Health Care Manag Sci
DOI 10.1007/s10729-016-9370-6

Simulation-optimization model for production planning in the blood supply chain

Andres F. Osorio[1,2] · **Sally C. Brailsford**[1] · **Honora K. Smith**[3] · **Sonia P. Forero-Matiz**[4] · **Bernardo A. Camacho-Rodríguez**[4]

Received: 1 October 2015 / Accepted: 24 May 2016

Abstract Production planning in the blood supply chain is a challenging task. Many complex factors such as uncertain supply and demand, blood group proportions, shelf life constraints and different collection and production methods have to be taken into account, and thus advanced methodologies are required for decision making. This paper presents an integrated simulation-optimization model to support both strategic and operational decisions in production planning. Discrete-event simulation is used to represent the flows through the supply chain, incorporating collection, production, storing and distribution. On the other hand, an integer linear optimization model running over a rolling planning horizon is used to support daily decisions, such as the required number of donors, collection methods and production planning. This approach is evaluated using real data from a blood center in Colombia. The results show that, using the proposed model, key indicators such as shortages, outdated units, donors required and cost are improved.

Keywords Production planning · Blood supply chain · Blood collection · Simulation · Optimization

✉ Andres F. Osorio
Afo1e13@soton.ac.uk

[1] Southampton Business School, University of Southampton, Southampton SO17 1BJ, UK

[2] Universidad Icesi, Calle 18 No. 122 - 135, Cali, Colombia

[3] Mathematical Sciences, University of Southampton, Southampton SO17 1BJ, UK

[4] Hemocentro Distrital, Cra. 32 No 12 - 81, Bogotá, Colombia

1 Introduction

The blood supply chain involves the collection, production, storing and distribution of blood and its components. Special features make the blood supply chain different from typical industrial supply chains and render it a very challenging study area. In many countries, blood is considered a highly scarce resource since only a small percentage of the eligible population actually donates blood. In the US this percentage is about 10 %; however, in medium- and low-income countries this rate is much lower [1]. A recent review by Osorio et al. [2] includes 110 papers containing quantitative models that study different aspects of the blood supply chain, and identifies several gaps in this literature. In particular, only eight of the 110 papers focus on the production stage. In this paper we address this research gap and present an integrated simulation-optimization model to support strategic and operational decisions in production planning in the blood supply chain.

The most common collection method is called whole blood donation, which consists of extracting approximately 450 ml of blood from a donor into a collection bag. There are different types of collection bag, each yielding different blood products. The whole blood is centrifuged and, depending on the type of bag used for collection, is *fractionated* (split up) into different components such as red blood cells (RBCs), platelets, cryoprecipitate and plasma. An alternative collection method is apheresis, which directly withdraws a single blood component from a donor. Apheresis is considerably more efficient than fractionation, but has the disadvantages of higher costs and longer collection times. The chosen collection method largely determines the production method, with the exception of blood units

Published online: 04 June 2016