Routing for Social Good: Optimizing Human Milk Bank Logistics

Abstract

This case challenges students to optimize donor milk collection for a human milk bank using real-world data. Students develop routing and scheduling models to minimize travel time while ensuring timely pickups. Variations of the case introduce predictive time series models to forecast donation volumes, enabling smarter collection plans. Ideal for analytics, OR, or supply chain courses, the case blends logistics, forecasting, and public health impact.

Introduction

Human milk banks are specialized healthcare organizations that collect, screen, pasteurize, and distribute donated breast milk to medically vulnerable infants, especially those in Neonatal Intensive Care Units (NICUs). These infants, often born prematurely or with serious health complications, have underdeveloped digestive and immune systems that make them particularly susceptible to infections and life-threatening conditions. When a mother's own milk is unavailable due to medical, logistical, or personal reasons, donor human milk is widely recognized as the next best alternative.

Extensive clinical research has demonstrated that donor milk provides critical health benefits. It significantly reduces the risk of severe conditions such as necrotizing enterocolitis (NEC), sepsis, and overall infant mortality—complications that disproportionately affect preterm newborns ([1]; [2]). Because of this, the American Academy of Pediatrics and other leading healthcare organizations strongly recommend pasteurized donor human milk over infant formula when maternal milk is not an option.

In response to this growing body of evidence and increasing demand from hospitals and NICUs, milk banks have become essential components of modern neonatal care. Across the United States, they work tirelessly to maintain rigorous safety protocols while ensuring a reliable and equitable supply of donor milk. However, this life-saving work also presents complex logistical challenges—from screening donors and managing frozen inventory to coordinating efficient collection and distribution networks. As the demand for donor milk continues to rise, milk banks are increasingly turning to data science, optimization, and operational analytics to strengthen their impact and sustainability.

Milk Bank Operations

The donor milk journey begins with a thorough screening process to ensure safety and quality. Prospective donors complete a detailed health history questionnaire, undergo blood testing for infectious diseases (e.g., HIV, hepatitis B/C, syphilis), and receive approval from a healthcare provider. These safeguards mirror protocols used in blood donation.

Once approved, donors are given supplies and instructions for safe milk collection. They pump, label, and freeze their milk at home (Figure 1). When ready, donations are either dropped off at a local milk depot—often located in hospitals or clinics—or shipped directly to the milk bank in insulated packaging.

Upon arrival, donations are logged, stored in medical-grade freezers, and scheduled for processing. The milk is thawed, pooled into standardized batches, and tested for bacteria. Batches that pass safety checks undergo Holder pasteurization (62.5°C for 30 minutes), which kills pathogens while preserving key nutrients.

After pasteurization, the milk is re-tested, refrozen, labeled, and stored until distribution. Hospitals place orders based on NICU needs, and traceability is maintained throughout. Every step is designed to ensure the milk remains safe, potent, and life-saving for medically fragile infants.

Figure 1: Frozen and labeled breast milk bags.

While milk banks maintain highly controlled protocols for processing, pasteurizing, and distributing donated milk, the front end of their operations depends entirely on a consistent and timely inflow of donations from approved mothers. This supply chain begins not with trucks or freezers, but with human generosity—and ensuring that donors can easily contribute is fundamental to the entire system's success.

For many donors, accessibility starts with the availability of nearby milk depots. These depots serve as critical drop-off points, enabling mothers to deliver their frozen milk

without the burden of long-distance travel or complex shipping arrangements. Far from high-tech infrastructure, a depot is often as simple as a commercial-grade freezer, placed in a hospital lobby, community health center, or clinic hallway—locations selected for both accessibility and trust. As shown in Figure 2, the setup is modest, but its role in the system is indispensable.

The Oklahoma Mothers' Milk Bank (OMMB), for instance, operates an expansive network of 36 depots distributed across multiple states (Figure 3), providing regional coverage to maximize donor convenience. Once a donor's freezer at home is full, she can bring her labeled, stored milk to the nearest depot, where it will be safely held until it is collected by the milk bank's logistics team.

However, each depot has a fixed storage capacity, and when that freezer fills up, donations must be turned away—a deeply unfortunate scenario, both in terms of lost milk and donor discouragement. To prevent this, milk banks must manage pickups efficiently and proactively, based on both forecasted and real-time donation volumes.

That responsibility falls on the logistics team, typically located at milk bank headquarters. Their task is to coordinate pick-up schedules and optimize routing across dozens of depots, often spanning hundreds of miles. The goal is to strike a careful balance: collect frequently enough to avoid overflows, but not so frequently that resources are wasted on underutilized routes. This is not a simple calendar scheduling problem—it is a dynamic optimization challenge rooted in real-time data, geographic dispersion, donor behavior patterns, and operational constraints such as freezer capacity, travel time, and staff availability.

