MedCrave
Step into the World of Research
Biometrics & Biostatistics International Journal

Research Article
Open Access
CrossMark

Mathematical model to obtain the adjustment equation, blood donation/energy consumption in Cienfuegos blood bank

Abstract

In Cienfuegos Blood Bank, the research problem of electric energy consumption versus the number of daily blood donations is presented due to fluctuations and non-compliance with the Cuban Norm 299 of MINSAP. In the present work, the situation of blood donations is analyzed, its components, a database of donations in the last 5 years is created and the Least Squares Method is applied to obtain the polynomial adjustment equation: electricity consumption/number of donors, which will allow further studies on the subject. The objective of the research is to find the equation that best fits the relation energy consumption/number of donors in the Cienfuegos Blood Bank. This equation serves as a basis for future research on the mathematical modeling of the donation process in the Cienfuegos City Blood Bank.

Keywords: donations, simulation, electrical consumption, mathematical models

Volume 12 Issue 4 - 2023

David Loreno Calles,[1] C Manuel Cortés Cortés[2]
[1]Cienfuegos Blood Bank, Cuba
[2]University of Cienfuegos, Cuba

Correspondence: Manuel Cortés Cortés Cortés, Consultant Professor, University of Cienfuegos, Cuba
Email corte2m@gmail.com

Received: June 30, 2023 | **Published:** July 13, 2023

Introduction

The Provincial Blood Bank of Cienfuegos, belonging to the Ministry of Public Health, is an institution established in the province of Cienfuegos since 1965. The Blood Bank has the necessary equipment to carry out its productions with efficiency, safety and quality. A team of highly competent professionals, made up of physicians and technologists specialized in transfusion medicine and clinical laboratory and other professionals from different branches of knowledge, make up the human capital of the institution.

The Blood Bank has a functional distribution in its three floors, a large waiting room for donors, and other facilities for the collection of blood and plasma by automated apheresis. The mobile units bring the services closer to the donor, through visits to the different municipalities of the province of Cienfuegos. The area for the processing of blood or elaboration of blood components and/or serum, has the necessary equipment to carry out its productions with quality.

It has several laboratories

Immunohematology Laboratory, Seroepidemiological Laboratory, Clinical Laboratory and Physical-Chemical Quality Control and Microbiological Laboratory. From the administrative point of view, it functions as a Provincial Budgeted Unit, with an annual budget of more than half a million pesos.

Main processes developed

1. Blood and plasma donation.
2. Certification of blood by the Seroepidemiological Laboratory.
3. Certification of blood by the Immunohematology Laboratory.
4. Physical, chemical and microbiological quality control.
5. Blood components production process.
6. Traceability and release of blood components.
7. Blood dispatch.

Different blood components that are elaborated

1. Modified whole blood.
2. Erythrocyte concentrate.
3. Erythrocyte concentrate poor in leukocytes.
4. Concentrate of washed erythrocytes.
5. Leukocyte concentrates for clinical use.
6. Leukocyte concentrates for interferon production.
7. Platelet concentrate.
8. Cryoprecipitate.
9. Frozen plasma.
10. Fresh frozen plasma
11. Frozen plasma for fractionation.
12. Anti-tetanus hyperimmune plasma.
13. Anti-D hyperimmune plasma.
14. Anti-rabies hyperimmune plasma.
15. Serum.
16. Anti A, Anti B, Anti AB and Anti D hemoclassifying serum.

Blood donations have multiple benefits for the donor's health such as: Balancing iron levels in the blood,

Reducing the risk of heart attacks and cardiovascular accidents. Each year worldwide, blood transfusions and blood products help save millions of people, increase the life expectancy and quality of life of patients with life-threatening diseases and support complex medical and surgical procedures.

Method

Blood donations help to save lives and improve health. Here are some examples of people who need transfusions:

1. Women with obstetric complications (ectopic pregnancies, hemorrhage before, during or after delivery, etc.).
2. Children with severe anemia, often caused by malaria or malnutrition.
3. People with severe trauma caused by natural and man-made disasters.
4. Patients undergoing complex surgical and medical interventions and cancer patients.

Blood is the most valuable gift we can give to another person: the gift of life. The decision to donate blood can save a life, or even several lives if the blood is separated into components - red blood cells, platelets and plasma, which can be used individually for patients with specific diseases.

Donation screening

Blood bank services will promote voluntary, altruistic and repetitive blood donation through population education programs. Donors will undergo a screening process, which includes a medical interview and physical examination, to ensure that they meet established donor screening standards, in addition to a pre-donation laboratory test consisting of hemoglobin and hematocrit and blood type.

