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A Comparative Study of Four Systems of Tray Distribution as to Delivery Time, Temperature Control and Cost Factors

Ruth Marie Deming

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GRADUATE SCHOOL

A COMPARATIVE STUDY OF FOUR SYSTEMS OF TRAY DISTRIBUTION AS TO DELIVERY TIME, TEMPERATURE CONTROL AND COST FACTORS

by

Ruth Marie Deming

A Thesis in Partial Fulfillment

of the Requirements for the Degree

Master of Science in the Field of Dietetics

June 1965

86616

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Paul S. Damazo, M. S., Assistant Professor, School of Nutrition and Dietetics

Rose Budd, M. A., Director of Dietary Service, Glendale Sanitarium and Hospital

Fonda Chaffee, M. S., Director of Food Service, La Sierra Academy

Verna Mae Marsh Hanson, M. S., Assistant Professor, School of Nutrition and Dietetics

Lydia Sonnenberg, M. A., Director of Dietary Service, Loma Linda Sanitarium and Hospital

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Orthopedic Hospital, Los Angeles, California

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

Food service is recognized as one of the most important factors in the recovery of a hospital patient. Food does play a vital part in the care, happiness and recovery of the patient.[65] For food to be at its very best it needs to be served at the proper temperature. The 'hot' food should be hot and the 'cold' and 'chilled' foods cold or chilled. The hospital dietitian of 1935 recognized this fact. In a survey that was conducted then this was a point which was most emphatically stressed by the hospital dietitian.[98]

'Hot' food hot and 'cold' food cold is still of concern to the hospital dietitian of today. Thompson and Johnson have recently published a study in which they determined the preferred temperature of hot foods among hospital patients.[119]

Not only does the dietitian want the food to be served at the right temperature, she also wants an efficient and economical system of patient tray distribution. The administrator is also interested in this problem. The food service not only helps in the building of the hospital's reputation, but this department is also responsible for a large portion of the hospital budget.[58, 68, 89]

In choosing a system of patient tray distribution, the dietitian is faced with choosing a system from the fifteen to twenty that are available from the different manufacturers of various food

equipment. The dietitian must also consider the many other factors which will influence the choice of a system for any given hospital at this time.

Very little study has been done on these systems of tray distribution. It is not known which method of patient tray distribution is the most effective or economical in terms of time and money.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study to (1) compare four of the major systems of patient tray distribution, (2) determine which method of patient tray distribution was the most effective and economical in terms of time and money.

Importance of the study. Food service is a very important part of a hospital patient's care. In many cases the patient's satisfaction with the food has been a determining factor in his recovery. The reputation of the hospital also is determined by the quality of the food service. Both of these points are determined by the acceptability of the food when the patient receives it.

Due to the nature of this study and the materials available, the study was limited to (1) a calculated time element in transportation and distribution of the trays to the door of the patient's room; (2) temperature control within a twelve minute period after arrival on the nursing unit; and (3) cost factors which were present in the Los Angeles area at the time the study was conducted.

The temperature control was limited as to how the participating operated it or controlled it.

II. DEFINITIONS OF TERMS USED

Cost factors. The term cost factors referred to the factors of purchase and installation and the yearly operating expense which were considered in the study.

Delivery time. The delivery time factor was taken to be the time involved in delivering the trays, from their arrival at the patient area until delivered to the door of the patient's room. The delivery time stopped at the door because the time element from there on would be the same in all systems.

Double unit hot and cold carts. This term referred to the double unit hot and cold carts which were taken to mean any one of the several heated and refrigerated carts that are available for tray distribution. These may further be defined as carts with two units; one unit, refrigerated, containing the tray with the cold foods and non food items, and the other unit heated, for the hot foods.

Patient area. Patient area was determined as the area adjacent to the patient's room such as the hall or corridors.

Pellet-like system or pellet system. The pellet system of tray distribution refers to a method of heating the dinner plate only. A metal disk or pellet, that is preheated is placed below the plate, sometimes this is within an insulated bottom shell and at other times directly on the tray.

Single unit hot and cold carts. The term single unit hot and cold cart is interpreted as a cart which is designed to carry the hot and cold foods all on one tray. Each tray has a hot and a cold side. An elevated section in the tray divides the tray into two areas. These two areas are heated and refrigerated respectively.

Temperature Control. The term temperature control refers to the temperature that was maintained or lost during the temperature portion of the study.

Transportation time. The term transportation time refers to that calculated time involved in the transportation of the trays from the kitchen to the patient area.

CHAPTER II

REVIEW OF THE LITERATURE

There has been much written on the problems of quality food service. Only a brief summary of the literature as it deals with hospital food service will be covered in this review. Specifically, it will cover (1) the important factors of hospital food service as it deals with it's importance, the financial control, the layout and planning, the temperature control and time factors; and (2) the types of food service with emphasis on method of temperature control and delivery factors.

