SIMULATION IN HOSPITAL SYSTEMS: THE DIETARY DEPARTMENT

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ABSTRACT

A hospital dietary department was modeled using systems dynamics. The model includes the purchase and inventory of food supplies, food preparation, manpower, and tray assembly and distribution. Through simulation using GASP IV, some management problems involving tray distribution methods were solved.

1. INTRODUCTION

The dietary department has a rather special status within the hospital: not only does it have a clinical role through food therapy, but also it serves a support role with the operation of a food service. A well-run department with good food can contribute greatly to patient morale. In addition, improvements in the operation of the dietary section can help lower the over $100-per-day hospital costs.

The study reported here was an outgrowth of a seminar presented to administrators of hospital dietary departments. It appears that, while professional dieticians are well trained for the clinical aspects of their work (such as preparing special diets), they are often less well prepared to manage a large food service.

The dietary department of a medium-sized (500-bed) hospital was observed in detail. The objective was to construct a mathematical model of the operation of the department so that proposed changes in procedure and functioning could be tested without tampering with the present system. The following activities of the department must be included in any such model:

1. Purchase and Inventory of Food Supplies
2. Food Preparation
3. Tray Assembly and Distribution
4. Manpower Requirements

Another intention in modeling was to focus attention on precisely what information is needed for administrative control. There was no one to spare for data gathering and reporting, so it was important to identify the essential operational data.

2. OPERATION OF THE DIETARY DEPARTMENT

The system under investigation is a particular dietary department. Its activities include preparing menus; obtaining, storing, and preparing food; assembling trays with food; delivering trays to patients' rooms; operating a cafeteria for the hospital staff; and working with the medical staff in administering special diets. This study does not include the cafeteria operation, but instead focuses on the patients' food needs.

There is a clear separation of activities based on the patient's following of either the "general" diet or one of a number of "special" diets. The latter are used because of a patient's special dietary requirements (e.g. a salt-free diet). The control of these special diets is given to a separate staff within the department. Nearly one-half of the patients receive special diets.

There are two separate conveyor lines - one for assemblying general-diet trays the other for special diet trays. Once trays are complete, they continue along the two conveyor tracks until they reach a vertical tray-carrying dumbwaiter which lifts the trays to the floors above.

Patients receive three meals and extra nourishments each day. They have some choice over the meals they will get next day by circling their selections on a menu card.

3. MODEL DESCRIPTION

Systems dynamics was chosen as a framework for modeling chiefly because of its explicit handling of information flows. Recall that a better understanding of essential information flows was one of the objectives of the study.

The model is displayed in Figure 1 using the distinctive symbols of systems dynamics (1).

A brief explanation of Figure 1 may help to clarify the model. The quantities appearing as strings of capital letters (like IAPF and UMOG) are defined in the Appendix. Beginning with the bottom right of Figure 1, NPG and NPS are levels outside the system which give us the number of patients on general and special diets. The separation of general and special diets continues into the model where we encounter the levels of unfilled meal orders, UMOG and UMOS. Inputs to these levels are controlled by the meal order rates, MORG and MORS.

The information take-offs from UMOG and UMOS are used to control the calculation, EMAX, of the maximum number of employees that can be applied to work on these order backlogs. Continuing, EAV gives the number of employees on hand, and EACT, the actual number which will be used for food preparation.

Information about the meal order rates is used at the top of Figure 1 in connection with the purchase of food supplies. A smoothed meal order rate is calculated (MORSM) and used to help determine the desired food supply level (FSLD). The critical calculation of how much to order (FSP) determines the rate at which food supply orders are generated. Once orders are issued they remain in the "pipeline" (FSPA) for a length of time which averages DRFS as shown in the delay symbol at the upper left of Figure 1.

Food supplies are received at a rate FSR and increase the level of stock on hand (FSOH). The food supply is depleted as food preparation rate starts (FPRS) at a level governed by the employee calculation earlier. Again there is a delay while food is in preparation. It is received into the prepared food inventory (IAPF) at rate FPR.

The rate at which general-diet trays are assembled TARG, is computed as the minimum of TARTG, and NIRG. TARTG is a sample from the distribution which describes the tray assembly activity, while NIRG is the negative inventory rate - the rate which would deplete the inventory IAPF. The trays themselves are subjected to a delay before they arrive at the patients' rooms at rate TSFG. Likewise, for special diet trays, the quantities TARS, TARTS, NIRS, and TSFS determine the tray assembly and distribution.

GASP IV was used to simulate the present operation of the system. From historical data maintained by the department, the average numbers of general and special diet trays served each meal were calculated at 207 and 195 respectively. This same data was used to construct a distribution which specified the <u>change</u> in the number of patients each day. By sampling this distribution, the model will experience different meal order demands in a way similar to the real system.