As the demand for donor milk continues to grow, solving this logistical puzzle becomes increasingly important—not just to streamline operations, but to ensure that every safe, nourishing drop of human milk can reach the infants who need it most.

Problem Statement

Milk banks must decide how to create efficient milk collection plans that keep costs low while ensuring milk is collected while the depot freezer still has space. The plans consist of deciding when to collect the milk from depots, which depots should be visited for milk pick up and which should ship donations directly to the bank.

This presents a classic logistics challenge: balancing service frequency, travel time, depot volume, and operational capacity. Collecting milk from depots too often wastes resources, while infrequent collections can lead to storage overflows, rejected donations, or expired milk. Donor milk typically has a shelf life of six months when kept frozen, so collecting and processing it promptly is critical. The goal is to develop a collection schedule, and shipping and routing plan that maximizes efficiency without compromising safety or service. At its core, this problem blends vehicle routing and inventory management, topics commonly studied in operations research, but with especially high

Figure 2: Typical chest freezer containing donated frozen milk.

stakes, as these decisions directly impact the health of vulnerable infants relying on donor milk.

In this case study, you'll take on the role of a data science team supporting a milk bank's logistics team. Your task is to use real-world data and optimization techniques to design efficient pickup schedule and routing plans for donor milk depots. You'll need to consider factors like depot volume, travel time, milk expiration, and cost constraints to ensure timely collection without overburdening resources. The goal is to help the milk bank make data-driven decisions that keep the process of collecting milk from donation depots running smoothly and maximize the amount of milk delivered to infants in need. Through this exercise, you'll see how data science can be applied to solve complex, real-world logistics challenges, and make a tangible difference in public health.

The Available Data

The available dataset includes a comprehensive list of all depots currently operated by OMMB (Depot Information), along with historical milk donation records for each

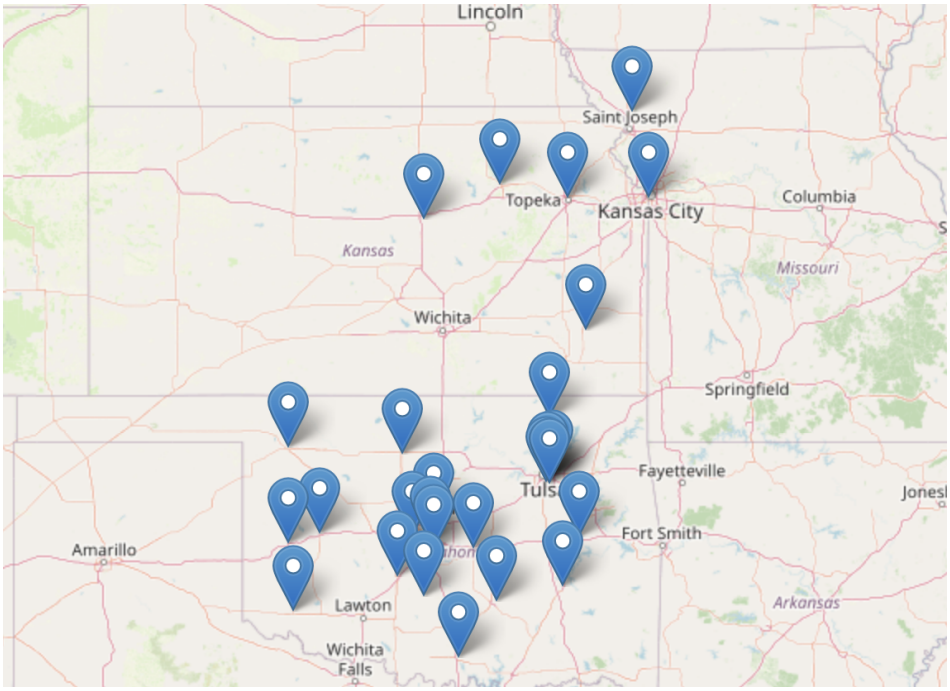

Figure 3: OMMB Depots.

depot from 2023 and 2024 (Deposits Transactions 2023 2024). Additionally, note that the typical storage capacity of a chest freezer at each depot is approximately 1,000 ounces. Furthermore, milk collection is carried out by a single driver operating one truck, which is stationed at the main milk bank. The driver's daily operations are constrained to a maximum driving duration of 12 hours per day.

References

[1] *American Academy of Pediatrics. (2012). Policy statement: Breastfeeding and the use of human milk. Pediatrics, 129(3), e827–e841. https://doi.org/10.1542/peds.2011-3552*

[2] *Colaizy, T. T., Carlson, S., Saftlas, A. F., Morriss, F. H. (2016). Growth and development in very low birth weight infants after receiving predominantly donor human milk or maternal milk diets: A randomized controlled trial. Archives of Disease in Childhood - Fetal and Neonatal Edition, 101(1), F3–F8. https://doi.org/10.1136/archdischild-2014-307691*