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ECONOMIC DOSE SIZE FOR HOSPITAL PHARMACY DISPENSATION

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INTRODUCTION

The classical unit dose size is prepared by the pharmacy hospital for inpatients for 24 hours. But, when there is a change in the inpatient medical conditions, the prescription must be modified and the former unit dose is lost or recuperated at a high cost. Some hospitals, especially those using the Lean doctrine, for which no waste is acceptable, have shifted to shorter unit doses, 12 hours, or less.

The objective of this paper is to develop a formula for the most economic unit dose size (EUDS). The formula, similar to the classical production economic lot size, takes into account, to find the optimal unit dose size, the opposite costs of labor and medical materials.

BACKGROUND

The 24 hours unit dose dispensation system was developed in the first half of last century in American University Hospitals. The unit dose is prepared in the hospital pharmacy from bulk constituents. Every drug necessary for the patient medication for the next 24 hours is disposed in a container, a bag or a strip. All necessary medical materials, such as syringes, catheters or bandages, are added in the package, which is sent to nursing. At the prescribed times, the nurse dispenses the medication to the patient.

In the earlier dispensation system, called collective dispensation system, medication was separated from bulk constituents directly by nursing and dispensed to the inpatients. Medication errors were very frequent, as high as 17%. With pharmacists in charge error frequency decreased. It was also found that the unit dose system reduced substantially drugs waste caused by the lack of inventory control in the collective system. Traceability is more difficult to achieve in the collective system.

Unnecessary to say, the unit dose system cannot be used in emergency not in intensive care units, due to the impossibility to forecast the demand in those situations.

But there is also a drawback in the 24 hours unit dose system, which results in waste and rework. Whenever the inpatient medical conditions change abruptly, the medication must be modified. The former unit dose is difficult to recover and is frequently lost. Data already entered in the control system must be reverted, causing rework and confusion. Hence some hospitals have shifted to a 12 hours or 6 hours unit dose system.

The purpose of this paper is to show the cost elements involved in the choice of an optimal unit dose size and develop a formula which allows to compute the best number of hours of the unit dose. Two numerical examples are given.

THE ECONOMIC UNIT DOSE SIZE FORMULA

The elements used in the formula are listed below:

- M, cost of all the medicine and medical materials prescribed to the inpatient for the next 24 hours.
- *f*, the frequency for which medical conditions of an inpatient modify in the next 24 hours, requiring therefore a medication change, assumed to be a total medicine and medical material loss. It might be as high as 20%.
- P, the labor cost pharmacists and attendants necessary to prepare and check the 24 hours unit dose. It is assumed that the labor cost is the same for a 12 hours or a 6 hours unit dose, since it is constituted by the time necessary to find and read the prescription, pick up the drugs and materials out of the store shelf, return them to the shelf, prepare and put the dose in a container and register data in the inventory and prescription records. This time is assumed to be fixed, independently of the number of medicine and materials used, because it is made mostly of setup times.
- L, the cost of the messenger who picks up the unit dose at the pharmacy counter and delivers it to the nursing sector. If a robot does the job, it is the cost of operating the robot for the time required. It is a fixed cost per delivery, independently of the amount transported.

- N, the cost of the time the nurse takes to check the prescription and the items she receives. It is assumed to be proportional to the number of unit doses received, independently of their size.
- x, the optimal number of unit dose hours, taking theoretically any value between 1 and 24, in practice limited to values like 2, 4, 6, 8, 12 and 24 hours.

The total cost of this operation, for each inpatient-day, is given by the following expression. The first term is the loss of material, the second, the labor cost.

$$TC = \frac{x}{24} f\,M + \frac{24}{x} (P + L + N) \qquad (1)$$

If x = 24, the formula becomes: $TC = f\,M + (P + L + N)$

If x = 12 (hours), (1) becomes:

$$TC = \frac{1}{2} f\,M + 2\,(P + M + N),$$

meaning that the cost of the lost material is half of in the 24 hour unit dose, but the labor cost is doubled.

