Management of Plasma Donation System: Literature Review

Introduction

Applying optimization methods to healthcare management and logistics is a developing research area with numerous studies. Specifically, facility location, staff rostering, patient allocation, and medical supply transportation are the main themes analysed. Optimization approaches have been developed for several healthcare related problems, ranging from the resource management in hospitals to the delivery of care services in a territory. However, optimization approaches can also improve other services in the health system that have been only marginally addressed, yet. One of them is the Plasma Donation (BD) system, aiming at providing an adequate supply of Plasma to Transfusion Centres (TCs) and hospitals.

Plasma is necessary for several treatments and surgeries, and still a limited resource. The need for Plasma is about ten million units per year in the USA, 2.1 in Italy and 2 in Turkey; moreover, people still die in some countries because of inadequate supply of Plasma products (World Health Organization 2014). Hence, BD plays a fundamental role in healthcare systems, aiming at guaranteeing an adequate Plasma availability to meet the demand and save lives. In Western countries, Plasma is

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Generally, there are two types of donations: whole-Plasma donation, in which the whole Plasma is directly collected in a plastic bag, and *apheresis*, i.e., the donation of specific components in which a mechanical gathering unit decays the required Plasma parts.

Plasma requires particular precautions for collection and storage, and its shelf life from donation to utilization is limited, thus requiring a continuous feeding of the system (Greening et al. 2010). Hence, a successful BD supply chain should meet the daily demand of Plasma and follow its temporal pattern. According to Sundaram and Santhanam (2011), BD supply chain and the related management problems can be classified based on the main phases of a Plasma bag life: donor registration, Plasma collection, Plasma screening/evaluation, inventory storage and delivery. A slightly different classification is proposed in Pierskalla (2004), according to which the management of BD supply chain concerns both strategic decisions (e.g., location of Plasma centres) and tactical operational decisions (e.g., production of multiple products, control of inventory levels, Plasma allocation to hospitals, and delivery to multiple sites). In our review, we refer to the first classification scheme.

Phases of Plasma Donation System

BD supply chain can be divided into four main steps, as reported in Fig.1: collection, transportation, storage and utilization. First, the Plasma is collected: donors are checked in Plasma centres to assess their eligibility and, if eligible, they make the donation. Once the Plasma is gathered, tests are independently performed on each individual's Plasma in order to prevent infectious diseases (screening process). Afterwards, the Plasma is transported and stored. Components are then distributed to the hospitals based on their inventory needs. Finally, it is transferred to the final users for transfusion.

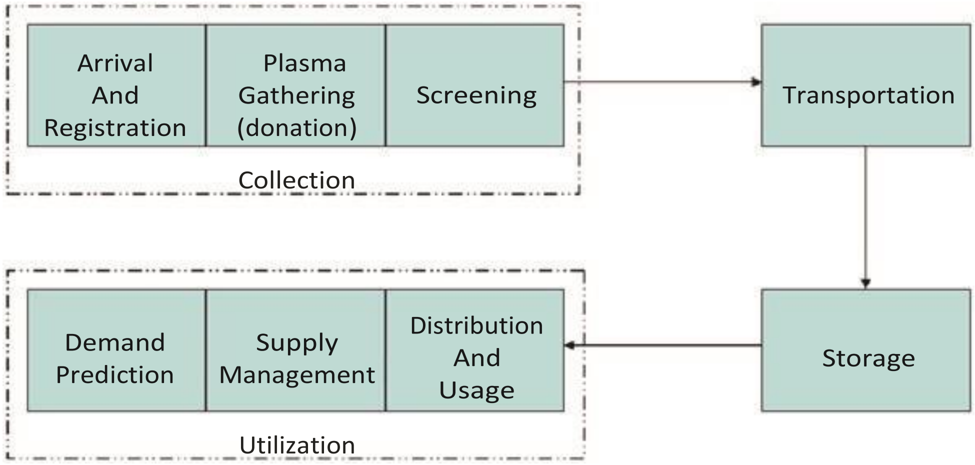

Fig. 1 Phases of the life cycle of a Plasma bag

Donors, Plasma Collection and Screening

BD process starts with the arrival of the donor at the Plasma center. Donors can be divided in returning donors, who donate on an almost regular basis, and walk-in donors, who are entering the system occasionally or for the first time. In any case, donations can be made after a defined rest period from the previous one, which is defined by law. As donors have a crucial importance in the system, their availability, frequency and motivation have been studied from both a statistical and a social perspective.

Social Aspects The main reasons for Plasma donation and their relative importance have been studied by Bani and Giussani (2011). Moreover, it is also documented that the organization of Plasma collection phase may have an impact on donors' availability. Poor treatment, poor staff skills, and a bad experience are the main reasons of not returning to donate (Schereiber et al. 2003). Also prolonged queuing times are negatively correlated to BD satisfaction (McKeever et al. 2006; Katz et al. 2007). Hence, a well-organized donation management has a strong impact on the availability of Plasma bags, and also on donors' motivation, thus possibly increasing/decreasing their availability.

