored for less time than the average platelet unit in high income countries. If the units evaluated in this study had been stored longer, there could possibly have been an increased number of positive Gram stains, positive cultures and/or clinically significant septic transfusion reactions.

The Gram stain does not appear to be an effective method to identify platelet units with bacterial contamination in a low resource setting. In addition to its known lack of sensitivity - while bacterial concentrations 10^5 CFU/mL are considered to be of clinical significance, units with bacterial concentration lower than 10^7 colony forming units per mL would likely be missed by Gram staining^{13,25} - we encountered a number of other logistical challenges. In the setting of our study, it proved difficult to perform the Gram stain in a timely fashion: there was no official telephone connection between the laboratories, the laboratories were physically distant from one another, there was no routine method for transportation of specimens between the laboratories. Even within the context of a study setting, the Gram stain often took longer than one hour to complete and report due to these difficulties thus limiting the remaining time available to transfuse the unit. In a non-study setting where these difficulties would likely also exist and in addition experienced staff available to accurately perform the Gram stain in a timely manner might be less available, it is quite likely that platelet units either would not be transfused within the four hour time limit after breach of the closed system or if this time frame was respected, that the (already limited supply of) platelet units would be compromised.

Patients in this study generally received just one to three whole blood derived platelet units during any one transfusion episode. While these platelet transfusion doses are small, the PLADO trial data show this practice is reasonable.²⁶ The majority of the platelet transfusions appeared justified. The median platelet count was 10,900 cells/ μ L which is within the recently published platelet transfusion guidelines.²⁷⁻²⁹ Since only 22% of study participants during each transfusion episode had some form bleeding, it appears that the majority of platelet transfusions were given prophylactically. There were 26.9% of platelet transfusion in this study that were ABO plasma incompatible, likely reflecting the short supply of platelet products in this region.

The observed acute transfusion reaction rate for platelet transfusion is similar to that reported in high income countries prior to the introduction of leukoreduction.³⁰ None of the patients in this study received premedication, but their utility is questionable for preventing transfusion reactions.³¹ None of the units with positive cultures led to septic acute transfusion reactions. This could be due to the fact that all patients who received these units were receiving broad spectrum antibiotics at the time of transfusion of the contaminated/ potentially contaminated unit. The rate of allergic transfusion reactions at 1.3% appears to be similar to the rates seen in high income countries.^{32,33}

There are some limitations with this study. First, we were unable to evaluate all platelet units transfused during the study period. However, this should not have affected the rate of bacterial contamination or acute transfusion reactions. Potentially this limitation could have led to an overestimation of the ratio of prophylactic versus therapeutic platelet transfusion. Nevertheless, this study does show that prophylactic transfusions are used in SSA. Second, due to concern for removing too many platelets from the relatively small single whole blood derived platelet units, all cultures were of limited volume and only performed in an aerobic bottle, and the second culture also had an even smaller volume which likely limited the positive results for the confirmation tests. Third, the side sample couplers of the first 42 units were cleaned with chlorhexidine prior to removing the aliquot which could have reduced the

growth of bacteria in the culture bottle (as discussed more fully above). However, this study is strengthened by the large number of platelet units evaluated compared to the currently available literature in SSA and the prospective monitoring of the patients for transfusion reactions.

In summary, the rate of platelet bacterial contamination that we observed in this study is significant and solutions are needed to prevent this source of potentially fatal transfusion reactions. Unfortunately, the Gram stain is not the solution. At a minimum, bacterial cultures for quality control process control should be recommended throughout SSA. In addition, the standard practices in high income countries, such as improved skin cleansing and diversion pouches, should be encouraged. While bacterial cultures for every platelet unit would be ideal, it may not be practical and/or affordable. Pathogen inactivation, if affordable, could play a major role in these setting by not only eliminated bacteria, but other pathogens such as malaria and HIV that often plague these regions.^{34,35} Further research into these methods and how to bring them to low resources setting are needed.