In order to find out the minimum cost TC*, one differentiates (1) in relation to x, and equals the differential to zero, obtaining the best x*:

$$\frac{dTC}{24} = \frac{f\,M}{24} - \frac{24}{x^2} (P + L + N) = 0$$

Then

$$x^{*2} = \frac{24^2 (P + L + N)}{f\,M} \quad \text{and} \quad x^* = 24 \sqrt{\frac{(P + L + N)}{f\,M}} \qquad (2)$$

which reads: the economic unit dose size, expressed in hours, equals 24 times the square root of labor cost divided by the potential loss of material due to change in the inpatient medical conditions.

Two numerical examples are given, the first when labor is expensive and materials relatively cheap, the second when labor is relatively cheap and supplies expensive.

In the first case, the values are:

M = US$ 500

f = 20%

P = US$ 8.53 (one half hour of a monthly cost of US$ 3,000, and 176 hours worked per employee per month)

L = US$ 4.27 (one half hour of a monthly cost of US$ 1,500, and 176 hours worked per messenger per month)

N = US$ 8.53 (like for P)

Formula (2) gives:

$$x^* = 24 \sqrt{\frac{8.53 + 4.27 + 8.53}{.2 \times 500}} = 24\sqrt{\frac{21.33}{100}} =$$

$$= 24 \sqrt{.2133} = 24 \times .4618 = 11 \text{ hours}$$

The economic unit dose size corresponds to 12 hours.

The total cost of the economic dose size is, using formula (1):

$$TC^* = \frac{12}{24} \times .2 \times 500 + \frac{24}{12}(21.33) = 50 + 42.66 = \$\ 92.66$$

while the 24 hour unit dose would have the total cost of:

$$TC = .2 \times 500 + 21.33 = \$\ 121.33$$

In the second case, the following values are assumed:

M = US$ 400

f = 20%

P = US$ 5.68 (one half hour for a monthly cost of US$ 2,000 and 176 hours worked per employee per month)

L = US$ 1.70 (one half hour for a monthly cost of US$ 600 and 176 hours worked per messenger per month)

N = US$ 5.68 (same as P)

Formula (2) gives:

$$x^* = 24 \sqrt{\frac{5.68 + 1.70 + 5.68}{.2 \times 400}} = 24 \sqrt{\frac{13.06}{80}} =$$

$$= 24 \sqrt{.1633} = 24 \times .40 = 9.7 \text{ hours}$$

which can be approximated to 8 hours.

The economic unit dose size in this example corresponds to 8 hours.

Its total cost is:

$$\frac{8}{24} \times .2 \times 400 + \frac{24}{8} \times 13.06 = \$\ 65.85$$

while the 24 hours unit dose would cost: $ 93.06.

CONCLUSIONS

The following conclusions should be drawn from the development of the economic unit dose size formula (EUDS).

First, every hospital could easily compute, from its own specific data, its EUDS for its inpatients. The numerator of the formula (2) – the labor cost – is a constant. In the denominator, factor f depends on the patients conditions and the cost M depends on the medical drugs and supplies used. Formula (2) shows that EUDS will be 24 hours whenever labor cost equals the probability f M of wasting materials; when labor cost is smaller than f M, EUDS will be smaller than 24 hours.

Secondly, instead of applying the 24 hours unit dose to all patients, one could segregate then in categories, computing the EUDS for each group of cases. Criteria of classification are f and M, since the numerator of (2) is fixed for the hospital. Patients with high f (unstable) and high M (expensive drugs) will have EUDS smaller than 24 hours.

In a number of less developed countries, medical supplies used in some diseases are imported and quite expensive. Many times they are lacking in the local regular market and are only accessible for a much higher price. The nominal price M should, in this case, be substituted by a more realistic price M', larger than M. The unit dose would become smaller, reflecting the economic and social convenience of avoiding any material waste, so much costly to the community.

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