RESEARCH IMPACT CASE STUDY

Canadian Blood Services
BLOOD PLASMA STEM CELLS ORGANS & TISSUES

Mitigating risks of bacterial contamination in transfusion

What was achieved?

Over the last two decades, our research team has studied the growth of bacteria in blood components during storage. Although rare, bacterial contamination of blood components creates a significant risk of infection to transfusion recipients. The team's groundbreaking research has led to changes at Canadian Blood Services and internationally that have resulted in enhanced safety measures and innovations in blood products.

How was this achieved?

The most common bacteria that contaminate blood products come from people's skin and are likely introduced at the time of blood donation. Historically, bacteria that live on the skin, like *Staphylococcus epidermidis*, were considered harmless. But in 2007, our research team was the first to discover that these bacteria attach to surfaces when platelets — the component of blood that helps it clot — are stored, creating what are known as biofilms (Greco et al., 2007). Related studies identified other bacteria that can form biofilms during platelet storage, including the bacteria most likely to cause complications for people who need blood transfusions, like *Staphylococcus aureus* and *Serratia marcescens* (Greco-Stewart et al., 2012).

The team recently uncovered new information about how bacteria change at the molecular level when they grow in platelet concentrates (Loza-Correa et al., 2021). Unlike red blood cells and plasma, which are stored at cold temperatures, platelets are stored at room temperature. The warmer storage temperature for platelets increases the risk that bacteria will spread and contaminate the blood product. The molecular changes that happen in bacteria during platelet storage increase the production of toxins, resistance to antibiotics, and secretion of molecules that trigger inflammation — findings with important implications for transfusion recipients (Chi et al., 2023).

What was the impact and outcome?

The evidence generated by our research team has been documented in over 90 peer-reviewed research papers over the last two decades and has led to several improvements in Canadian Blood Services' processes.

This research has changed the way donor skin is disinfected during donation (Ramirez-Arcos & Goldman, 2010) and revealed skin factors that affect efficient donor skin disinfection (Kumaran & Ramirez-Arcos, 2024). It has supported the implementation of sterility testing of blood components and cord blood and stem cell products (Ramirez-Arcos et al., 2015). It has underpinned a decision to extend the shelf life of platelet components from five to seven days (Ramirez-Arcos et al., 2020).

Dr. Sandra Ramirez-Arcos (left) pictured with Dilini Kumaran (right) in one of Canadian Blood Services' labs in Ottawa

Our work has changed the paradigm of what we used to call 'harmless' platelet contaminants. We are proud of our cumulative work revealing that platelet storage makes bacteria more virulent with potential safety implications for transfusion patients.

Dr. Sandra Ramirez-Arcos,
Senior scientist, Canadian Blood Services

And it has supported the development of new blood products, such as cold-stored whole blood (Ramirez-Arcos et al., 2022). Notably, in 2016 the team's work led to an important change in a CSA Group (formerly the Canadian Standards Association) standard, doubling the length of time that red blood cells can be exposed to uncontrolled temperatures from 30 to 60 minutes (Ramirez-Arcos et al., 2016).

Our research team's expertise also equips Canadian Blood Services to address challenges related to emerging pathogens. Future work includes exploring the risk of transfusing blood components contaminated with tick-borne bacteria like *Anaplasma phagocytophilum*. This work will complement our current surveillance activities as tick populations expand northward with climate change.

Bibliography

Chi, S.I., Yousuf, B., Paredes, C., Bearne, J., McDonald, C., & Ramirez-Arcos, S.(2023). Proof of concept for detection of staphylococcal enterotoxins in platelet concentrates as a novel safety mitigation strategy. *Vox Sanguinis*, *118*(7), 543–550. https://doi.org/10.1111/vox.13440

Greco, C., Martincic, I., Gusinjac, A., Kalab, M., Yang, A.-F., & Ramirez-Arcos, S.(2007). Staphylococcus epidermidis forms biofilms under simulated platelet storage conditions. *Transfusion*, *47*(7), 143–1153. https://doi.org/10.1111/j.1537-2995.2007.01249.x

Greco-Stewart, V.S., Brown, E.E., Parr, C., Kalab, M., Jacobs, M.R., Yomtovian, R.A., & Ramirez-Arcos, S. (2012). Serratia marcescens strains implicated in adverse transfusion reactions form biofilms in platelet concentrates and demonstrate reduced detection by automated culture. *Vox Sanguinis*, *102*(3), 212–220. https://doi.org/10.1111/j.1423-0410.2011.01550.x

Kumaran, D. & Ramirez-Arcos, S. (2024). Sebum components dampen the efficacy of skin disinfectants against Cutibacterium acnes biofilms. *Microorganisms*, *12*(2), 271. https://doi.org/10.3390/microorganisms12020271

Loza-Correa, M., Yousuf, B., & Ramirez-Arcos, S. (2021). Staphylococcus epidermidis undergoes global changes in gene expression during biofilm maturation in platelet concentrates. *Transfusion*, *61*(7), 2146–2158. https://doi.org/10.1111/trf.16418

Ramirez-Arcos, S., Evans, S., McIntyre, T., Pang, C., Yi, Q., DiFranco, C., & Goldman, M. (2020). Extension of platelet shelf life with an improved bacterial testing algorithm. *Transfusion*, *60*(12), 2918–2928. https://doi.org/10.1111/trf.16112

Ramirez-Arcos, S., & Goldman, M. (2010). Skin disinfection methods: Prospective evaluation and postimplementation results. *Transfusion*, *50*(1), 59–64. https://doi.org/10.1111/j.1537-2995.2009.02434.x

Ramirez-Arcos, S., Kou, Y., Ducas, E., & Thibault, L. (2016). Changing the 30-min rule in Canada: The effect of room temperature on bacterial growth in red blood cells. *Transfusion Medicine and Hemotherapy*, *43*(6), 396–399. https://doi.org/10.1159/000445753

Ramirez-Arcos, S., Kou, Y., Kumaran, D., Culibrk, B., Stewart, T., Schubert, P., &McTaggart, K. (2022). Assessment of bacterial growth in leukoreduced cold-stored whole blood supports overnight hold at room temperature prior to filtration: A pilot study. *Vox Sanguinis*, *117*(5), 678–684. https://doi.org/10.1111/vox.13246

Ramirez-Arcos, S., Kou, Y., Yang, L., Perkins, H., Taha, M., Halpenny, M., & Elmoazzen, H. (2015). Validation of sterility testing of cord blood: Challenges and results. *Transfusion*, *55*(8), 1985–1992. https://doi.org/10.1111/trf.13050