

REGIONALIZATION OF BLOOD BANKING SERVICES

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The study reported here was undertaken in recognition of the need to understand the economic and organizational consequences of different forms of regionalization of blood banking services. In addition it was felt by many in the industry that there were serious inadequacies in the blood service system of metropolitan Chicago, and that there was insufficient knowledge of both the quantitative and qualitative aspects of this situation upon which to base any improvements.

In order to understand the organization and operation of a regional system and measure its economic impact, data were gathered from the 7 Chicago metropolitan blood centers and 66 Chicago area hospitals as well as 5 other regional blood centers from around the Nation.

The ultimate aims of the study were to provide an understanding of some of the implications of various regional structures as a basis for planned change in a region when such change is warranted. This planning takes the form of determining which blood banking functions should be performed at what locations, which donor areas and transfusion services should be assigned to which community blood centers, how many community blood centers should be in a region and where they should be located and how supply and demand should be coordinated.

Before examining the data and their subsequent analysis, the following discussion considers various system models and functions.

SYSTEM MODELS

Three basic models alone or in combination represent most blood banking systems:

- i) The single center (SC) model, a single community blood center which serves the entire needs of a particular region.
- ii) The multiple independent centers (MIC) model, a collection of communicating community blood centers under independent control, which service the blood needs of the region.
- iii) The coordinated multiple centers (CMC) model, a regional blood center which either coordinates or controls the activities of a collection of community blood centers which in turn fulfill the needs of the communities in that region.

These models are depicted in figure 1. As a general rule, as the size of a region changes due to an increase in demand or geography, the single community blood center may not adequately fill the needs of the region and one of the other two structures will tend to replace it over time.

A Single Community Blood Center for an Entire Region, the SC Model. A single community blood center provides all the blood services for a network of hospitals in a specified geographic region. The managerial control of the services to the network of hospitals is exercised or coordinated through the single central facility. The degree of control depends upon which activities are performed at the community blood center or at its member transfusion services (TS's) and upon whether or not the central facility maintains "authority" over the units in the unassigned inventories at the TS's.

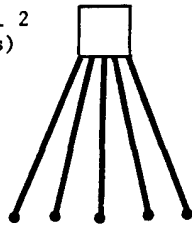
This is an issue of central importance since the management of inventories of whole blood and components involves a complex and often interrelated set of decisions concerning the collection, processing, record keeping, storage, issuing and transportation of units of blood.

FIGURE 1

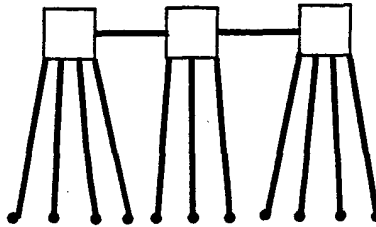
CENTRALIZATION ← → COORDINATION MODELS

Level 1
(RBC)

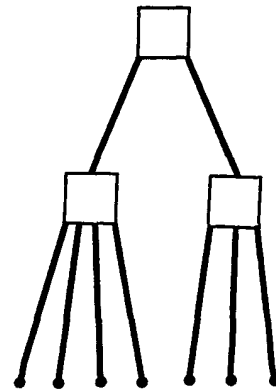
Level 2
(CBCs)



Single Center
SC



Multiple Independent Centers
MIC



Coordinated Multiple Centers
CMC

A Collection of Independent Community Blood Centers for a Region: The MIC Model. Since each community blood center (CBC) is independent, it faces all of the management problems of the SC model. In addition, it must decide on what levels to compete against or cooperate with the other CBC's.

The additional costs of this system are:

- i) Lack of economies of scale since CBC size is established by noneconomic considerations.
- ii) Overlapping jurisdictions for donors and transfusion services.
- iii) Duplication of facilities, services and personnel.
- iv) Confusion among donors, recipients and physicians.

A possible benefit of this system might be the independence and autonomy available to TS's to bargain for extra services (at a higher cost perhaps) and less rigid organizational rules for the system's management.

A Collection of Community Blood Centers Controlled or Co-ordinated by a Regional Blood Center: The CMC Model. This generic regional system is an extremely flexible organizational structure with regard to the work location of the functional areas and the degrees of control/coordination exercised by the RBC. In this latter regard, the RBC could be simply a shared service for functions such as unified donor recruitment, information/data processing and educational training programs. At the other extreme the RBC could carry full authority for the operation of the entire system.

This flexibility stems from the addition of a third layer to the hierarchy and the apportioning of the different functions of the system between the two levels.

The functional areas which have major impact on the cost and efficiency of operation are: information systems, donor services, phlebotomy, processing, inventory management and distribution. It is recognized that while administrative activity also contributes to cost, its component in each functional area cannot be separated from the area. Table 1 illustrates some of the range of coordination/control available in the CMC model.

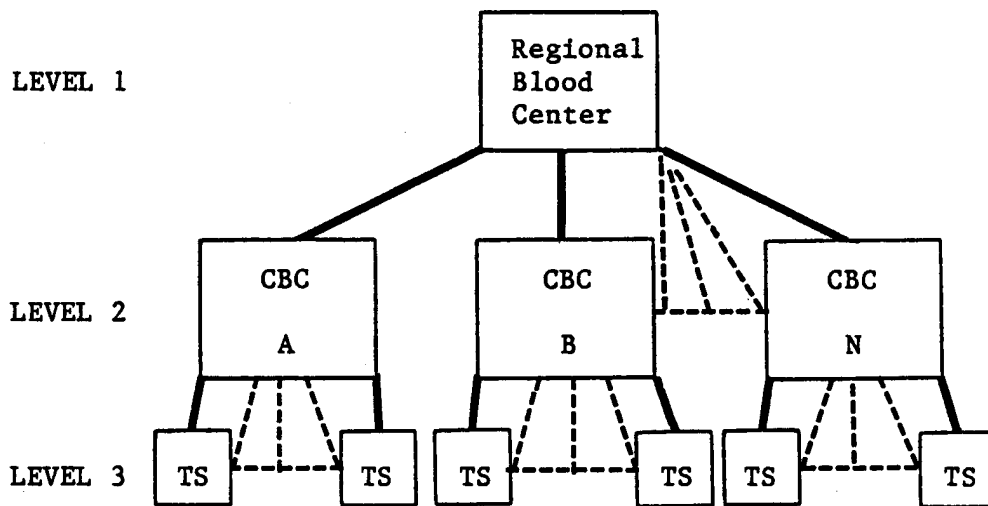
In addition to the differing degrees of authority within this generic structure, the performance of various blood banking functions can be located at the RBC (figure 2, level 1) and the remainder at the CBC's (figure 2, level 2). A separation of the locations of the different functional components may be neces-

TABLE 1

<u>Degree of Authority</u>	<u>Activities</u>
Coordination	Gather data and disseminate to CBC Conduct Educational Training Programs for CBC's and TS's Hold periodic meetings for CBC directors, etc.
Full Control	Determine and enforce donor services policies at all levels Hire all CBC directors Approve all CBC budgets Determine all CBC functions Plan and initiate all regional changes to meet needs.

FIGURE 2

REGIONAL STRUCTURE



Hierarchical Regional Structure

sary to achieve overall optimality for a given set of circumstances. The optimal separation may be affected by such factors as geography, facilities' size limitations or political considerations. The appropriate structure for any area depends on a complex interaction between the level of activity, the economies or diseconomies of scale, the cost effectiveness and efficiency as well as the interactions of the interested parties.

The impact of size, authority and allocation of functions on different costs of blood banking activities in a region is an important concern. The main determinants of the costs are personnel, space and the equipment used to carry out the activities of the blood center(s). We have concentrated primarily on personnel costs, since they represent the largest amount of variable costs under the control of the administrator, and also since space and equipment costs are indirectly reflected in the organizational structures and in the number of personnel available.

TABLE 2

BLOOD CENTER FUNCTIONS

Information Systems

Donor Services

Phlebotomy

Processing

Inventory Management

Distribution

The various functional areas listed in table 2 can be considered for assignment to either level 1 or level 2 of figure 2. The rationale for any particular assignment of functions involves trade-offs between their utility and their cost at each level. The assignments chosen for analyses and illustrated in table 3 represent a step-by-step allocation of functions from CBC's to the RBC. This approach was taken because it is often the case that regionalization will take place by an evolutionary change in the status quo of an existing system rather than from the development of a system de novo, or by revolution.