Acknowledgments

Funding: Funding for this study was provided by the Research Group for Transfusion Medicine, CHU Ste-Justine, University of Montreal and The Johns Hopkins University School of Medicine. A.A.R.T. was supported by the NIH 1K23AI093152-01A1 and Doris Duke Charitable Foundation Clinician Scientist Development Award (#22006.02).

References

1. Damgaard C, Magnussen K, Enevold C, Nilsson M, Tolker-Nielsen T, Holmstrup P, Nielsen CH. Viable bacteria associated with red blood cells and plasma in freshly drawn blood donations. *PLoS One*. 2015; 10:e0120826. [PubMed: 25751254]
2. Benjamin RJ, Dy B, Perez J, Eder AF, Wagner SJ. Bacterial culture of apheresis platelets: a mathematical model of the residual rate of contamination based on unconfirmed positive results. *Vox Sang*. 2014; 106:23–30. [PubMed: 23815166]
3. McDonald CP, Allen J, Roy A, Robbins S, Moule R, Vasconcelos M, Brailsford S, Pitt T. One million and counting: bacterial screening of platelet components by NHSBT, is it an effective risk reduction measure? *Vox Sang*. 2015; 109:61.
4. Fatalities Reported to FDA Following Blood Collection and Transfusion. Annual Summary for Fiscal Year 2014. 2014. <http://www.fda.gov/downloads/BiologicsBloodVaccines/SafetyAvailability/ReportaProblem/TransfusionDonationFatalities/UCM459461.pdf>
5. Public_Health_Agency_of_Canada. Transfusion Transmitted Injuries Surveillance System Program Report 2006–2012. 2014. <http://www.phac-aspc.gc.ca/hcai-iamss/ttiss-ssit/index-eng.php>
6. Bolarinwa RA, Aboderin OA, Odetoyn BW, Adegunloye AB. Bacterial contamination of blood and blood components in a tertiary hospital setting in Nigeria. *International Journal of Infection Control*. 2011;7.
7. Adjei AA, Kuma GK, Tettey Y, Ayeh-Kumi PF, Opintan J, Apeagyei F, Ankrah JO, Adiku TK, Narter-Olaga EG. Bacterial contamination of blood and blood components in three major blood transfusion centers, Accra, Ghana. *Jpn J Infect Dis*. 2009; 62:265–9. [PubMed: 19628902]
8. Makuni N, Simango C, Mavenyengwa RT. Prevalence of bacterial contamination in blood and blood products at the National Blood Service Zimbabwe. *J Infect Dev Ctries*. 2015; 9:421–4. [PubMed: 25881533]
9. Hassall O, Maitland K, Pole L, Mwarumba S, Denje D, Wambua K, Lowe B, Parry C, Mandaliya K, Bates I. Bacterial contamination of pediatric whole blood transfusions in a Kenyan hospital. *Transfusion*. 2009; 49:2594–8. [PubMed: 19682331]
10. Opoku-Okrah C, Feglo P, Amidu N, Dakorah MP. Bacterial contamination of donor blood at the Tamale Teaching Hospital, Ghana. *Afr Health Sci*. 2009; 9:13–8. [PubMed: 20842237]