I. IMPORTANT FACTORS OF HOSPITAL FOOD SERVICE

Importance. It has been well recognized that food service has a very important part in the functions of a hospital. Many authors have recognized that food is essential in the treatment of the sick. Food plays a vital part in the care, happiness and recovery of the patient. [65] It also plays an important part in influencing the morale of the employees.[58] The food service is important also in terms of public relations for the hospital. [68] It becomes a part of the reputation that the hospital builds for itself. [89]

Financial Control. Harrington and Kahrs, both have expressed the view that financial basis of the food service department needs to be given more attention. One third of the entire hospital budget is spent in the operation of this department. [45, 55, 58, 68]

Ways for tighter controls are necessary. Hospital administrators are having their attention directed towards the importance of having a food service which is highly regarded both within the hospital and the community.[51]

It has been noticed that the food service department is responsible for 25-30 percent of the hospital's expenditures. Several factors influencing this expense can be controlled if they are given consideration when hospital plans are being made. Labor costs, which constitute a large item in the dietary budget will be reduced if the layout is arranged in such a way that food will move forward in a straight line from receiving until serving.[121]

Damazo states that it is not uncommon to find two hospitals of equal size, with equal quality food service but each with a staggering difference in their annual operating costs. He felt that the higher operating cost in almost every case was largely due to poor equipment selection and inefficient layout.[26]

A well planned layout is essential if the facility is to operate with maximum efficiency and high standards.[69] Since the layout of the food service department and the equipment provided plays a significant role in the development of an efficient food service department much thought should be given to its planning.[92]

Layout and planning. The food service department has three basic administrative responsibilities. These are: (1) to serve the patients nourishing and appetizing meals, (2) to provide the same nourishing and appetizing meals to the hospital personnel, and (3) to provide this food as economically and efficiently as possible.

The successful discharge of these responsibilities depend upon careful planning of the layout and selection of equipment.[24]

In planning the food service department and its facilities, Hannaford feels that there are certain basic objectives which must be recognized. These objectives are that the food must be nutritious, palatable and served promptly and in perfect condition, and that the department must be economical in its equipment investment and in the space which it occupies. Both of these should be designed for the operating system and personnel under which it will function.[56]

The team for planning the hospital food service department should consist of the hospital administrator, the dietitian or group of dietitians concerned, the hospital engineer and the architect. This team must think and plan for the future.[13, 92]

The first consideration needed in planning a food service department is on the type of service desired for the patients and personnel.[13] Each hospital differs with respect to such factors that influence the type of service. These factors are the physical structure and layout of the building, the financial resources and administrative policies; and the need and economic status of the patient. The best method of food distribution is the one that most adequately meets the needs of a given institution.[108]

Hargrave made the following statement about the selection of equipment. "The selection of the proper equipment to insure the best possible food service within the hospital budget deserves and demands more than mere guesswork or personal preference on the part of the

program planners. It demands the scientific approach - what is the need and how is this need to be met." [57]

In planning a food service it should be remembered that administration is but one function of this department. Before any one system of a given tray service is favored, its relative value as to a therapeutic and educational program should be considered. Refshauge feels that when there is no duplication of administrative duties, more time is available for therapeutic and educational work. The most effective development of all aspects, administrative, therapeutic and educational is even more essential today. [90]

Time and temperature control. The temperature of the food is of great importance to the over all qualities of the food service. Patients and dietitians alike feel that food should be served at the proper temperature, that is with 'hot' foods hot and 'cold' foods cold. A critical factor in the selection of a hospital food distribution system is the ability of the system to deliver the food to the patients at the temperature he or she considers desirable. [74, 98, 119]

The authors Thompson and Johnson state that, "it is disconcerting to find hospital food service personnel talking about serving 'hot food hot' without knowing what 'hot' means in terms of degrees Fahrenheit." They also posed the question that there might be a waste of money in serving foods which are too hot - the waste comes in over heating, since the extra heat would cost money. [119]

The following table of 'Temperature for serving food to patients as recommended in the literature' was taken from the article by Thompson and Johnson. [119]

Temperature for serving food to patients as recommended in the literature

Literature Citation	Recommended Temperature	
	Meat	Vegetables inc. Potatoes
	°F	°F
Foley-Gillan, 1928	160-170	160-170
Wartman, 1933	130-140	140-150
Thomas, 1954	-	140 or higher
May, 1955	-	155 or higher
Stenton, 1955	130-155	145-150
Blaker, et al., 1961	140-145	140-145

Another line might be added to the table from the information received from a study by Thompson and Johnson. Results from a total of 400 opinions indicated that the recommended temperature standards for hospital food service to these patients should be from 160-170° F. for potatoes and vegetables and from 150-160° F. for meat.[119]

In 1961 it was noted that the United States Public Health Service was proposing a revision of the ordinance and code regulating eating and drinking establishments. The code at the time required that certain foods be held at 140° F. and certain refrigerated food be maintained at 50° F. or below. The proposed code was to require that all hot food be maintained at 140° F. or over and all refrigerated food at 40° or below.[15]

Danderin thoughts about cold food bring out another point in that the reason the food is cold is because it was cold when it was put on the plate. He feels that the use of a thermometer would be more accurate in determining whether the food is really hot.[27]

In 1955, May reported on an extensive study in food service. Part of the study dealt with a time temperature relationship of hot foods. The summary of this portion of the study included the following points.

> "1. There is a very important relationship between,
> a. The temperature at which foods start to cool;
> b. The temperature of the containers;
> c. The time required for delivery of trays from cooling point to patient's bedside.
> 2. Having started with a given temperature, the next important step is to keep the tray moving. All other factors then are secondary to time saving. . .
> 3. Any hospital which for any reason increases its elapsed time of delivery, is automatically reducing its thermal efficiency.
> 4. No system of service, no matter how efficient theoretically, can possibly produce satisfactory results continuously unless it is operated continuously as it is supposed to be."[76]

One other author has expressed the following in relation to the time factor, "The most important factor in any method of food distribution is the period of time between the serving of the food and the delivery to the patient. This period of time should be as short as possible."[93]

The table on the following page, as compiled from the literature indicates the recommended tray delivery time.