Of the regional options shown in table 3, the simplest form of regionalization is option 2 where the only truly regional functional activity is a coordinated donor recruitment system. This first step in moving from the MIC model to the CMC model implies that the blood centers maintain their identity, continue as separate corporations and operate under separate licenses. While this appears to be only a modest change, in order to function well there must be single donor recruitment effort with a philosophy and approach to donors arrived at by consensus of all the participating CBC's. In addition, any information that will flow in the system must be uniform and requires that the participating blood centers be willing to share their information gathering and maintaining it in an integrable form at the RBC.

It is possible that the regional coordinating center be a separate corporation formed by the CBC's for the purpose of unified donor recruitment and equitable allocation of donor resources, and that it not be tied to any of the functional components of a "wet" blood bank. The format of option 2 is likely to be the logical first step in regionalization in an area where there are well developed independent blood centers with a history of brisk competition. The most important disadvantage to this sys-

Table 3

<u>Option</u>	<u>Functions at RBC (Level 1)</u>	<u>Functions at CBC (Level 2)</u>
1.	None	Inventory and Distribution, Processing, Phlebotomy at Center, Phlebotomy on Mobiles and Donor Services (this is equivalent to the MIC of figure 1)
2.	Donor Services	Inventory and Distribution, Processing, Phlebotomy at Center and Phlebotomy on Mobile
3.	Phlebotomy on Mobiles and Donor Services	Inventory and Distribution, Processing and Phlebotomy at Center
4.	Processing, Phlebotomy on Mobiles, and Donor Services	Inventory and Distribution, and Phlebotomy at Center
5.	Processing, Phlebotomy at Center, Phlebotomy on Mobiles, and Donor Services	Inventory and Distribution
6.	All Functions (this is equivalent to SC of figure 1)	None

tem is that the donor scheduling functions must interdigitate with the phlebotomy function across a structural division. The donor recruitment function must work closely with the inventory management functions to predict and meet short-term demands and with general management to plan for anticipated long-term changes in demand.

Option 3 adds the responsibility for phlebotomy on mobile blood drawings to those already housed in the RBC while processing remains at the community blood centers. There are advantages to be gained from this seemingly artificial separation of other apparently closely linked functions such as processing and inventory management.

Housing the regional mobile phlebotomy staff at one central location has the advantage of permitting the most efficient use of personnel and permits the easy reallocation of staff in response to last minute changes in staffing requirements.

Similar flexibility in mobile equipment and personnel vehicle dispatching and scheduling can derive from a centrally located vehicle pool. Finally, central location of mobile phlebotomy personnel permits closer scrutiny of performance and engenders greater consistency and a higher level of quality control than would a decentralized staff with its additional layer of liaison management personnel.

The separation of mobile phlebotomy from processing simply requires the separation of delivery of blood to the processing labs from the delivery and pick up of the mobile drawing equipment.

There are disadvantages to separating the in-house phlebotomy (in option 3 this is housed at the CBC) in the area of staff education and supervision. Also there may be the requirement of separate recruiting staff for the CBC in-house phlebotomy activity.

The choice between option 3 or option 2 must be made only after assessing the trade-offs involved. These hinge on the advantages versus disadvantages of the in-house phlebotomy function at centers each responding to individual demands.

The maintenance of the in-house phlebotomy activity under this format is likely to derive more from the need to decrease the inconvenience to donors by eliminating long travel distances to the RBC or to take advantage of the community identification in recruiting donors, than from the need to bring in donors for the purpose of making up type specific blood shortages. This latter activity will more likely be under the in-house phlebotomy function at the RBC. The separation of functions required in option 3 has an important ramification which will have serious impact on the cost of operation and the structure of administrative support. This is the fact that the Bureau of Biologics of the Food and Drug Administration requires that the same licensee responsible for phlebotomy also be responsible for processing. The most feasible and realistic form of implementation of option 3 (and 4 and 5 as well) is one in which the CBC's and the RBC all operate under one license and belong to one corporation.

Option 4 moves blood processing to the RBC while continuing in-house phlebotomy at each of the CBC's along with inventory handling and distribution. This format appears to decompose the system into a SC model with satellite donor drawing stations and blood depots. This format is one which arises when the RBC in

the SC model recognizes that its service area has expanded to include geographic areas with either disproportionate increases in transportation costs or unacceptable delays in response to orders. This could arise when the services are provided in large rural areas or metropolitan areas with several travel restrictions such as rivers, bays, mountains or other geographic factors leading to long travel times.

The arguments about the locus of the recruitment staff presented for option 3 hold for option 4 as well. The transportation problems are somewhat different. The RBC now has the transport functions of delivery and retrieval of mobile teams, retrieval of blood units drawn, delivery of processed blood to CBC (depots) and pickup of unprocessed blood at CBC in-house drawing facilities. The transport function of the CBC is limited to the movement of blood between the CBC and the transfusion services allocated to it as well as the transshipment of blood among transfusion services. Option 4 has all the advantages of centralized processing with potential economies of scale in use of staff and equipment, greater consistency and more effective quality control. These benefits are effected by the greater magnitude of the transportation costs. The trade-off between these costs and benefits must be assessed in concert with all the trade-offs in the stepwise progression through the preceding options.

Option 5 moves all phlebotomy to the RBC. The CBC (now, truly, a misnomer) serves simply as a depot with very simplified function. Control of virtually all activities has passed to the RBC. The only information flow between the RBC and CBC pertains to issues such as blood in inventory levels and vehicle maintenance. Again, option 5 is one which would grow from the SC model where the response to increasing demands, either of volume only or volume and geography, were problems in inventory allocation

and shipment. Also, the transshipment costs among TS's would have increased to the point at which they were greater than the problems and costs of maintaining satellite blood distribution depots. Option 5 would be most applicable to an RBC with a large rural constituency of TS's.

Option 6 consolidates all functions in the RBC. In this case the RBC is a single center and there are no CBC's.

To recapitulate, these six options of the coordinated multiple centers model of a regional blood system represent the spectrum between "option zero," the multiple independent center model with no coordination, stepwise through increasing centralization of functions to option 6, the single center model. The constraints forcing merger and consolidation with major changes in management, image and governance grow and peak with option 3. Options 4 and 5 represent a partially decentralized form of the SC model in which the advantages of the decentralized mode may outweigh the costs.

It is important to keep in mind that this study emphasizes quantifiable considerations but recognizes that there are non-quantifiable factors, i.e., qualitative aspects such as image, degree of market saturation and political considerations which may weigh against pure costs in the decisionmaking process.

Not included in this discussion of the various options are special functions such as antibody identification or consultation service, and other functions which are characterized by infrequent and random demands for either rare products or special services, such as HLA typing, random or specific donor platelets and/or granulocytes, and rare red cell phenotypes. These services clearly are best provided in a regional setting since the

most efficient provision of these services requires a high level of expertise and some minimum number. Regionalization of these activities requires the least redundancy in expertise and provides sufficient numbers of the unusual services to create the critical mass necessary to maintain availability and proficiency.

DATA

Data for the years 1975, 1976 and 1977 were requested from the 7 community blood centers and 115 hospitals with transfusion services in the greater metropolitan Chicago (GMC) area and from 5 other community blood centers: greater New York, Milwaukee, Minneapolis War Memorial, St. Paul and the Los Angeles/Orange County Red Cross. All community blood centers responded and 66 hospitals responded. Partial data from 45 of the nonresponding hospitals were available in the responses of the CBC's with whom they have a "total service" arrangement. Some of the highlights from these data are presented below. Although limited in amount, the data will lead us to some conclusions as to why an area should or should not regionalize and if regionalization is warranted, what forms seem reasonable to consider.

These data were analyzed according to the functional areas listed earlier using regression models to determine where economies of scale exist and to predict the cost of operation of the system under each of the three basic models described earlier. Further, within each model the cost of operation of the system is assessed with the various options of hierarchical distribution of functional areas shown in table 3. The results of the analysis of these data are presented in a later section of this paper entitled "Economies of Scale."