11. Esmael A, Dagnew Z, Degu G. Bacterial contamination of stored blood ready for transfusion at a referral hospital in Ethiopia. *J Clin Res Bioeth.* 2014; 5:176.
12. Matte Aloysius GB, Joel B, Apecu R, Yap B, Byarugaba F. Bacterial contamination of blood and blood products at Mbarara Regional blood bank in rural South Western Uganda. *Advances in Infectious Diseases.* 2013; 3:205–9.
13. Ramirez-Arcos, S., Goldman, M. Bacterial Contamination. In: Popovsky, MA., editor. *Transfusion reactions.* Bethesda, MD: AABB Press; 2012.
14. Sonnekus PH, Louw VJ, Ackermann AM, Barrett CL, Joubert G, Webb MJ. An audit of the use of platelet transfusions at Universitas Academic Hospital, Bloemfontein, South Africa. *Transfus Apher Sci.* 2014; 51:44–52. [PubMed: 25457007]
15. Pitman JP, Wilkinson R, Liu Y, von Finckenstein B, Smit Sibinga CT, Lowrance DW, Marfin AA, Postma MJ, Mataranyika M, Basavaraju SV. Blood component use in a sub-Saharan African country: results of a 4-year evaluation of diagnoses associated with transfusion orders in Namibia. *Transfus Med Rev.* 2015; 29:45–51. [PubMed: 25573416]
16. Meza BP, Lohrke B, Wilkinson R, Pitman JP, Shiraishi RW, Bock N, Lowrance DW, Kuehnert MJ, Mataranyika M, Basavaraju SV. Estimation of the prevalence and rate of acute transfusion reactions occurring in Windhoek, Namibia. *Blood Transfus.* 2014; 12:352–61. [PubMed: 24333079]
17. Webert KE, Arnold DM, Lui Y, Carruthers J, Arnold E, Heddle NM. A new tool to assess bleeding severity in patients with chemotherapy-induced thrombocytopenia. *Transfusion.* 2012; 52:2466–74. quiz 5. [PubMed: 22486274]
18. Centers_for_Disease_Control_and_Prevention. National Healthcare Safety Network Biovigilance Component Hemovigilance Model Surveillance Model. 2013. www.cdc.gov/nhsn
19. Palavecino EL, Yomtovian RA, Jacobs MR. Bacterial contamination of platelets. *Transfus Apher Sci.* 2010; 42:71–82. [PubMed: 19939734]
20. McDonnell G, Russell AD. Antiseptics and disinfectants: activity, action, and resistance. *Clin Microbiol Rev.* 1999; 12:147–79. [PubMed: 9880479]
21. Centers_for_Disease_Control_and_Prevention. Guideline for Disinfection and Sterilization in Healthcare Facilities. 2008. http://www.cdc.gov/hicpac/disinfection_sterilization/6_Odisinfection.html
22. Ramirez-Arcos SM, Taha M, Schubert PS, Maurer EM, Jenkins CJ. NetCAD. Insights into bacterial survival and distribution during buffy coat platelet production. *Vox Sang.* 2015; 109:P-422.
23. Benjamin RJ, McDonald CP. Workgroup ITTIDB. The international experience of bacterial screen testing of platelet components with an automated microbial detection system: a need for consensus testing and reporting guidelines. *Transfus Med Rev.* 2014; 28:61–71. [PubMed: 24636779]
24. Pietersz RN, Reesink HW, Panzer S, Oknaian S, Kuperman S, Gabriel C, Rapaille A, Lambermont M, Deney V, Sondag D, Ramirez-Arcos S, Goldman M, Delage G, Bernier F, Germain M, Vuk T, Georgsen J, Morel P, Naegelen C, Bardiaux L, Cazenave JP, Dreier J, Vollmer T, Knabbe C, Seifried E, Hourfar K, Lin CK, Spreafico M, Raffaele L, Berzuini A, Prati D, Satake M, de Korte D, van der Meer PF, Kerkhoffs JL, Blanco L, Kjeldsen-Kragh J, Svard-Nilsson AM, McDonald CP, Symonds I, Moule R, Brailsford S, Yomtovian R, Jacobs MR. Bacterial contamination in platelet concentrates. *Vox Sang.* 2014; 106:256–83. [PubMed: 24654780]
25. Jacobs MR, Good CE, Lazarus HM, Yomtovian RA. Relationship between bacterial load, species virulence, and transfusion reaction with transfusion of bacterially contaminated platelets. *Clin Infect Dis.* 2008; 46:1214–20. [PubMed: 18444858]
26. Slichter SJ, Kaufman RM, Assmann SF, McCullough J, Triulzi DJ, Strauss RG, Gernsheimer TB, Ness PM, Brecher ME, Josephson CD, Konkole BA, Woodson RD, Ortel TL, Hillyer CD, Skerrett DL, McCrae KR, Sloan SR, Uhl L, George JN, Aquino VM, Manno CS, McFarland JG, Hess JR, Leissinger C, Granger S. Dose of prophylactic platelet transfusions and prevention of hemorrhage. *N Engl J Med.* 2010; 362:600–13. [PubMed: 20164484]
27. Kaufman RM, Djulbegovic B, Gernsheimer T, Kleinman S, Timmouth AT, Capocelli KE, Cipolle MD, Cohn CS, Fung MK, Grossman BJ, Mintz PD, Sesok-Pizzini DA, Shander A, Stack GE, Webert KE, Weinstein R, Welch BG, Whitman GJ, Wong EC, Tobian AA. Platelet Transfusion: A