TIME FOR SERVING FOOD TO PATIENTS AS RECOMMENDED IN THE LITERATURE

Literature Citation	Recommended Time	
	Set up	Delivery
Gillan, 1949 [49]	10 trays/ min.	9 minutes
Black, 1959 [10]	-	7-10 minutes
Peffers, 1963 [86]	-	6 minutes
Hepple, 1947 [61]		
Dumbwaiter I	-	6 minutes
Dumbwaiter II	-	4 minutes
Tray Cart III	-	14.15 minutes
Vertical Conveyor IV	-	8.20 minutes

Black has stated that if the time element cannot be met it is time to seek opportunities and appliances which are designed to keep 'hot' food hot and 'cold' food cold in transit and to accept if necessary the additional cost to assemble trays on the floor or in the corridors adjacent to the patient's room.[10] The time lapse between service of the food and presentation to the patients will indicate the need for insulated materials.[72]

May's final statement about a time temperature relationship is that, "by far the most important, simplest, easiest and most certain place to control food temperature is at its point of service onto the dish in which the food will reach the patient. Note that this has nothing whatsoever to do with any type of tray service! It is a function of food production."[76]

II. TYPES OF FOOD SERVICE

In general there are two types of basic food service systems used in hospital food service. These are centralized and decentralized. In the decentralized system the food is delivered in bulk to a unit and then served from there, whereas in centralized it is served all from one main or central serving unit and then delivered by a variety of methods. [63, 82]

Littouer and Mowry list three ways to meet good food objectives. The first of these methods would be to prepare the entire meal in kitchens on each floor and then serve directly to the patients. The second method is the decentralized method and the third is the centralized system of food service. [74]

Requirements of centralized service. There are two basic requirements for a centralized system of food distribution. They are a moving line for the assembly of the trays, which may be a mechanical operated belt or one which is pushed manually, and a vertical method of transportation, which may be either accomplished by a subveyor or the use of carts with either an elevator or a dumbwaiter. [70, 82, 83, 108]

Advantages of a centralized service. Many authors have listed advantages for the centralized system of hospital food service distribution. [10, 48, 58, 83, 90, 92, 103, 109, 118] Littouer and Mowry have listed them in the following way, central service most nearly meets the requirements of an ideal food service for patients

for the following reasons; (1) it permits food to be dished neatly and in uniform portions, (2) trays are checked before they leave the kitchen, (3) food waste is reduced, (4) the floor pantry stock can be kept low, (5) there is less noise and confusion of the floor at serving time, and (6) expensive complete kitchen installation on each floor are not necessary. [74]

One other author states that there is no demand made on other departments to help serve food, also there will be less maintenance and replacement costs because fewer people handle the equipment. [90]

Specific systems of centralized service. The preceeding advantages apply in general to all types of centralized service. There are however several distinct systems in use. These systems differ in respect to the type of equipment in use and method of tray assembly so that the food will remain at the proper temperature until served, and the method of conveying the trays to the patients. [109]

The methods that are used for keeping the food at the proper temperature are speed, and thermal control with a heated unit, be it a hot metal pellet under the plate or all over temperature control by the use of carts. There are three basic types of carts which have some degree of temperature control. Peffers described them as the following:

> " (1) There is the type of cart in which the cold section holds the full size tray that contain the rechilled foods as well as foods and utensils that are at ambient or room temperature prior to being put into the cart. This cart also has a heated section with drawers to hold the plate and dishes of prepared hot foods.
>
> (2) There is the 'tray on tray' heated and refrigerated type of cart. This cart has a section for the large full-size tray with prechilled foods and another section that

is heated and holds a smaller or half-size tray with the hot foods.

(3) The third electrically heated and refrigerated tray cart was recently introduced into the hospital food service. The cart is different from the two described heretofore in that a completely assembled tray can be loaded into the cart because specially designed gasket-divider allow the hot food on one side of the trays to be maintained at proper temperature in the heated section of the cart and the cold foods on the other side to be maintained at proper temperature within refrigerated sections." [86]

Stokes describes the pellets," In the case, the food is kept warm by a preheated metal disk or pellet which is inserted in the insulated bottom shelf of the container... ...the hot food plates is positioned on it and covered." Thermal containers are used for the beverages and soups in this system. [109]

Transportation also becomes a very important part of centralized tray service. One author feels that it is best if the food service is provided with separate vertical transportation reserved exclusively for delivery of trays at the critical meal time. [10]

Others feel that transportation equipment will be the key to operational success when the service of food is separated from preparation in time or space. [111]

Black feels that the carts and elevators are more efficient over dumbwaiter or subveyor, since a cart is needed to deliver the trays. [8]

In a study reported by Damazo however, it was felt that the use of the inexpensive; unheated and unrefrigerated cart with the use of high speed dumbwaiter and the pellet system was the most efficient. It required the smallest original equipment and building investment. [26]

There are many factors which will influence the choice of the system that will be used. [5, 82, 83, 129]

The best method of distribution is the one which most adequately meets the need of a given institution. [108]