DRAWINGS AND TRANSFUSIONS

As noted in table 4 the rate of increase in drawings from 1975 to 1976 was greater than from 1976 to 1977. For the larger standard metropolitan statistical areas, these rates of increase range from 7 percent to 11 percent for 1975 to 1976 and only 2 percent to 3.5 percent for 1976 to 1977. Clearly there are not enough data to see if this leveling off reflects a national trend or just a 1 year variation. If there is a leveling off it may be due to a saturation of the donor market, changing therapeutic needs with a shift toward more component use complete with a correspondingly better utilization of the total blood resource and/or stability in the demand for red cells.

If stabilization occurs in the drawing of whole blood and if this is caused by the leveling of demand for red cells rather than a saturation of the donor market, then from the donor services perspective there may be less reason to regionalize. However, these data do not illustrate the three most important aspects of a nonregionalized system, namely, (i) the great variations in daily and monthly drawings, (ii) the great variation in daily, weekly and monthly transfusions, and (iii) the need to smooth these fluctuations and coordinate the drawings with the transfusion demands. Figures 3 and 4 show the daily fluctuations in mobile units scheduled and in drawings for the seven blood centers in the greater metropolitan Chicago area.

These fluctuations are large, reflecting the fact that drawings are not coordinated among the centers and there is little attempt to smooth the daily available supply of whole blood. Consequently, there are times when all centers have surpluses, times when some centers have surpluses while others have shortages and times when all centers have shortages. If it were possible to shift some drawings and reallocate the supplies of blood, many of the fluctuations could be smoothed.

TABLE 4

PHLEBOTOMY

Geographic Area	1975 Population SMSA (000's)	1976 Phlebotomy as a % of 1975 Population	Phlebotomy		
			1975	1976	1977 (est)*
GMC	7,015	4.58			
i) All community blood centers			196,763	234,358	247,871
ii) Reporting Hospitals			50,656	39,704	35,196
iii) Estimates for non reporting hospitals			NA	47,146**	NA
iv) Total (est.)			NA	321,208	NA
Los Angeles R.C.	6,987	4.44	290,544	310,241	318,841
Milwaukee B.C.	1,409	5.96	82,908	83,986	83,944
Minneapolis W.M.	2,011	9.09	38,858	42,556	43,033
St. Paul R.C.			138,828	140,211(est)	NA
New York B.C.	9,561	6.50	572,315	621,600	636,167

* For most blood centers the 1977 data covered only part of the calendar year. These figures are a projection of the 1977 figures furnished by the centers.