- Clinical Practice Guideline From the AABB. *Ann Intern Med.* 2015; 162:205–13. [PubMed: 25383671]
28. Kumar A, Mhaskar R, Grossman BJ, Kaufman RM, Tobian AA, Kleinman S, Gernsheimer T, Tinmouth AT, Djulbegovic B, Panel APTG. Platelet transfusion: a systematic review of the clinical evidence. *Transfusion.* 2015; 55:1116–27. quiz 5. [PubMed: 25387589]
29. Nahirniak S, Slichter SJ, Tanael S, Rebull P, Pavenski K, Vassallo R, Fung M, Duquesnoy R, Saw CL, Stanworth S, Tinmouth A, Hume H, Ponnampalam A, Moltzan C, Berry B, Shehata N. International Collaboration for Transfusion Medicine G. Guidance on platelet transfusion for patients with hypoproliferative thrombocytopenia. *Transfus Med Rev.* 2015; 29:3–13. [PubMed: 25537844]
30. King KE, Shirey RS, Thoman SK, Bensen-Kennedy D, Tanz WS, Ness PM. Universal leukoreduction decreases the incidence of febrile nonhemolytic transfusion reactions to RBCs. *Transfusion.* 2004; 44:25–9. [PubMed: 14692963]
31. Tobian AA, King KE, Ness PM. Transfusion premedications: a growing practice not based on evidence. *Transfusion.* 2007; 47:1089–96. [PubMed: 17524101]
32. Savage WJ, Tobian AA, Savage JH, Wood RA, Schroeder JT, Ness PM. Scratching the surface of allergic transfusion reactions. *Transfusion.* 2013; 53:1361–71. [PubMed: 22998777]
33. Tobian AA, Savage WJ, Tisch DJ, Thoman S, King KE, Ness PM. Prevention of allergic transfusion reactions to platelets and red blood cells through plasma reduction. *Transfusion.* 2011; 81:1676–83.
34. McCullough J. Pathogen inactivation: a new paradigm for preventing transfusion-transmitted infections. *Am J Clin Pathol.* 2007; 128:945–55. [PubMed: 18024320]
35. Snyder EL, Stramer SL, Benjamin RJ. The safety of the blood supply--time to raise the bar. *N Engl J Med.* 2015; 372:1882–5. [PubMed: 25902384]

Previous studies evaluating the rate of bacterial contamination of whole blood and blood components in sub-Saharan Africa

Table 1

Study country (reference)	Year Study Conducted	Number WB/RBC units tested*	Platelet units tested	Gram positive organism detected	Gram negative organism detected	Total positive (%)
Ethiopia (11)	2013	120	---	10	5	15 (12.5%)
Ghana 1 (10)	2007	80	---	10	4	14 (17.5%)
Ghana 2 (7)	2008	192	22	15	11	26 (13.5%)
Kenya (9)	2006–2007	434	---	14 [‡]	24 [‡]	38 (8.8%)
Nigeria (6)	2009	160	2	14	0	14 (8.8%)
Uganda (12)	2012	510	---	18	0	18 (3.5%)
Zimbabwe (8)	2013	157	39	3 [#]	1 [#]	6 (3.1%)
Total		1553	63	84 (65% of positives)	45 (35% of positives)	125 (8.0%)

* Whole blood is abbreviated as WB

[‡] Approximate since 38 units/44 organisms; 64% gram negative

[#] The two units of RBC that had positive Grams stains, but Gram positive vs. Gram negative organisms were not specified