CHAPTER III

METHODS OF PROCEDURE

The method of procedure employed are discussed under two general classifications:

I. Selection and description of systems.

II. Method of study which included:

A. Delivery and transportation time.

B. Temperature control.

C. Cost factors.

I. SELECTION AND DESCRIPTION OF SYSTEMS

Selection of systems. Four seperate systems of hospital patient's tray distribution as used by hospitals in the area were included in this study. These hospitals were chosen to be in this study for the specific system of tray distribution which was used in the hospital. Willingness to participate in the study and close proximity to the area in which the study was conducted also were factors which effected the selection of the hospitals. The hospitals which were included were the following with the specific system indicated:

1. Mount Sinai Hospital, Los Angeles , using the double unit hot and cold cart.

2. Hoag Memorial Hospital, Newport Beach, using the single unit hot and cold cart.

3. Holy Cross Hospital, San Fernando, using the ascending subveyor.

4. Orthopaedic Hospital, Los Angeles, using the pellet system with carts.

These hospitals were used for the delivery time and temperature control portion of the study. Four advertised systems of tray transportation and distribution were used to determine the cost factors. These systems were the 'Electra Royal' of Meals on Wheels, 'Unitray' cart of Swartzbough, 'Lampson Trayavors', and the 'Dri Heat Food System'.

Description of systems. The specific systems of tray distribution as used in the delivery time and temperature control portion of the study are described in the following way as they were used:

1. The double unit hot and cold carts referred to the carts which had two specific areas that is, one heated for the hot foods and the other refrigerated for the tray with the cold or chilled foods and non food items, the hot food items were placed in the heated unit of the cart. The cold or chilled foods and non food items, which were on the tray, were placed in the refrigerated section. When the cart had been completed, it was taken to the patient's area where it was connected to the electrical outlet. The final assembly of the tray was made in this area by placing the hot foods on the tray. It was then delivered to the patient after being checked by the dietitian.

2. The single unit hot and cold carts were also heated and refrigerated units. With this system however, the carts were so designed as to have all the food items on the same tray. The cart had a flexible rubber section which met the dividing ridge on the specially designed tray. It is by this flexible rubber section and the dividing ridge on the tray that kept the temperature difference with this cart. The tray was completed in one assembly line, checked by the dietitian and then placed in the cart. Upon completion of all the trays the cart was taken to the patient area where it was plugged into an electrical outlet. The trays were then delivered to the patients.

3. The ascending subveyor was a method of vertical transportation. As the trays were completed, they were moved on the subveyor which then lifted them through the hospital. At each floor they were removed from the shaft and delivered to the patients. A small cart which held four trays was used to deliver the trays from the subveyor outlet to the patient's room. With this system, there was no provision made for temperature control other than the speed of the system.

4. With the pellet system of tray distribution, a preheated metal disk was used to keep the food on the plate at the proper temperature. This metal disk was inserted into the insulated bottom shell. The plate of hot food was placed over this preheated pellet. The remaining portion of the shell was used as a cover, thereby having a completely enclosed unit around the plate. The hot plate unit was then placed on the tray with the other food items. The hot drinks

and soups were placed in insulated containers. The completed tray was then placed in the unheated, unenclosed cart. When the cart was complete, it was taken to the patient area and the trays delivered to the patients. With this system, no provisions were made for the cold and chilled foods to remain at their suitable temperature other than the speed employed in the delivery of the trays.

II. METHOD OF STUDY

Delivery time. The delivery time portion of this study dealt with the necessary time involved in delivering the completed tray to the door of the patient's room. This time factor began as the completed tray arrived in the patient area and was ready to be delivered to the door of the patient's room. The factor was to be complete when the tray had been delivered to the door of the patient's room.

A standardized floor plan was used in each hospital. This plan was standardized in that the distance between the rooms was the same in all participating hospitals. In some of the cases, it involved placing markers on the floor to determine where a doorway should have been.

The delivery time portion of this study was done in order to determine the necessary time involved in delivering the completed tray for each system. This portion of the study was taken to the door of the patient's room, only because the service was the same for all systems from this point on. An average delivery time was computed for each of the systems in this study.

A second factor that was considered in the delivery time portion of this study was the amount of walking that was required with the various systems. The amount of walking or the number of feet walked was determined from a scale model of the floor plan that was used in the study. The scale model floor plan may be seen in Appendix 1, page 46.

Temperature control. The temperature control portion of this study dealt with the degree of temperature control which was present with the system at the time the study was conducted. This degree of temperature control was taken on the existing system as used in the participating hospitals.

A Pyro Surface Pyrometer, model No. 31, was used to determine all of the temperature readings. Thermocouple type 305 was used with the pyrometer. It was very adaptable to use with food due to it's length and sharp point.

Temperature reading was taken on the serving counter at serving time. Other readings were taken in the patient area at two minute intervals until twelve minutes had elapsed. An average temperature percentage of heat retention was determined for the hot food at each time interval for each system. A sample of the form used to record the temperatures is found in Appendix 2, on page 47.

Cost factors. Included within this portion of the study were the factors which dealt with the cost of purchasing and installation of the systems. Some of the yearly operating costs which could be computed were also considered. This information was gathered from

several sources such as catalogues or printed materials as supplied by the manufacturers or by personal contact with the representative of the firm concerned.

The original purchase cost included the entire system itself, and the elevators or dumbwaiters that would be required for vertical transportation and the building costs which provided space to park the carts.