** Estimate based on three month actual data and adjusted to twelve months by proportionality, to reporting hospitals.

FIGURE 3

DAILY MOBILE UNIT USAGE BY CBCS

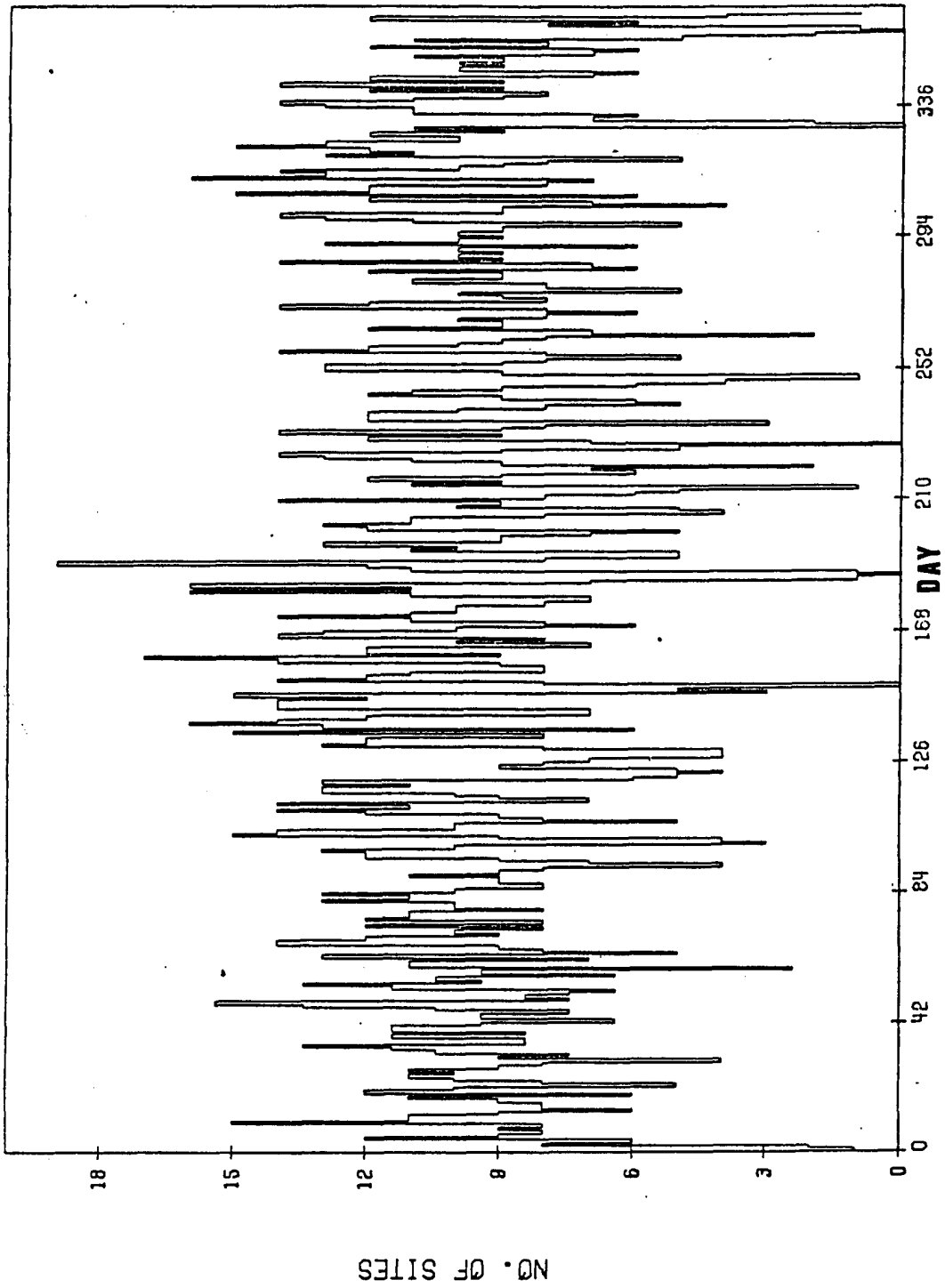


FIGURE 4
DAILY PHLEBOTOMY BY CBCS

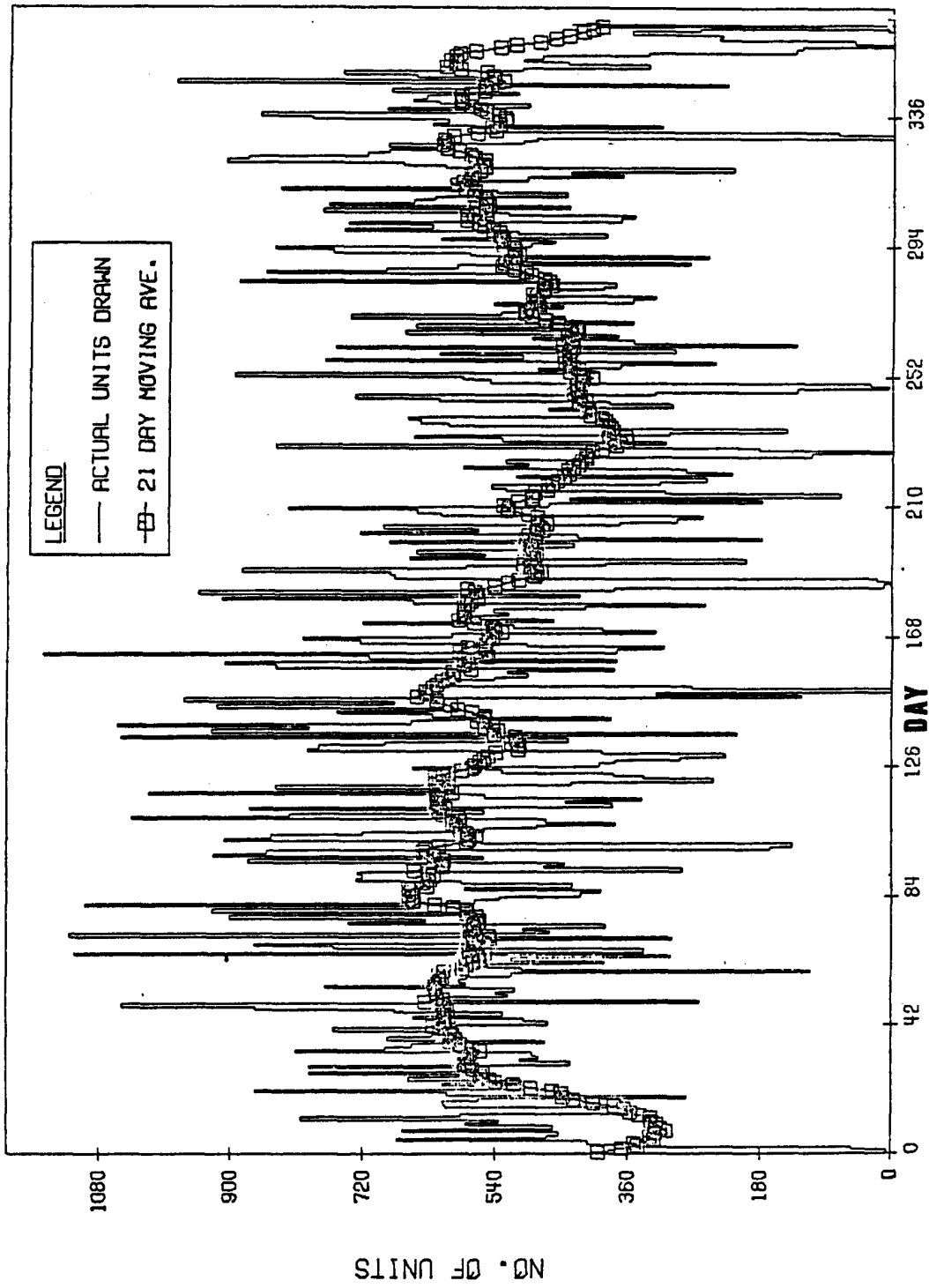


Figure 5 shows the daily demand for 0+ blood in a major Chicago medical center. In this center other ABO-Rh groups show even greater daily fluctuations. Consequently, the suppliers of this medical center (including its own donor recruiting staff) face large fluctuations in the need to maintain adequate inventory levels.

Fortunately, except for times of major disasters, the fluctuations in a region tend to average out as the daily demand of more and more transfusion services are added together. Consequently, the total demands in a region tend to be much smoother for nonrare bloods than the demand reflected in figure 5. Regional coordination and smoothing of donor drawings in concert with regional demand predictions and optimal inventory control policies therefore would tend to eliminate most shortages and almost all frantic telephoning among centers and transfusion services. In addition, outdated units could be held to a minimum. It should be noted that all reporting hospitals in the GMC area with red cell demands greater than 4,000 units annually did some of their own phlebotomy and processing. In this way, these hospitals hedged against shortages at the centers.

COMPONENT PRODUCTION AND TRANSFUSIONS

While drawing of whole blood may be indicating some leveling off, the manufacture of blood components from 1975 through 1977 has shown rapid growth. This growth is illustrated in table 5 for the GMC area and is similar to the other geographic regions in this study.

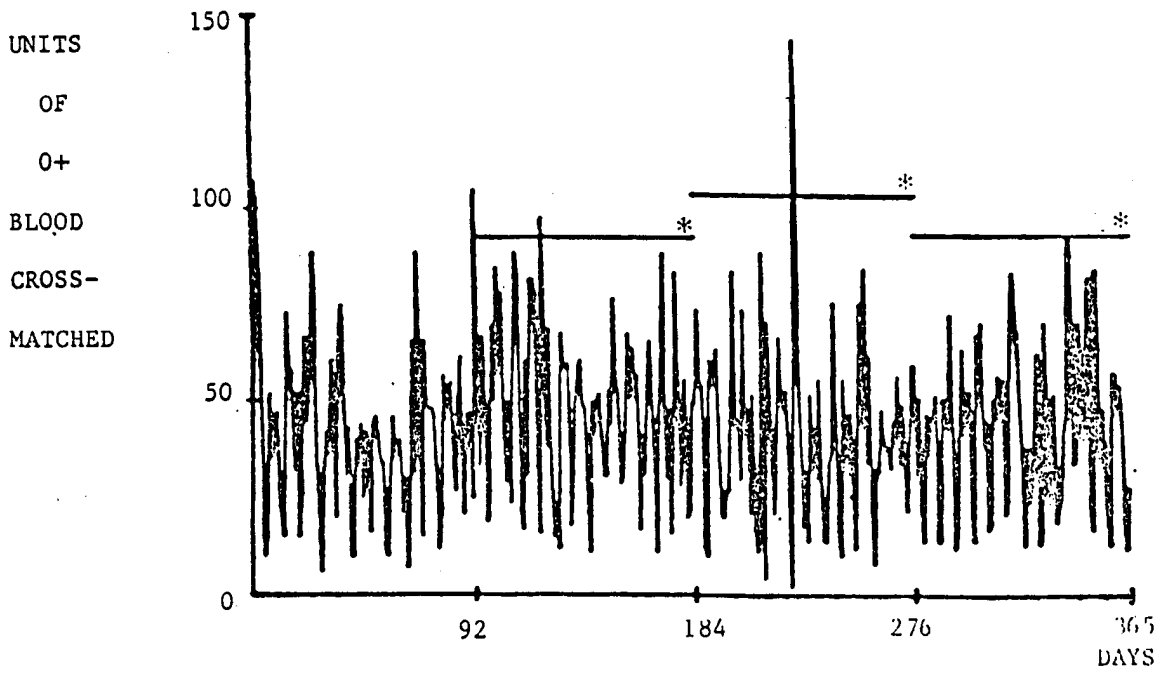


FIGURE 5

DAILY UNITS OF O+ BLOOD CROSSMATCHED
 AT A LARGE METROPOLITAN MEDICAL CENTER
 (WITH TARGET INVENTORY LEVELS INDICATED BY ASTERISKS)

TABLE 5

ALL COMMUNITY BLOOD CENTERS-GMC AREA
COMPONENT PRODUCTION REPORT

<u>COMPONENT</u>	<u>1975</u>	<u>1976</u>	<u>1977 (EST)</u>
Whole Blood	103992	105483	93835
Regular Packed Red Cells	83455	116988	140336
Frozen Packed Cells	3230	4268	5045
Liquid Washed Packed Cells	270	830	1221
Leukocyte Free PC	34	96	80
TOTAL RED CELLS	190982	227665	240517
Platelet Concentrate	27199	41409	51825
Fresh Frozen Plasma	21026	33099	40812
Platelet Rich Plasma	11	1765	6926
Cryoprecipitate	5291	4834	5401
Leukocyte Concentrate	0	0	0
Single Donor Plasma	0	6	4
Miscellaneous	0	0	0

Transfusions of components from reporting hospitals in the GMC area are shown in table 6. The significant change from 1975 through 1977 is represented by the large increases in the quantity and proportion of packed red cells, platelets and fresh frozen plasma transfused. These increases reflect more effective utilization of the blood resource but also indicate the need for more management of this resource.

OUTDATING

Some regions experience considerably more outdating of red cells than others. Since the causes of outdating involve a complex relationship among drawings, inventory levels, cross-match to transfusion ratios, cross-match release times, transshipment among hospitals and other factors, it is not possible to say which causes are primary in a given region. The culprits are often the wide fluctuations in supply and demand, and also may be inventory control and distribution. In all cases systematic management can aid greatly in the reduction of outdates by: (i) coordinated donor scheduling, (ii) coordinated supply of hospitals, (iii) establishment of accurate target inventory levels, (iv) control of the C/T ratio and cross-match release times and (v) transshipments to anticipate shortages or outdates.