Donor Arrival and Registration When a donor enters in the system for the first time, he/she is requested to provide personal (e.g., name, address, age, job, gender) and medical/health (e.g., diagnosis, lab results, treatments) data, which are digitally collected. Digital registration provides a good traceability of the transfusion cycle, from collection to Plasma distribution and transfusion. The registration also includes a visit from a physician, followed by Plasma exams. If the donor is eligible, Plasma collection centres check that he/she makes the first donation within few days from the declaration of eligibility. Sometimes, the first visit is directly followed by a donation. A visit is also made before each donation or exam, during which the donor is re-evaluated and his/her personal data are updated.

Several management problems arise, both at a planning level (e.g., Plasma collection centre location or staff dimensioning) and at an operational level (e.g., appointment scheduling). However, only few papers focus on optimization issues arising in the registration and donation phase, despite the strong impact of donors' arrivals on the overall system performance. Michaels et al. (1993) developed a simulation study to evaluate scheduling strategies of donors arriving at a Red Cross Plasma drive, and compared these strategies in terms of donors' mean transit time to find out the most effective one.

Other papers focus on estimating the supply of Plasma from donations, considering annual donor retention rates, donor recruitment rates, and mean numbers of donations per donor and per year . Ritika and Pau (2014) examined different classification algorithms to find out a fair classification technique for the prediction of donations. Flegel et al. (2000) developed a logistic regression model to compute the donation probability within a given time frame, considering different regression coefficients for walk-in and returning donors. Ferguson and Bibby (2002) used a prospective design to predict the number of future Plasma donations. Boonyanusith and Jittamai (2012) investigated the pattern of donors' behaviors based on factors influencing Plasma donation decision using a questionnaire.

Finally, on-line applications and database systems for donors' and bags management are also investigated (Chau et al. 2010; Khan and Qureshi 2009; Kulshreshtha and Maheshwari 2011).

Plasma Collection and Screening Plasma collection centres should be located according to their accessibility from hospitals in order to improve the overall system performance. Moreover, centres are generally subject to regulatory control, designed to ensure the maximum quality and safety of Plasma products. They guarantee that Plasma bags are produced according to standardized procedures, to achieve consistency of each product (Council of Europe 2007).

Despite the importance of this phase, the literature on Plasma collection system planning is rare (Ofori et al. 2005; WHO 2008; Lieshout-Krikke et al. 2013). De Angelis et al. (2003) proposed a stochastic methodology to analyse and certify the optimal configuration of servers by integrating simulation and optimization for a transfusion centre in Rome.

After collection, the screening phase starts with few tests performed against infectious diseases, e.g., HIV, Hepatitis B and C, and syphilis. They are repeated on each gathered Plasma sample, and are generally the same all around the world. Based on screening results, the Plasma bag is either released for clinical and manufacturing use or discarded (WHO 2008, 2010). An effective, well-organized screening program and a good quality system are essential for provisioning safe Plasma bags to patients and meeting the transfusion requirements.

LITERATURE SURVEY

In year 2015, a IEEE paper on A Health-IoT Platform Based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor and Intelligent Medicine Box was authored by Geng Yang, Li Xie, Matti Mantysalo, Xiaolin Zhou, Zhibo Pang, Li Da Xu, Sharon Kao-Walter, Qiang Chen, Lirong Zheng. In this paper, an intelligent home-based healthcare platform is proposed and implemented. It involves iMedBox with connectivity, iMedPack with communication capability enabled by RFID, Bio-Patch and SOC. It fuses with IoT.

The body-worn Bio-Patch can detect and transmit the users bio-signals to the iMedBox in real time. The only limitations are, comprehensive platform missing. And the Physical size, rigid nature and short battery become limitation for long term use.

In 2016, an IEEE paper was authored on Data Mining for Better Healthcare: A Path towards Automated Data Analysis? By Tania Cerquitelli,Elena Baralis, Lia Morra and Silivia Chiusano. This paper addresses the mining activity from the medical database perspective. The mining system should be able to devise which knowledge could be most interesting to the user extract actionable knowledge from large medical dataset with minimal user intervention. System should be capable of yielding actionable knowledge extracting manageable sets. Large parameter spaces need to be explored at abstraction level to envision a system capable of evaluating and comparing many data-mining technique configurations at a time.

In 2015, a IEEE paper on Mobile Based Healthcare Management using Artificial Intelligence was authored by Amiya Kumar Tripathy, Rebeck Carvalho, Keshav Pawaskar, Suraj Yadav, Vijay Yadav. In this paper, the health-care management system is proposed which will consist of mobile based heart rate measurement so that the data can be transferred and diagnosis based on heart rate can be provided quickly with a click of button. The system will consist of video conferencing to connect remotely with doctor. The system will also consist of Doc-Bot and an online Blood Bank. In this implemented project, heart rate calculation differs from actual one due to noise present in input signal. So the performance is not efficient in practical. Methodology used Clustering, Text Mining, Pattern Matching, Support Vector Machine, Partitioning Algorithm and DonorHART tool used in collecting donor reaction information. Limitations are Difficulty in handling emergency situation and No proper security for personal details misuse.