Operating costs included depreciation, maintenance, electrical consumption to supply necessary heat, the labor costs involved in delivering the trays, collection of the soiled trays, and in cleaning the carts and parking area. These figures were summarized and suitable comparisons were made.

CHAPTER IV

RESULTS AND DISCUSSION

The results are discussed under three areas; time study which includes transportation and delivery time, temperature control and cost factors.

I. TIME STUDY

Transportation time. The mean transportation time for each of the three systems, where it applies, is seen in Table I on page 23. In the Table, the figures to the right indicate the number of seconds that was necessary to move the respective carts the stated distance of thirty feet. The mean transportation time does not apply to the conveyor system in that the outlet for the trays was in the patient area as stated by the requirements of the study and all movements of these trays by cart was taken up in the delivery time section of the study.

The system which showed the lowest mean transportation time was the pellet system with carts. The single unit hot and cold cart had an increase of 21.5 percent more transportation time over that of the pellet system and the double unit hot and cold cart showed a 50.0 percent increase in transportation time to that of the pellet system.

Delivery time. The mean delivery time for each of the four systems may be seen on Table II, on page 24. The figures to the

TABLE I

TIME REQUIRED TO MOVE A SPECIFIC CART A STATED DISTANCE

SYSTEMS	DISTANCE	TIME
D.U.H. & C.C.	30 feet	21 seconds
S.U.H. & C.C.	30 feet	17 seconds
CONVEYORS	does not apply	-
PELLETS	30 feet	14 seconds

TABLE II

TIME REQUIRED TO DELIVER TWENTY TRAYS OF A SPECIFIC SYSTEM AFTER ARRIVAL AT PATIENT AREA

SYSTEMS	TIME
D.U.H. & C.C.	42 minutes 5.5 seconds
S.U.H. & C.C.	4 minutes 52.5 seconds
CONVEYORS	4 minutes 14.0 seconds
PELLETS WITH CARTS	3 minutes 10.0 seconds

right in this table indicate the mean time necessary to deliver the trays from their arrival in the patient area to the door of the patient's room. In one case (D.U.H. & C.C.) the delivery time included the time to assemble the hot and cold food items on one tray and checked before delivery to the patient's doorway.

The system which showed the lowest delivery time was the pellet system with carts. The conveyor system was second but it had an increase of 33 percent more time over that of the pellet system. The single unit hot and cold cart had a 54 percent increase in time over that of the pellet system and the double unit hot and cold cart had a 1228 percent increase in delivery time over the pellet system.

An added factor in the delivery time besides the time involved in carrying the trays to the patient's room is the necessary distance required to walk to deliver the trays. A summary of the required walking distance for each of the four systems may be seen on Table III, on page 26. This walking distance varied considerable with the various system. With the conveyor, three small carts each holding four trays were used to carry the trays from the conveyor outlet to the door of the patient's room. With only four trays, several trips had to be made back to the outlet for more trays and this was a doubling up on walking distance. This distance was 582 feet for the delivery of twenty trays.

The single unit hot and cold cart and the double unit hot and cold carts both were parked where the electrical outlets were installed and the trays were delivered in both directions from this cart.

TABLE III

WALKING DISTANCE REQUIRED TO DELIVER TWENTY TRAYS
BY FOUR SYSTEMS OF TRAY DISTRIBUTION

SYSTEM	DISTANCE
D.U.H. & C.C.	920 feet
S.U.H. & C.C.	920 feet
CONVEYORS	582 feet
PELLETS WITH CARTS	232 feet

With these two systems, it was necessary to walk back to the cart each time to receive a new tray, therefore, one-half of the walking distance was taken up by walking back to the cart with nothing in hand in relation to the tray delivery. The distance walked to deliver twenty trays with these two systems was the same, 920 feet. It might be noted that the manufacture of the single unit hot and cold cart indicated that it is possible to have effective heat use of their cart without it being plugged in so that it would be possible to wheel this cart down the halls also if one desired although the weight of the cart is a factor which also must be considered.