STAFFING

To analyze the staffing levels at the blood centers, several factors had to be considered. Not every center performed the same tasks or produced the same proportions of components. However, each center handled donor services, phlebotomy on mobiles and at the center, processing and inventory control and distribution. In addition, each center had administrative and house-keeping staffs.

TABLE 6

TRANSFUSION OF COMPONENTS IN GMC
(Reporting Hospitals Only)

TRANSFUSION REPORT

<u>COMPONENT</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
Whole Blood	58867	61002	50223
Regular Packed Red Cells	84587	104204	114604
Frozen Packed Cells	2988	3293	3972
Liquid Washed Packed Cells	4037	6549	8733
Leuko Poor PRC	328	475	668
Fresh Frozen Plasma	10580	14495	18144
Platelet Concentrate	20326	27606	35275
Platelet Rich Plasma	114	94	66
Cryoprecipitate	2603	1428	1977
Pheresis - Platelet	301	794	1178
Pheresis - Leukocyte	28	146	413
Leuko Free PC	39	38	50
Leuko Concentrate	0	0	0
Single Donor Plasma	0	0	0
Miscellaneous	0	0	0

To compare the workload at centers across functional activities with regard to different proportions of components, a study of the times required to make the different components was undertaken. Using the results of these time studies, time-weighted volumes of activity were defined for each blood bank function and each center. In this manner, it was possible to compare the workload activities at all the centers for each function. In mobile phlebotomy, the number of units used to measure the work load were the amounts of whole blood drawn on the mobiles. In donor recruiting, the units were the whole blood drawn at the blood center, satellites and mobiles. In processing, the units were the whole blood drawn, plus weighted handling and processing times for the other components based on a normalized weight of 1.0 for whole blood. In the inventory and distribution area, the units were the total units shipped including whole blood and components. In the administrative and total manpower areas, the units were the appropriate units for each of the functional areas weighted by the percentage of the staff in each of the areas.

Man-hours per unit rather than dollar costs per unit was chosen as the basis of measurement to compare the "costs" at the 12 CBC's in the study. The choice of man-hours removes the need to adjust dollar costs for the different wage rates experienced throughout the country. Great variation in man-hours per unit occurs across centers. Some of this variation is due to economies of scale, as discussed in the next section, or may result from differential geographic distance, saturation of the donor market, style of management and expansion dislocations.

ECONOMIES OF SCALE

If regionalization is to be effective it must make a positive contribution to the achievement of one or more of the following objectives: reducing costs, reducing shortages and

outdates, reducing extraregional dependencies, improving the quality of the products, reducing the confusion of overlapping jurisdictions. A search for economies of scale was thought to be the most logical starting point to analyze these factors. We have already noted that by well planned operations, regionalization can reduce shortages and outdates by smoothing the supply and demand fluctuations.

Because wage rates, depreciation, purchasing costs of goods and supplies, rent, utilities and other costs vary greatly from one region to another, costs expressed as man-hours per unit were used to derive the production function for each functional area of blood banking and for combinations of functional areas. The combination of functional areas are the options designated 1 to 6 in table 3. For example, option 5 reflects all tasks except inventory and distribution to be performed at level 1 (the RBC); option 2 reflects all tasks except donor services to be performed at level 2, and so on.

It was hypothesized that economies of scale exist in all options with the possible exception of donor services. In donor services, as the geographic area expands and the donor market reaches a saturation level, it was hypothesized that more and more donor recruiter hours are needed to obtain the additional units of blood.

If was found that the economies of scale hypothesis was reasonable for phlebotomy at the center, mobile phlebotomy and inventory/distribution and to a lesser extent donor services and administration. No strong conclusions about economies of scale could be drawn concerning processing. When all functions were combined, as in a single center, economies of scale exist and are significant.

Since the study was undertaken to examine regionalization, the specific functional areas play no direct role in the evaluation of regional economies of scale (except for the two cases, inventory and distribution, in option 5, level 2 and donor services in option 2, level 1 where the single functional areas coincide with a part of an option). The options which correspond to specific regional organizational structures ranging from totally centralized activities to totally decentralized activities are the critical structures to be examined for economies of scale. Figures 6a and 6b show the least squares regression curves, which clearly exhibit economies of scale. In particular, at the lower volumes (10,000 red cell units annually), the economies of scale are very significant. From 50,000-75,000 units, economies of scale are not as dramatic. Above 75,000 units the curves tend to flatten out but still show some small economies of scale; caution should be exercised in using the curves past 200,000 weighted units since they were derived with only four data points.

Essentially this analysis leads to two related conclusions. First, a regional system with community blood centers which are operating below 50,000 weighted units can realize significant economies of scale by increasing volume. These economies come from a more efficient utilization of space, equipment and vehicles, specialized skills and learning curve effects. Second, a regional system with one community blood center is more economical than a regional system with two CBC's, two are more economical than three, and so on. Both the curves and the example in table 7 show that none of these community blood centers should operate at less than 50,000 red cell units annually. Thus a region with slightly over 200,000 units annually is operated most economically with one center. The costs of two or three community blood centers (even if all are over 50,000 units) rises rapidly.

FIGURE 6a

Plots of Regression Curves for Level 1 (RBC)

Options 2 through 6

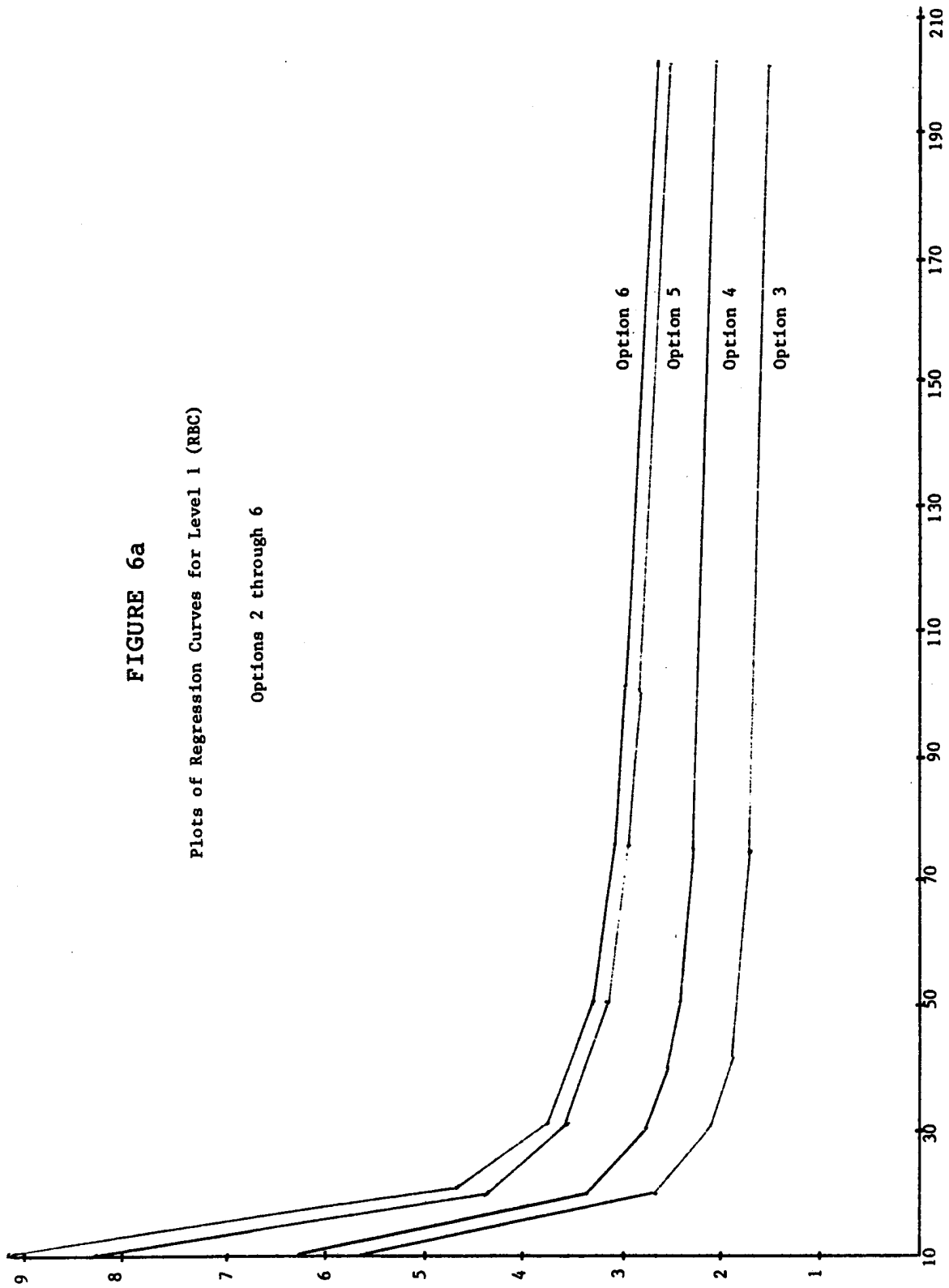


FIGURE 6b

Plots of Regression Curves for Level 2 (CBCs)