The data on the numbers of general-diet and special-diet patients is used to set the respective meal order rates MORG and MORS. It was handled in the model by setting these rates to zero during all but three of the time periods in the day. At those three time periods, MORG was set to NPG, the number of general-diet patients, and MORS was set to NPS. The effect of this is to generate three impulse inputs to the model each day.

As one step toward validating the model, the simulation of the present system was checked to see how long it took to deliver the trays at each meal. In the real system, tray delivery is accomplished within 1½ hours at each meal. As Figure 2 shows, tray delivery (TSFG) in the simulated system was completed in 1½ hours.

4. SIMULATING ALTERNATIVE TRAY DELIVERY PROCEDURES

Figure 2 is the GASP plotted output of the behavior of four quantities during the simulation of the present system:

1. Unfilled Meal Orders, General (UMOG)
2. Food Preparation Rate (FPR)
3. Trays Sent to Floors, General (TSFG)
4. Food Supply on Hand (FSOH)

Each unit of time on the plot corresponds to 15 minutes. The measures for food supply and food preparations are based on <u>equivalent</u> meals. Notice first that the unfilled meal orders show the effect of the impulse input which, in one time period, raises the level from zero to over 200 unfilled orders. This level decreases as trays are assembled and delivered. Just before the time for lunch (T = 20), again there is an impulse.

With the high level of unfilled orders the food preparation rate (FPR) increases; the food supply on hand decreases; and, lagging behind, tray deliveries start to increase. All of trays are delivered within six 15-minute time periods.

A proposal for a new tray delivery method was evaluated using the model. In the present system, complete trays proceed along a horizontal conveyor until they are lifted to the floors by a vertical tray-conveyor. A proposed method would have the completed trays loaded on carts. Dietary department personnel would use standard elevators to deliver the carts to the floors (The elevators are present in the tray assembly area. They are for the exclusive use of the dietary department, but have been used until now only for sending food to the cafeteria.)

Simulating the proposed system involved changing the pattern of delays after trays were assembled. Both the present and proposed systems were simulated. Identical meal order rates and tray assembly rates were used in each case. In addition, both systems were simulated under the condition that a new wing of beds was completed, thus increasing the load on the dietary service.

The proposed system using elevators would result in faster tray delivery than the present system. Table 1 compares the number of trays delivered during 15-minute time periods under each alternative, given that there were approximately 50 more general-diet patients in the hospital.

