Blood Management is of general human and societal interest. Dutch blood donations roughly involve 750,000 yearly voluntary donations. These encompass decision making and trade-offs as of general managerial interest as shown on the right.

It will be highlighted how the so-called field of Operations Research (OR) (a mathematical discipline for logistical problems) and techniques from this area can provide quantitative and formal support. The results are real-life based on Dutch Blood Supply.

1. Blood Inventory

1.1 Platelet logistics
- No production in weekends and holidays
- Uncertain demand (over 50%)
- Shelf life = 4, 5, 6, or 7 days

Goal
- Outdating: 15-20%

1.2 Approach

Step 1. Stochastic Dynamic Programming

\[ d: \text{ the day of the week } (d = 1,2,...,7) \]
\[ x: (x_1, x_2, ..., x_5) = \text{ the inventory state with} \]
\[ x_r = \# \text{ pools with residual shelf life of } r \text{ days}. \]
\[ V_n(d, x): \text{ minimal expected costs over } n \text{ days, with } V_0(\cdot, \cdot) = 0. \]
\[ V_n(d, x) = \min_k \sum_b p_b (b) \left( \frac{(b - \sum_r x_r) + c^s}{\sum_r x_r - b} + c^o \right) \]
\[ V_{n-1}(d+1, x+b+k) \]

Step 2/3. Simulation and validation of SDP: simple rule

1.3 Results
- Optimal ⇒ Simple rule
- Shortage ⇒ 0.1%
- Outdating ⇒ 1%

2. Blood Donor Delays

2.1 Collection sites
- Dutch (≈ 50) sites
- 750,000 donations
- Stochastic durations

Goal
- Minimize Staffing ⇒ Waiting delays

2.2 Approach

Step 1. Transient queuing analysis

\[ \mathbb{P}[W_i > t] = \frac{1}{2} \left( C_x^2 + C_y^2 \right) e^{-(1-\rho) \lambda t} \]

Step 2. Flexible (2 - 8 hours) shifts

\[ \min \sum_{i=\text{mon}}^{T} \sum_{d=1}^{7} x_{ij} \]
\[ s.t. \sum_{j=1}^{T} b_{jk} x_{ij} \geq a_{ik} \forall d, k \]

2.3 Results
- 3 real-life blood collection sites (S,M,XL)
- Staffing: Delay (waiting times)
  - 0 - 40%
  - 20 - 70%

3. Selective Donor Recruitment

3.1 Next of kin
- Arbitrary population
- Donor relatives useful?
- Genotype distributions standardly unknown

Goal
- Effectiveness of selective recruitment (e.g. siblings, parents)

3.2 Approach

Step 1. Step-up-down

\[ \mathbb{P}[y_i | y_i] = \sum_{y_0 \in \Phi} \mathbb{P}[y_0 | y_i] \cdot \mathbb{P}[y_0] \]

Step 2. Solving stochastic quadratic equation

\[ x: \text{ genotype distribution} \]
\[ x_{\text{father}}^T \cdot P \cdot x_{\text{mother}} = x_{\text{child}} \Rightarrow x^T P x = x \]

3.3 Results
- Approach applicable for arbitrary blood groups (> 300)

Conclusion: The mathematical discipline of Operations Research (OR) offers concepts and techniques (tooling) to balance (and optimize) capacities and service per.