Options 1 through 5

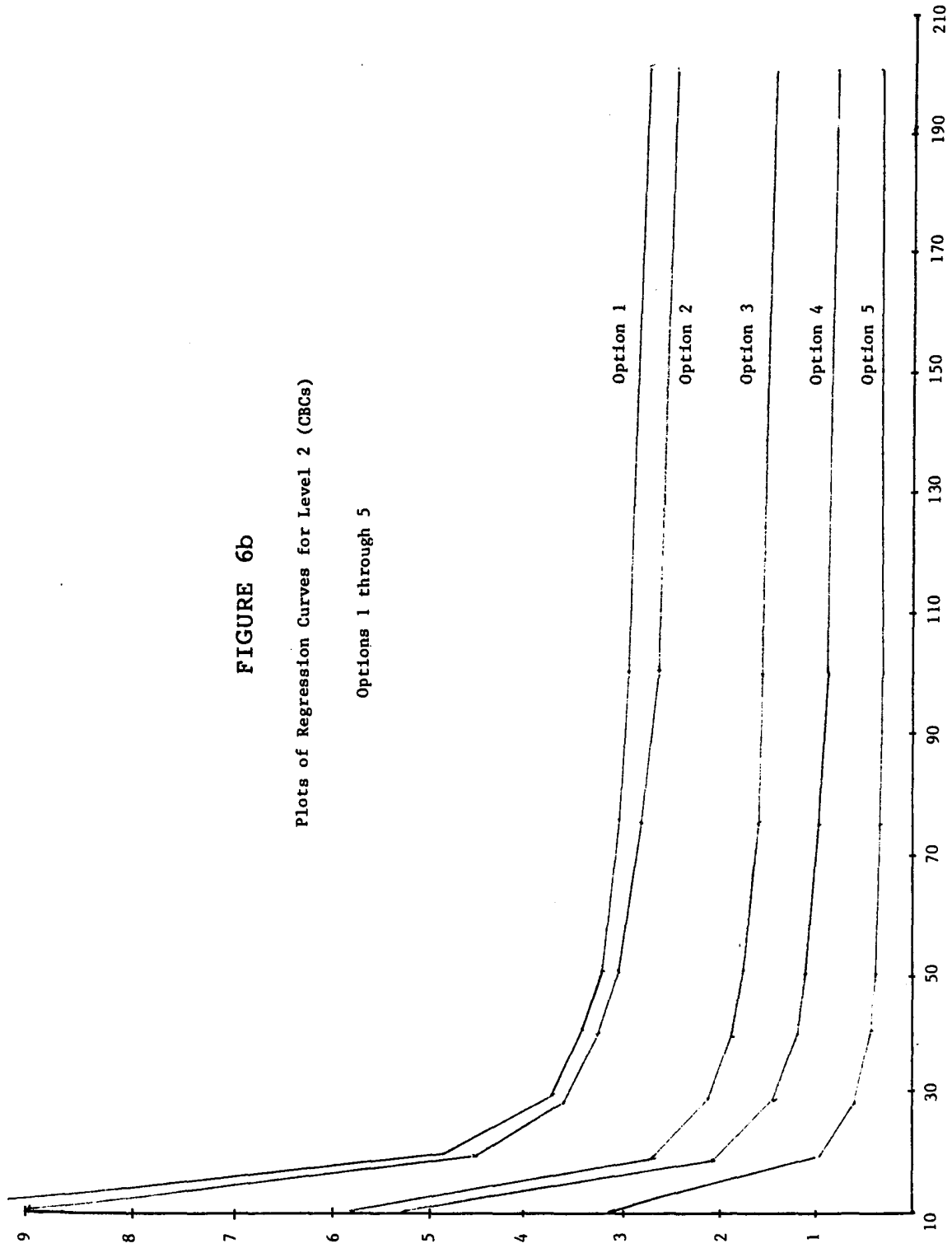


TABLE 7

Example of the Man-years Needed in a Regional System
 Drawing 234,000 Red Cell Units Annually
 Using Option 1

<u>Number of Centers</u>	<u>Annual Volume at Each Center</u>	<u>Total Regional Manyears</u>	<u>Difference</u>	
			<u>Net</u>	<u>Cumulative</u>
1*	234,000**	302	30	30
2	117,000	332	17	47
3	78,000	349	16	63
4	58,500	365	15	78
5	46,800	380	16	94
6	39,000	396	19	113
7	33,000	415	20	133
8	29,250	435		

* Option 1 when it has only one center is the same as option 6.

** Note: The seven Chicago community blood centers handled 234,000 units in 1976 and used 416.5 man-years. However not all seven centers are of equal size as the example above has assumed.

The donor services functional area did not exhibit statistically significant economies or diseconomies of scale for the survey data from the 12 community blood centers. There may be several reasons for this inconclusiveness but two of the main reasons may be: 1) donor services man-hours per unit recruited must be explained by a wider variety of independent variables such as a) the physical size of the region, b) the saturation of the donor market, c) the number of large, medium and smaller donor groups, d) the demographic characteristics of the population, and 2) competition for donors. Each of the five non-Chicago community blood centers had a reasonably well-defined donor region with no competition from other centers. The Chicago CBC's often find themselves in a competitive situation with extensively overlapping donor areas.

POSSIBLE REGIONAL STRUCTURES AND THEIR BENEFITS

In the preceding paragraphs it was concluded that some benefits of a regionalized structure would be: 1) smoothing of the supply of blood from donors and a reduction in competition for donors, 2) smoothing of the demands faced by a community blood center for blood and components by averaging the demands from many transfusion services, and 3) economies of scale by operating community blood centers at levels above 50,000 units annually. These benefits would lead to reduce shortages, outdated and costs.

The economic benefits of different regional structures also were examined with a location-allocation distribution model which takes as inputs the locations of transfusion services in a region, the distances separating them and their whole blood and component needs. The user then specifies the number of community blood centers to be evaluated (from 1 to 10) and their locations. In addition, the user specifies the desired option from

table 3 to be evaluated. The allocation of hospitals to the centers was made using the transportation-location-allocation model for regional blood banking developed as part of this study. The results of some runs of the computerized model are shown in figures 7 and 8. In these figures, the loops indicate which transfusion services are assigned to which community blood center to meet the demands for blood at minimal cost.

A second model was developed to allocate the supplies of blood to each CBC. This model takes as inputs the allocation of transfusion services with their demands given in the previous model and the available supplies of blood in the GMC by zip code area and then assigns the supplies to the centers in such a way as to meet the demands in each center and minimize costs of collection. Figures 9 and 10 illustrate the results of the supply assignment model corresponding to figures 7 and 8 respectively.

EQUIPMENT AND SPACE

In addition to manpower needs for operating the various regional systems, space and equipment also are needed. The study concluded that these needs tend to be proportional to size (with the possible exception of the Groupomatic) once a community blood center exceeded 50,000 red cell units annually. That is, above 50,000 units, as the size of the blood center doubled, its equipment and space needs tended to double.

This doubling of space needs tends not to be proportional in all functional areas. In some areas such as processing there are some economies of scale; however, there are additional space needs in larger centers for such expanded activities as conferences, education and research which often are not performed at smaller centers.