FIGURE 1
DIETARY DEPARTMENT

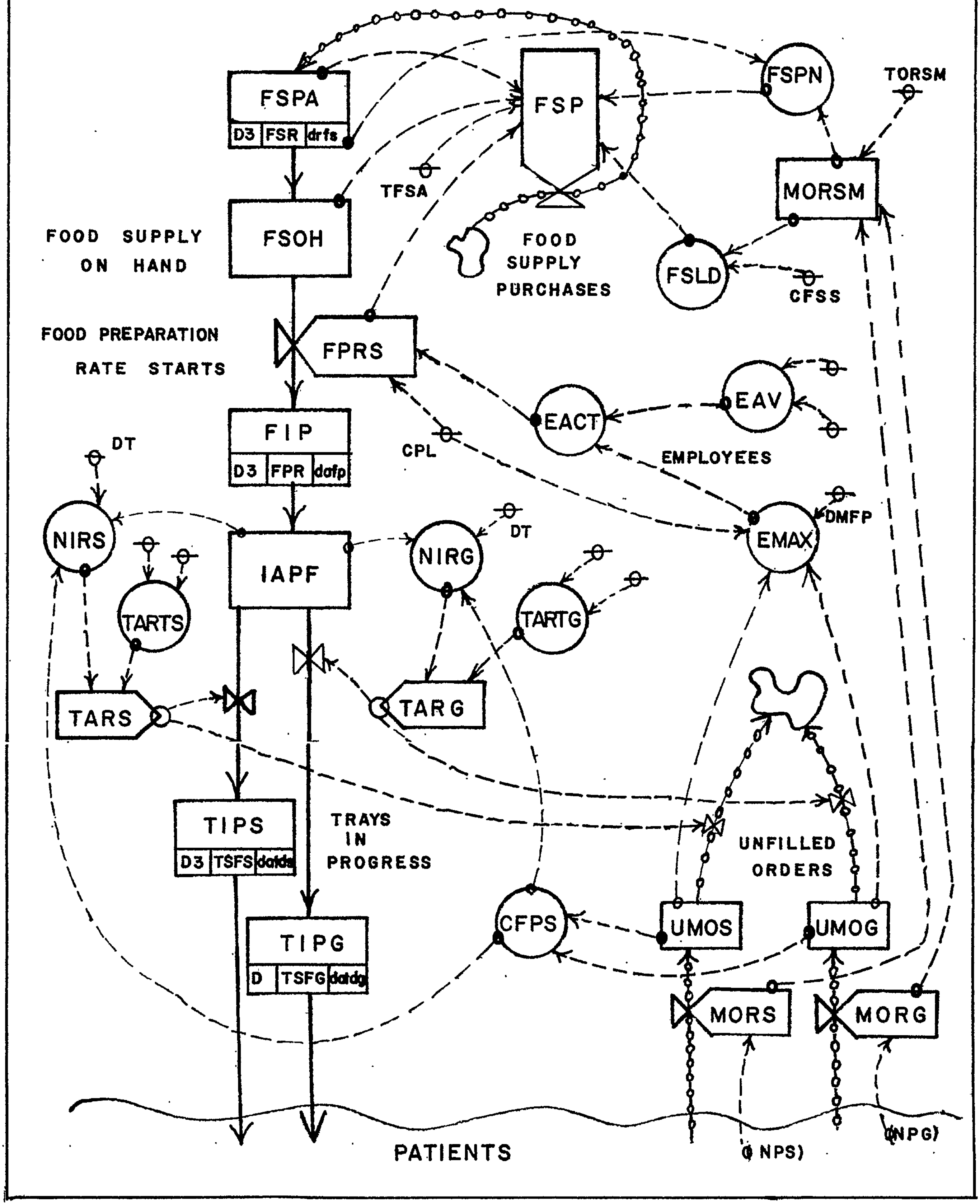

FIGURE 2
SIMULATION OUTPUT—TRAY DELIVERY

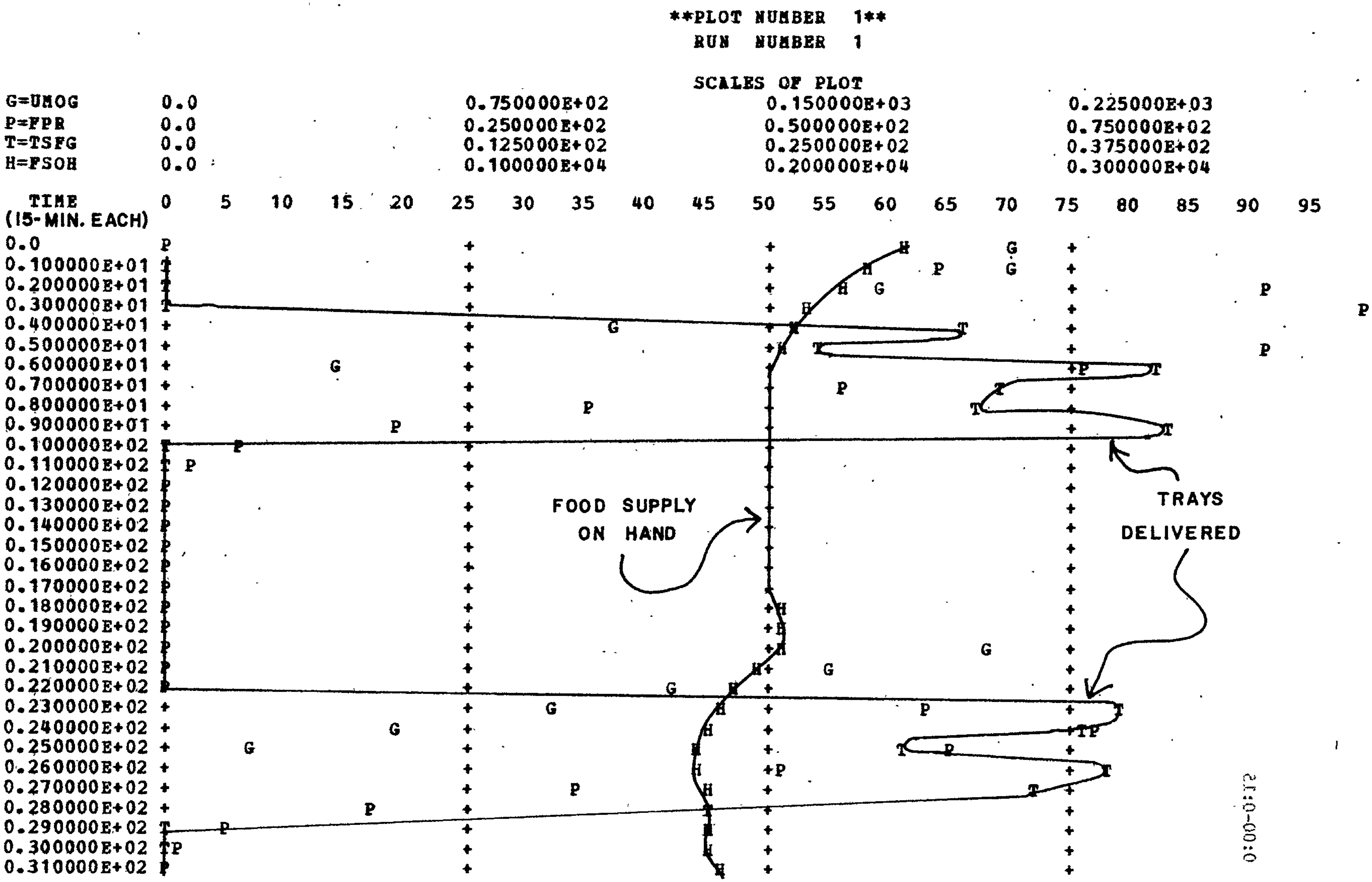

TABLE 1

TRAYS DELIVERED

TIME INTERVAL	PRESENT "CONVEYOR" SYSTEM	PROPOSED "ELEVATOR" SYSTEM
0:00-0:15	29	41
0:15-0:30	28	27
0:30-0:45	37	41
1:00-1:15	35	35
1:15-1:30	34	34
1:30-1:45	40	42
1:45-2:00	40	38
2:00-2:15	12	2
2:15-2:30	4	
2:30-2:45	1	

If the number of patients does increase, the model will offer additional help. By varying the tray assembly rate, we can determine what rate will be necessary if we are still to achieve serving all trays in 1½ hours. Also the number of employees required at all times during the day, which is an output of the simulation, will be very useful.

5. INFORMATION FLOWS AND ADMINISTRATIVE CONTROL

Most hospital departments don't have excess staff available for data gathering and reporting. At the same time, decisions are often made without having the right information available. It is important, therefore, that essential operational data be identified.

The systems dynamics model included information take-offs which are highly desirable for the decision making that must occur. In addition, data which permits calculation of performance measures should be collected. Such measures as direct expense per meal, meals served per manpower, and meals served per patient day will allow comparison with the performance of other dietary departments as reported through services like the Commission on Professional and Hospital Activities (CPHA). Also, an approach based on quality control will signal when changes in such measures are significant (2).

6. CONCLUSIONS

Simulation has been a useful tool for answering administrative questions in a hospital dietary department. The construction of the model forced the examination of the decision making and information flows which must exist in the department.