Collection

The supplies used for the donation must be sterile and disposable. Blood will be collected using aseptic methods and in closed sterile systems (blood collection bags must be transparent, sterile and with clear anticoagulant).

Analysis

The methodology used to evaluate the diseases that can be transmitted by transfusion of blood products has evolved rapidly in conjunction with all the technological advances. Over the years, techniques have been incorporated to detect new infectious agents and technology will evolve more and more every day. The tests that are mandatory to be performed to each blood donor are:

1. Hbsag (Surface Antigen)
2. Hbcore (Anti-Core Hepatitis B)
3. H.C.V (Hepatitis C Virus)
4. H.I.V (Human Immunodeficiency Virus)
5. CHAGAS (Chagas disease)
6. SIFILIS.
7. Irregular antibody screening (Indirect antiglobulin test).

Processing

Blood can be separated into different components.

1. Red blood cells
2. Plasma
3. Platelets
4. Cryoprecipitate of factor VIII and fibrinogen

All the efforts and work carried out in transfusion medicine services and blood banks to obtain, analyze and process the different blood products necessary for correct transfusion medicine, have their purpose in the transfusion act and the repercussion on the health of the person for whom they have been requested (Figure 1).

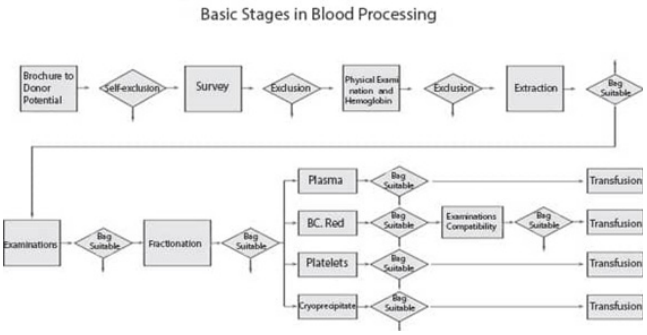

Figure 1 More complex production process of blood and components.

Behavior of the organization's energy matrix

The graph below shows the distribution of the organization's energy matrix, expressed in tons of oil equivalent. The most important carrier is electrical energy (91.7%). It is this energy carrier that should receive greater attention (Figure 2).

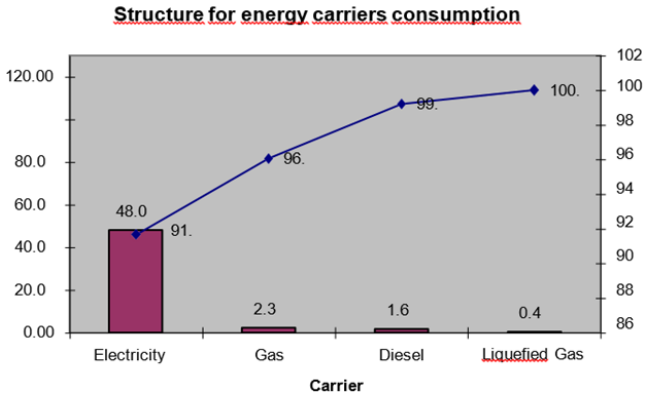

Figure 2 Energy carriers, statistical energy information.

Energy carriers statistical energy information. At the international level, several studies have been found[1] that relate the cost of production of the blood bank, but they do not focus on electricity consumption, but rather on the expenses incurred in supplies, workers' salaries and equipment.

Historical background of mathematical models used in other blood banks

Thesis work by Benites,[2] entitled Analysis and improvement of the operational process of the blood donation service in a blood bank in Piura applying discrete simulation, thesis of the University of Piura. In the work carried out by the authors,[3] the first results obtained from the application of the Total Efficient Energy Management Techniques Methodology in the International Health Center "La Pradera" are presented.

Article by Arboleda Zúñiga,[4] on Mathematical and Stochastic Models for inventory control in Blood Bank. Lozano,[5] Blood Donation Campaigns: Simulation model based on system dynamics, degree thesis, ICESI University Faculty of Engineering Industrial Engineering Program Cali. Lezaun,[6] Optimization of platelet concentrates production in blood bank, master´s degree thesis, Universidad Zaragoza. In Sánchez Torres,[7] it is appreciated that the procedures observed were mainly focused on controlling resources separately; that is, preference was given to a resource without conceiving the expenses in a general way incurred in each process.