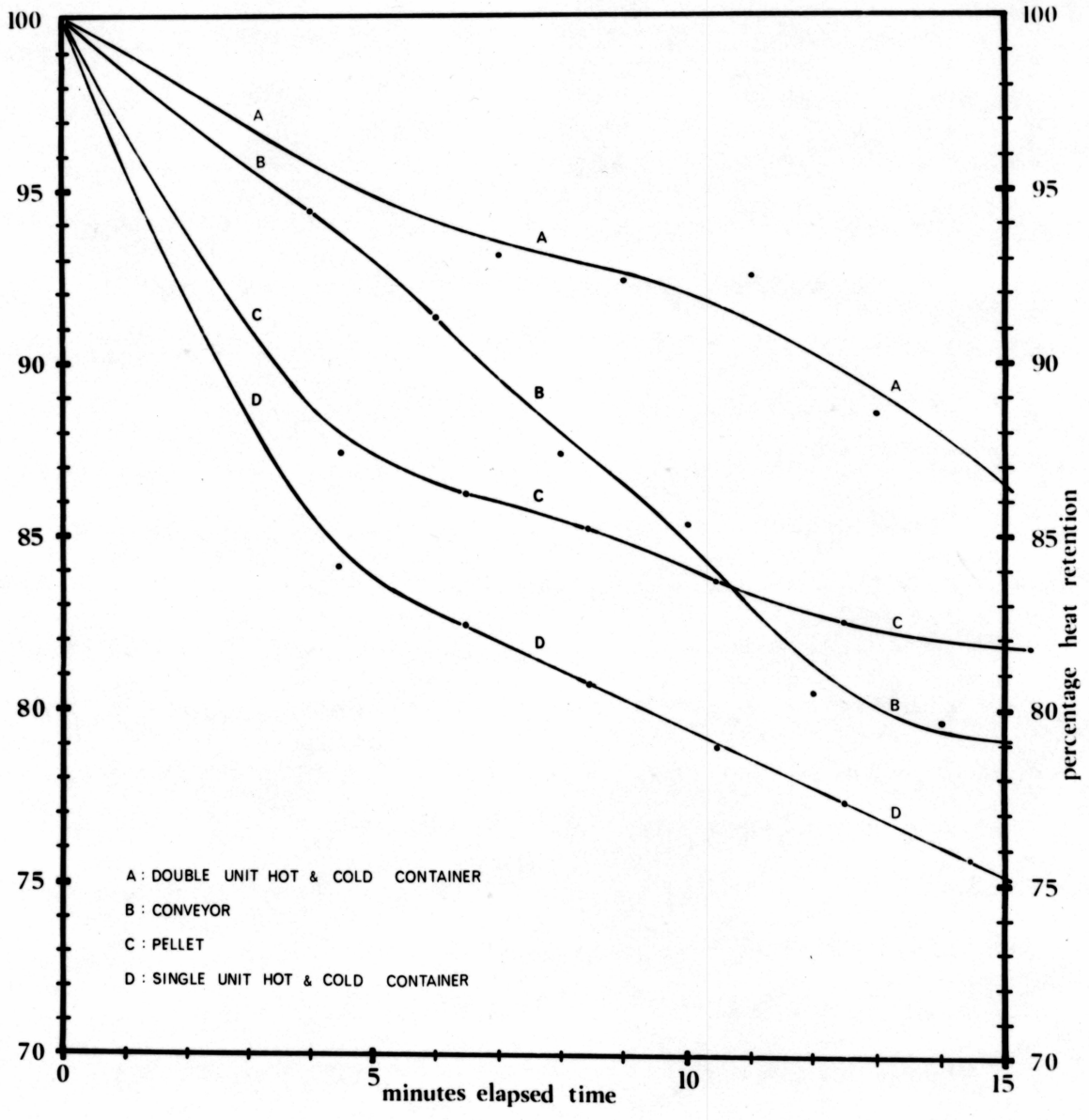
With the pellet system, the cart was pushed to each door and the tray removed and carried to the door. The only doubling up of walking with this system was the return trip to obtain the second cart. The distance amounted to 232 feet for the twenty trays.

It was noted that the system which had the greatest increase in transportation time was the same that had the greatest increase in delivery time also, that is the double unit hot and cold cart. This system also had one of the longest required walking distances. If the systems were placed in numerical order as to these three factors, the third one would be the single unit hot and cold cart with the subveyors as second and the pellet system as first, or the system of choice. The pellet system had the shortest transportation time, delivery time, and the required walking distance of the four systems studied.

II. TEMPERATURE CONTROL

An average percentage of heat retention was determined for all systems. This comparison study of heat retention may be seen in Figure I, on page 29. The percentage increment is on the left hand side of the figure. The percentage started at 100 percent, that was taken as the temperature of the food at the time it was served. The temperature reading was taken on the serving line. The time element in minutes is along the bottom of the figure and indicated the minutes after serving at which time the temperatures were taken at two minute intervals. In interpreting this figure, one must recognize that the doors (where there were doors) were opened for each temperature reading and the cover removed from the hot plate, thus a greater heat loss occurred than would normally be expected under standard serving conditions with the respective units.

The double unit hot and cold cart showed the greatest percentage of heat retention, that is 86.5 percent at the end of fourteen minutes. It was noted while working with this system, that some food items had an increase in temperature between the serving of the plate and the first temperature reading after arrival in the patient area. The pellet system was second in that it displayed a retention of 82 percent of the heat over the critical first twelve minutes time period. While the temperatures were being taken with the pellet system, it was noted that there was a difference in temperatures of some of the food items on the plate. This was noted to be due to the relation of the position which the food had on the plate. The food items were



Comparative Percentage of Heat Retention for Four Systems of Tray Distribution for a Fifteen Minute Period.

figure 1

hotter towards the center of the plate. This difference was noted but the temperature variance was not recorded. The temperature readings for this study were taken around the outside of the plate. The single unit hot and cold cart had a final heat retention of 75.2 percent at the end of fourteen minutes. The conveyor system had a 79.2 percentage of heat retention at the end of the fourteen minutes.

III. COST FACTORS

The cost factors were the final comparison for the four systems of tray distribution which were studied. These costs included both the total purchase cost and a yearly operating expense. The figures for these cost factors may be seen in Tables IV and V on pages 31 and 33.