BIBLIOGRAPHY

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2. Davis, Robert N. A Recipe for Dietary Management: Measurement, Improvement, and Control. Institute on Dietary Department Administration, American Hospital Association, 1969.

APPENDIX

DEFINITIONS OF CONSTANTS AND VARIABLES OF THE MODEL IN FIGURE 1

CFPS	Coefficient, Fraction of Patients on Special diets
CFSS	Coefficient, Food Supply desired to be held in Stock
CPL	Coefficient, Productivity factor of Labor
DAFP	Delay, Average, Food Preparation
DATDG	Delay, Average, Tray Delivery, General
DATDS	Delay, Average, Tray Delivery, Special
DMFP	Delay, Minimum in scheduling Food Preparation
DRFS	Delay, Receiving Food Supply
DT	Time interval
EACT	Employees, ACTual
EAV	Employees, AVailable
EMAX	Employees, MAXimum
FIP	Food in Preparation
FPR	Food Preparation Rate
FPRS	Food Preparation Rate Starts
FSLD	Food Supply Level Desired
FSOH	Food Supply on Hand
FSP	Food Supply Purchases
FSPA	Food Supply Pipeline, Actual
FSPN	Food Supply Pipeline, Normal
FSR	Food Supply Received
IAPF	Inventory, Actual, of Prepared Food
MORG	Meal Order Rate, General diet
MORS	Meal Order Rate, Special diet
MORSM	Meal Order Rate, SMoothed
NIRG	Negative Inventory Rate, General diet
NIRS	Negative Inventory Rate, Special diet
NPG	Number of Patients, General diet
NPS	Number of Patients, Special diet
TARG	Tray Assembly Rate, General diet
TARS	Tray Assembly Rate, Special diet
TARTG	Tray Assembly Rate to be Tried, General diet
TARTS	Tray Assembly Rate to be Tried, Special diet
TIPG	Trays in Process, General diet
TIPS	Trays in Process, Special diet
TFSA	Time, Food Supply Adjustment
TORSM	Time, Order Rate SMoothing
TSFG	Trays Sent to the Floors, General diet
TSFS	Trays Sent to the Floors, Special diet
UMOG	Unfilled Meal Orders, General diet
UMOS	Unfilled Meal Orders, Special diet