Table 2

Platelet bacterial screening results

Result	N (% units screened)	Gram staining results	Culture results	Comments
Negative	330 (97.9)	Negative	Negative	<ul style="list-style-type: none"> Median storage time - 2 days
True positive	1 (0.3)	Negative	<i>Streptococcus viridans</i>	<ul style="list-style-type: none"> Storage time - 4 days First culture positive at 24 hours Second culture done with only 0.5 mL - positive (identical) result No transfusion reaction. Patient was receiving antibiotic treatment.
Unconfirmed positives	3 (0.9)	All negative	<ul style="list-style-type: none"> Coagulase-negative <i>Staphylococcus</i> (1) <i>Bacillus</i> spp (2) 	<ul style="list-style-type: none"> Storage time - 3,3,4 days First cultures positive at 48–72 hours Second cultures done with only 0.5 mL - all negative No transfusion reactions. Patients were receiving antibiotic treatment.
Possible bacterial contamination	3 (0.9)	<ul style="list-style-type: none"> Gram-negative rod (1) Gram-positive rod (1) Gram-positive coccus (1) 	All negative	<ul style="list-style-type: none"> Storage time - 3,4,4 days Platelet units were not transfused For 2 of the 3 platelet units, chlorhexidine was used to disinfect the side sampler coupler

Table 3

Patient characteristics of individuals that had a platelet transfusion

Characteristics	
Age [*]	
0–18	25 (50.0%)
18+	25 (50.0%)
Sex [*]	
Male	27 (54.0%)
Female	23 (46.0%)
HIV status [*]	
Negative	39 (78.0%)
Positive	2 (4.0%)
Unknown	9 (18.0%)
Diagnosis [‡]	
Aplastic anemia	3 (6.0%)
Acute lymphoblastic leukemia	24 (48.0%)
Acute myeloid leukemia	12 (24.0%)
Non-Hodgkin's lymphoma	5 (10.0%)
Other solid tumor	5 (10.0%)
Patient platelet count prior to transfusion (median cells/uL, IQR) [‡]	10,900 (6,000–18,900)
Patient Bleeding Severity Measurement Scale status prior to transfusion [‡]	
0 - No bleeding	118 (78%)
1a/b - Trace/mild bleeding	30 (20%)
2a - Serious bleeding causing significant pain or intervention required	3 (2%)
2b/c - Serious bleeding causing significant morbidity/fatal bleeding	0 (0%)
Received chemotherapy within 14 days of platelet transfusion ^{‡,‡}	81 (53.6%)
Received antibiotic treatment within 2 days of platelet transfusion ^{‡,‡}	145 (96.0%)

^{*} Among the 50 patients, there were 151 platelet transfusion episodes

[‡] Data for one individual of the 50 individuals was not available for diagnosis, chemotherapy or antibiotic treatment

[‡] Calculated based on the 151 transfusion episodes. Among the episodes with bleeding, the median platelet count prior to transfusion was 6.1 (IQR 4.3–17.2) and the average was 12.3 +/- 12.5

Table 4

Platelet transfusion characteristics of 323 single donor units transfused to 50 patients

Platelet age at time of transfusion (median days, IQR)	2 (2 – 3)
Median single donor platelets transfused during each transfusion episode (IQR)	2 (2 –3)
ABO compatibility of platelet transfusion of the 323 units	
ABO identical	126 (39.0%)
ABO plasma compatible	110 (34.1%)
ABO plasma incompatible	87 (26.9%)

Table 5

Acute Transfusion Reactions in the 151 Transfusion Episodes

Case definition*	Number (%)	Imputability	Severity
Febrile non-hemolytic transfusion reaction [†] (7 definite, 1 possible)	8/151 (5.3)	3 probable 5 possible	All non-severe
Allergic transfusion reaction (2 probable)	2/151 (1.3)	2 definite	All non-severe
Transfusion associated dyspnea (1 definite)	1/151 (0.7)	1 definite	Non-severe
Total	11/151 (7.3)		

* Case definitions, imputability and severity as defined in CDC Hemovigilance criteria

[†] Blood cultures of platelet aliquots were negative for all implicated units; units/patients ABO isogroup except 1 group O unit given to 1 group B patient