The total purchase cost is seen in Table IV, on page 31. The total purchase costs included purchase cost of the system itself, elevators or dumbwaiters for vertical transportation as required and building costs for the parking or storage space of the carts which are used with the system. The system which exhibited the least expenditures as to the total purchase cost was the conveyor system. This factor is exhibited in this system because of the lack of external means of heat control, and also due to the fact that its vertical transportation is a built in feature of the system. The second ranked system in order of least total purchase cost was the pellet system. It had an increase of 175 percent over that of the conveyor system. Its cost factors were reflected in the fact that light weight unheated carts were used, these were transported vertically by

TABLE IV

PURCHASE AND INSTALLATION COSTS OF EQUIPMENT FOR TRANSPORTATION AND DELIVERY FOR A 240 BED HOSPITAL FOR FOUR SYSTEMS OF TRAY TRANSPORTATION

	D.U.H. & C.C.	S.U.H. & C.C.	CONVEYOR	PELLETS
PURCHASE COST	$ 21,300.00	$ 30,240.00	$ 10,000.00	$ 16,666.00
ELEVATOR COST	16,000.00	16,000.00	-----	11,000.00
BUILDING COST FOR EQUIPMENT PARKING SPACE	5,970.40	4,916.40	1,448.40	3,910.00
TOTAL COST	$ 43,270.40	$ 51,156.40	$ 11,448.40	$ 31,576.00

means of a high speed dumbwaiter system. The double unit hot and cold cart had a 277 percent increase, whereas, the single unit hot and cold cart had a 346 percent increase over that of the conveyor system. The increase in both of these systems is reflected in the carts which are used and their requirement for a full size passenger elevator for vertical transportation of the carts.

The annual operating expense is seen in Table V, on page 33. The annual operating cost was taken as depreciation, electrical consumption to heat the heated units and labor for tray distribution, cleaning of the parking space, cleaning of the carts and labor for tray collection.

The conveyor system had the lowest annual operating cost with the pellet system second with an increase of only 9.9 percent. The conveyor system had the lowest depreciation cost due to the low purchase costs but the pellet system had a lower labor cost for tray delivery and collection.

The single unit hot and cold cart was third with an increase over the conveyor system of 82.6 percent. The double unit hot and cold cart had the highest annual operating costs of all the systems studied. It had an increase of 373 percent over that of the conveyor system. This fact is attributed to the fact that the trays were assembled or put together as part of the delivery time in this study.

TABLE V

ANNUAL OPERATING COSTS FOR FOUR SYSTEMS OF TRAY DISTRIBUTION FOR 240 BED HOSPITAL

	D.U.H. & C.C.	S.U.H. & C.C.	CONVEYOR	PELLETS
DEPRECIATION	$ 2,130.00	$ 3,024.00	$ 1,000.00	$ 1,666.60
ELECTRICAL CONSUMPTION TO HEAT	235.73	152.99	---	91.10
LABOR				
TRAY DISTRIBTUION	12,368.60	1,494.64	1,345.40	970.90
TRAY COLLECTION	1,494.64	1,494.64	1,345.40	970.90
CLEANING PARKING SPACE	65.80	54.18	14.56	42.56
CLEANING CARTS	2,452.80	1,022.00	255.50	613.20
	$18,747.57	$ 7,232.45	$ 3,960.86	$ 4,355.26

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The importance of food being served at proper temperatures and at a reasonable cost is one of the most important factors in hospital food service. In this study four systems of tray transportation and distribution were considered in relation to delivery and transportation time, the effectiveness of temperature control and cost factors such as purchase and yearly operating expenses which could be determined.

The pellet system had the lowest delivery and transportation time. The double unit hot and cold cart had the highest percentage of heat retention, the pellet system had the second highest percentage of heat retention. The conveyor system had the lowest figure in the cost factor but here again the pellet system was second both in the purchase cost and annual operating cost.

On the basis of information gathered from this study and presented here, it would seem that the system of choice for fast delivery and maintained at a suitable temperature and all for a reasonable cost would be the pellet system. There is room however for more study in this area. The following recommendations for further study are an outgrowth of this present study. (1) A comparison of several of the pellet systems which are available as to purchase cost and their temperature control effectiveness, (2) further study into percentage of heat loss yet with a suitable or acceptable temperature retention.