Least squares method to find the coefficients in a polynomial

Polynomial regression can be used to model curvilinear relationships between variables. In polynomial regression, the function is fitted to the data, which allows modeling nonlinear relationships. The method of least squares is used to calculate the coefficients of a third degree polynomial of the form:

$$y = f(x) = co + c1x + c2x^2 + c3x^3$$

To approximate a given data set, $(x\_1,y\_1),(x\_2,y\_2),\ldots,(x\_n,y\_n)$, where n≥3. The best fit polynomial $f(x)$ has the following least square error:

$$\min(\Pi) = \min \sum_{i=1}^{n}\left[y_i - f(x_i)\right]^2 = \min \sum_{i=1}^{n}\left[y_i - \left(co + c1x + c3x^3\right)\right]^2$$

Matrix of the first derivatives of the function $f(x)$ equals zero (Necessary condition) to find the coefficients of the polynomial giving minimum values of the function Π.

$\left(J(x)\right)_{ij} = \frac{\partial f_i}{\partial x_j} = 0$ (Necessary Condition) the extreme point x0) is calculated. Where $J \in \mathbb{R}^{m*n}$ is the Jacobian matrix. Sufficient condition for obtaining the local minimum of the error is:

$Hf(x0)$ Positive defined Hessian matrix.

Results

In the case studied we have the database of the (number of donations, electricity consumption) in the last 5 years (Table 1):

Table 1 R - square obtained by polynomial degree of fit

Grado	1	2	3	4	5	6	7	8
r^2	0.4131	0.5103	0.6128	0.6126	0.6127	0.6126	0.6129	0.6131

Once the Least Squares method has been applied to the database and the R-squared coefficients obtained.[8]

R square obtained by polynomial degree of fit. We can select the best polynomial fit of degree 3:

$$f(x) = 235.9 + 5.013x - 0.102x^2 + 0.0003457x^3$$

Goodness of fit $R^2 = 0.6128$

(R-squared = Explained variation / total variation)

(95% confidence level)

The graph of the obtained fitting equation is shown Figure 3. This equation serves as a basis for future research on the mathematical modeling of the donation process at Cienfuegos City Blood Bank.

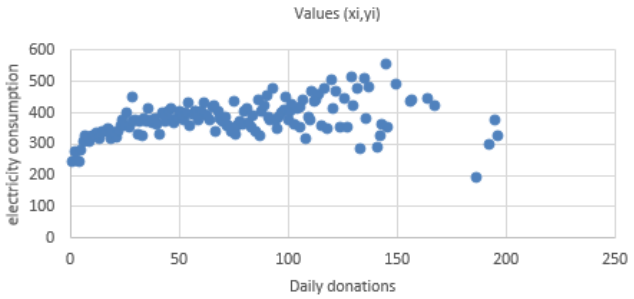

Figure 3 Database donations/electricity consumption.

Conclusion

The behavior that follows the distribution of donations in the Blood Bank and its relation with the electric consumption is studied. Mathematical procedures and the method of Least Squares are applied to study the blood donation system. A polynomial equation of degree 3 is proposed to adjust the number of daily donations with respect to the electrical consumption. This equation will serve as a basis for future simulation of the operation of donations in the Blood Bank with respect to electricity consumption and experiment with different conditions of number of daily donors. A new alternative is proposed that allows the number of donations and the electric consumption of the Blood Bank to be in correspondence with the Cuban norm 299 of MINSAP. The work constitutes a tool to improve the planning of daily donations and to decrease the waste of electricity in the Blood Bank when there are fewer daily donations.

Acknowledgements

None.

Conflicts of interest

The author declares that there are no conflicts of interest.

Funding

None.

References

1. Ramiro Cruz J, Dolores Pérez Rosales M. Guide for cost estimation of the regionalization of blood banks (PAHO). USA: Pan American Health Organization; 2000.
2. Benites FA. Analysis and improvement of the operational process of the blood donation service in a blood bank in Piura applying discrete simulation (Thesis). Cuba: Piura University; 2022.
3. Fernández Velázquez L, Carbonell Morales T, Aballe Infante L. Total efficient energy management application at the international health center «La Pradera. *Ingeniería Energética*. 2014;35(2):112–121.
4. Arboleda Zúñiga J. Mathematical and stochastic models for inventory control in blood banks: Literature review. *Inventum*. 2017;12(22):52–64.
5. Lozano OFR. Blood donation campaigns: simulation model based on system dynamics. Cuba: ICESI University; 2019.
6. Lezaun GL. Optimization of the production of platelet concentrates in blood banks. Cuba: Universidad Zaragoza; 2017.
7. Sánchez Torres RT, Vilariño Corella CM, Sánchez Torres RT, et al. Sustainable use of resources in the processes of the provincial Pediatric Hospital of Holguín, Cuba, 2014-2019. *Cubana de Salud Pública*. 2021;47(4):e2449.
8. Miles J, Shevlin M. *Applying regression and correlation: a guide for students and researchers*. 1st ed. UK: Sage Publications; 2000.