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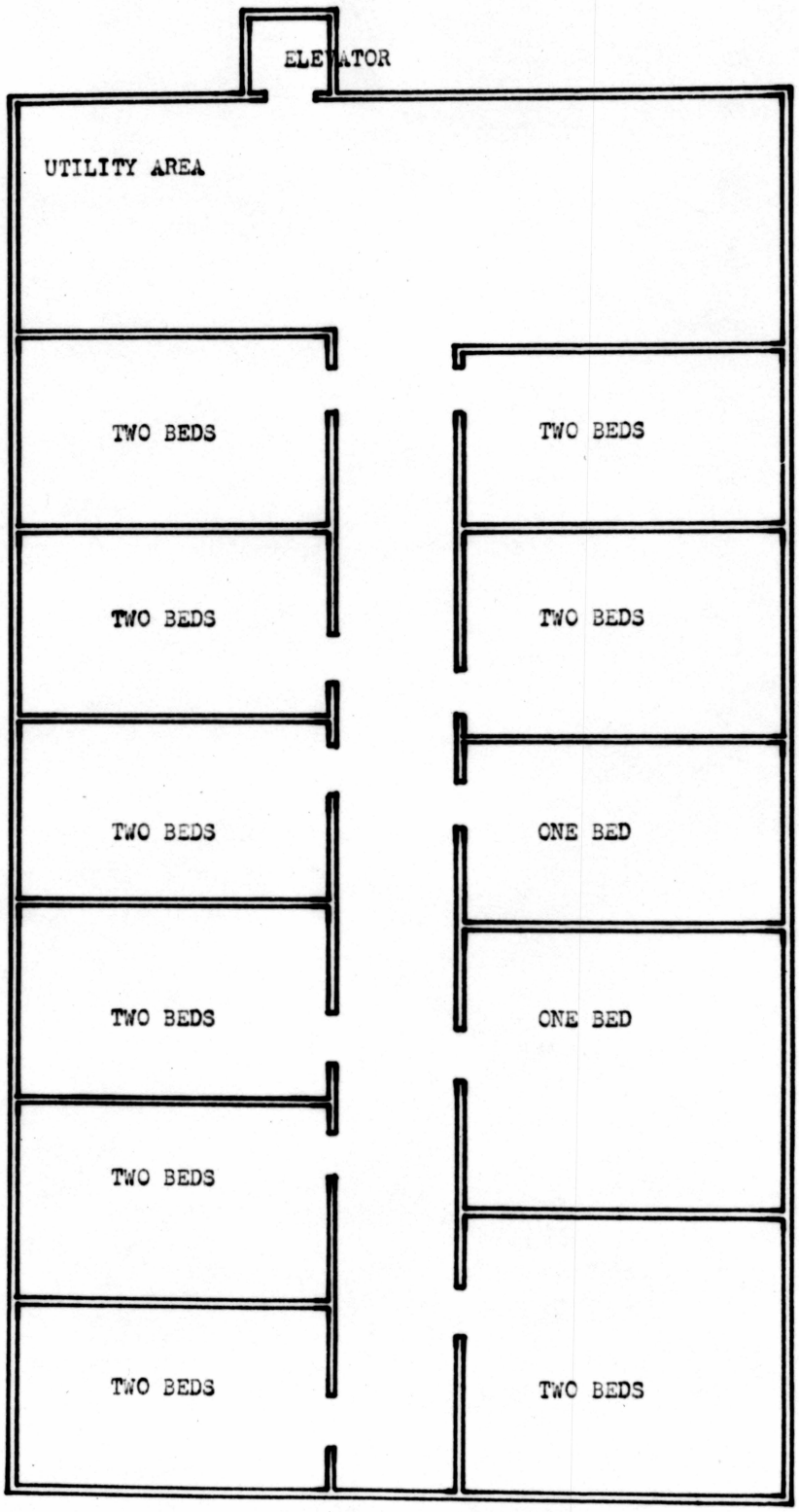
APPENDIX



FLOOR PLAN

one inch = ten feet

APPENDIX B

Hospital _____

Date _____

Time _____

Number _____

Food Items	In Kitchen	2 min.	4 min.	6 min.	8 min.	10 min.	12 min.	14 min.

LOMA LINDA UNIVERSITY

GRADUATE SCHOOL

A COMPARATIVE STUDY OF FOUR SYSTEMS OF TRAY DISTRIBUTION AS TO DELIVERY TIME, TEMPERATURE CONTROL AND COST FACTORS

by

Ruth Marie Deming

An Abstract of a Thesis

in Partial Fulfillment of the Requirements

for the Degree Master of Science

in the Field of Dietetics

June 1965

ABSTRACT

The delivery and transportation time, temperature control and cost factors of four systems of tray transportation and distribution were compared. The systems that were used were the following: 'Electra Royal' of Meals on Wheels, 'Unitray' Cart of Swartbough, 'Lampson Trayevors', and the 'Dri Heat Food System'. Hospitals which had the specific systems were used for the delivery and transportation time and for the temperature control portion of the study. Cost factors were obtained from printed price sheets or by personal communication with the factory representative of the firm concerned.

The delivery time was taken as the time required to deliver twenty trays from the time they arrived at the patient area until delivered to the door of the patient's room. The transportation time was a calculated time required to move the specific carts a stated distance.

All temperature readings were taken with a pyrometer. The temperatures being taken at the serving time and then at two minute intervals for fourteen minutes after arrival in the patient area. Since all beginning temperatures were different due to limiting factors of the study, a percentage of heat retention was determined for each system.

The cost factors were divided into two categories: (1) purchase and installation costs and (2) yearly operating costs, such as could be determined.

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The pellet system had the lowest mean transportation and delivery time. The transportation time did not apply to the conveyor system but it was second in delivery time. The single unit hot and cold cart was third in delivery time and second in transportation time. The system which required the most time for both the transportation and delivery time was the double unit hot and cold cart.

The double unit hot and cold cart showed the greatest percentage of heat retention, the pellet system was second. The third ranked system was the conveyor system. The single unit hot and cold cart had the lowest percentage of heat retention.

The cost factors were in the following order starting with the one which had the least cost: (1) conveyors, (2) pellets, (3) the double unit hot and cold cart and (4) the single unit hot and cold cart; this was for the original purchase and installation costs. The annual operating costs were as follows also starting with the lowest cost system: (1) conveyors, (2) pellets, (3) the single unit hot and cold cart and (4) the double unit hot and cold cart.

From the information gathered in this study, it would seem that the pellet system would be the system of choice in that it had the fastest delivery and transportation time, an acceptable heat retention and it's cost factors were reasonable, in that the lowest cost system was not much below it.

It was recommended, however, that further study be conducted on the pellet system and on the percentage of heat loss with a suitable or acceptable temperature retention.