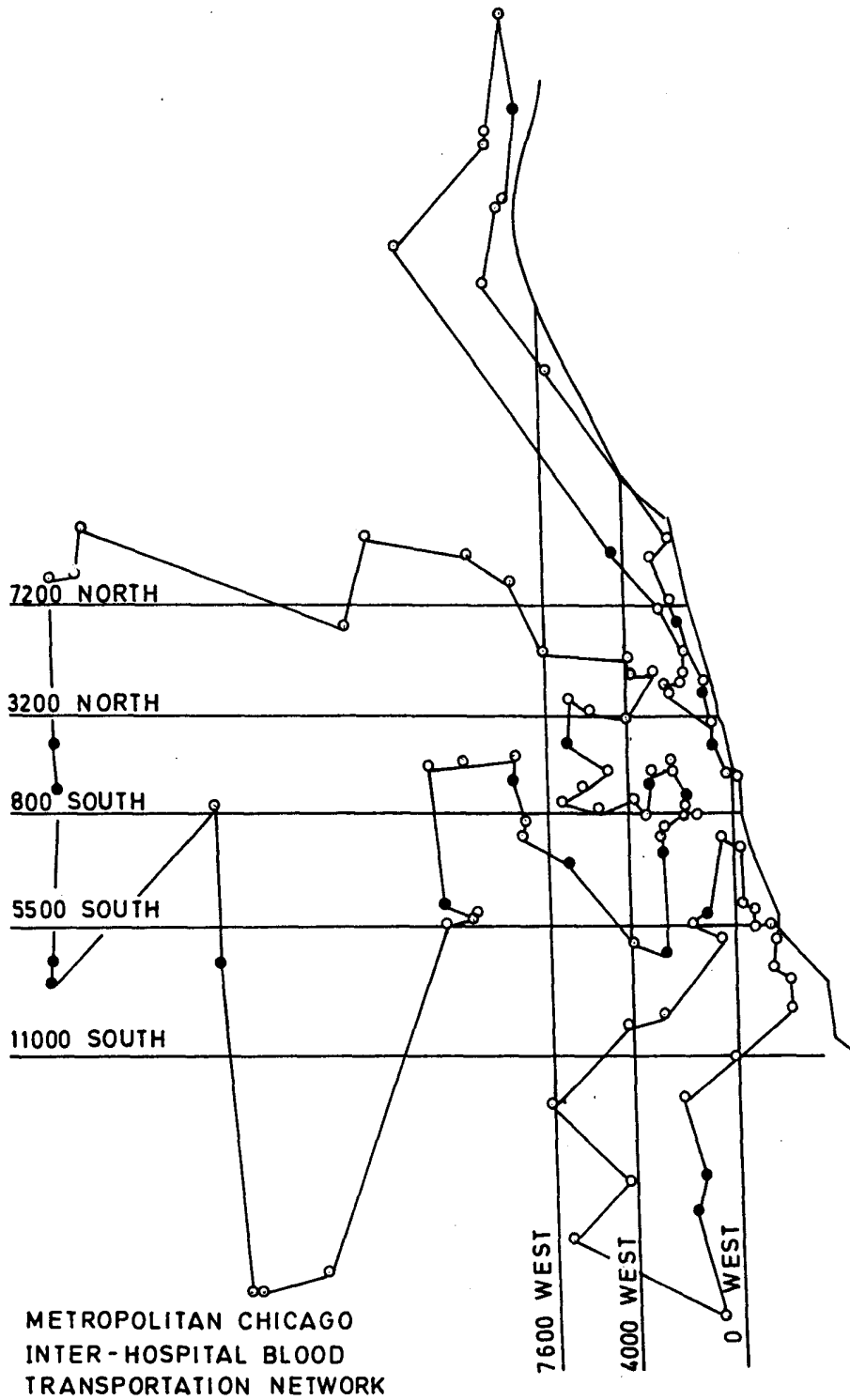


FIGURE 7. ALLOCATION BASED ON EMERGENCY ROUTING SYSTEM COSTS

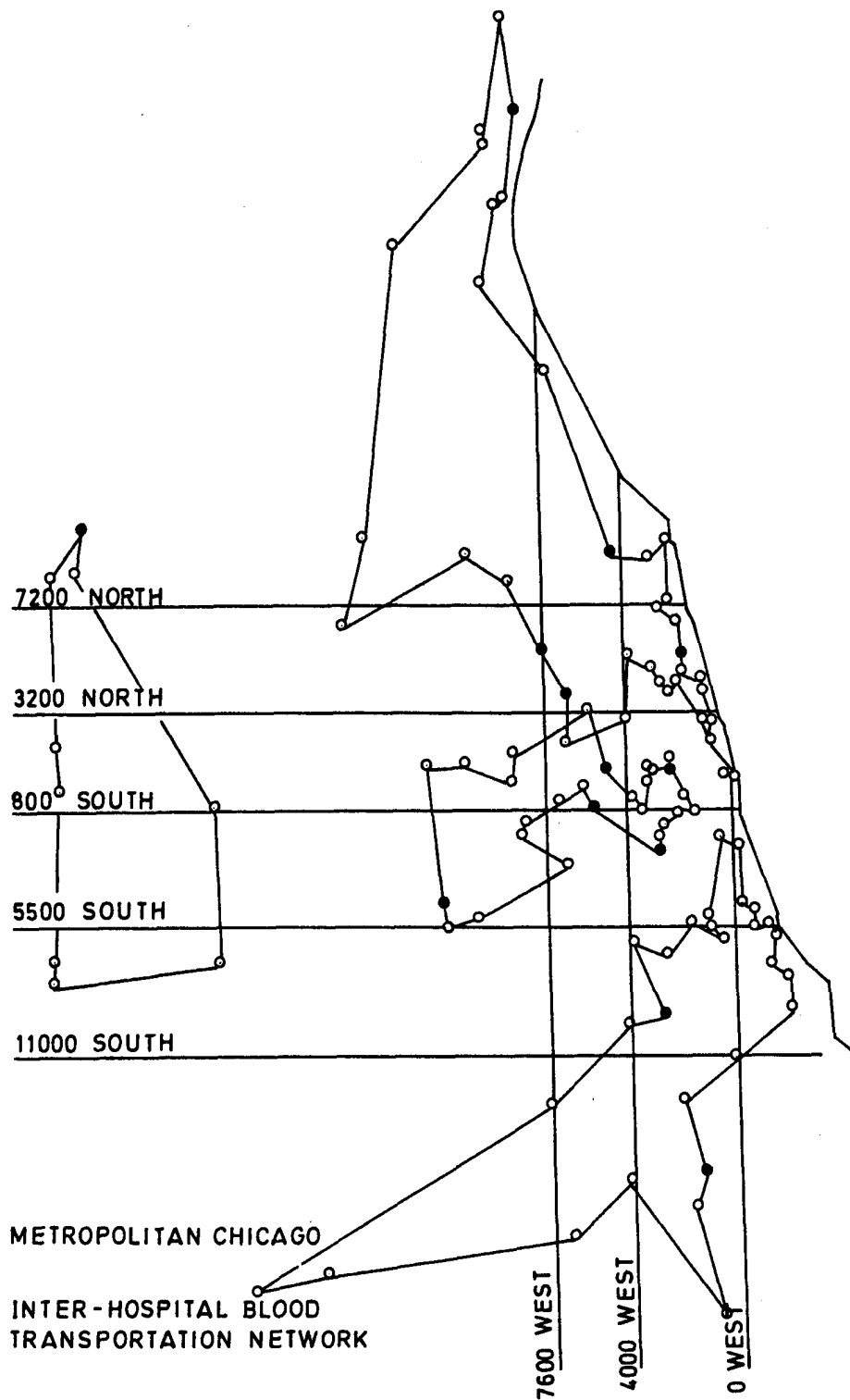


FIGURE 8. ALLOCATION BASED ON EMERGENCY ROUTING SYSTEM COSTS

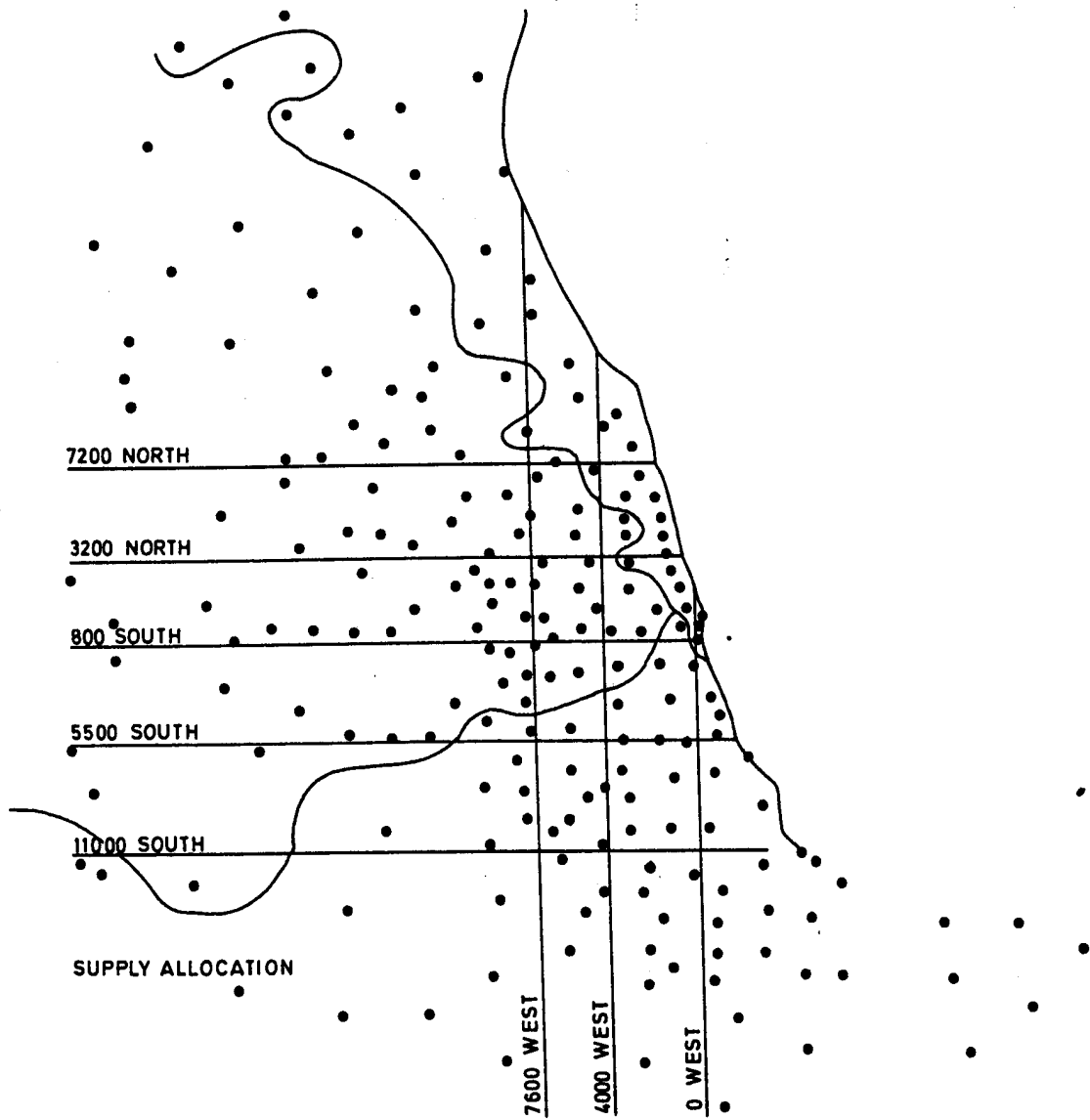


FIGURE 9. DONOR ZIP CODE AREAS ASSIGNED TO THE THREE COMMUNITY BLOOD CENTER REGIONS SHOWN IN FIGURE 7.

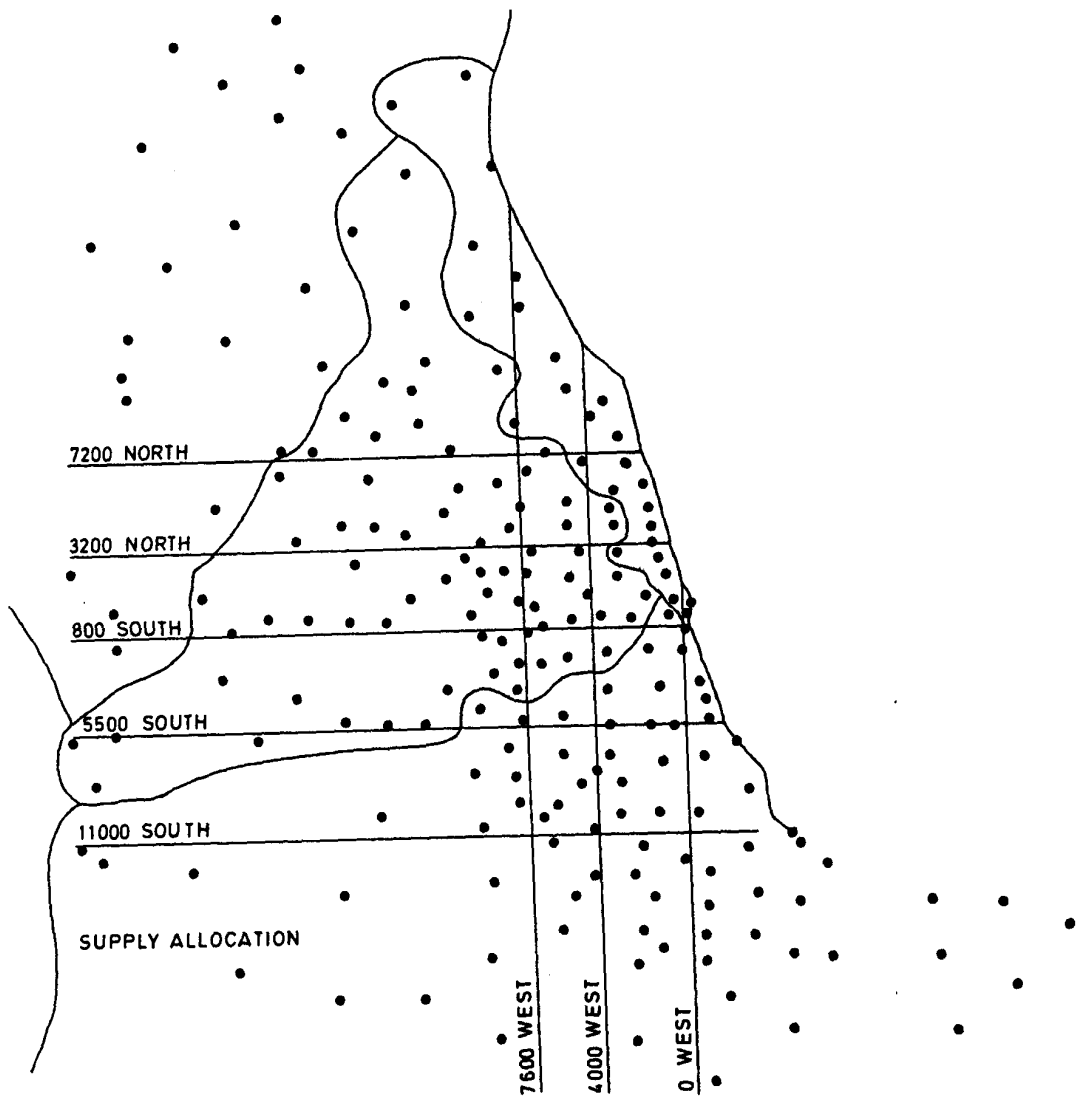


FIGURE 10. DONOR ZIP CODE AREAS ASSIGNED TO THE FOUR COMMUNITY BLOOD CENTER REGIONS SHOWN IN FIGURE 8.

CONCLUSIONS

The results reported in this paper represent an analysis of the data available. With a larger data base a more complete analysis could be performed which could include more explanatory variables and, it is hoped, would have stronger statistical significance. Our results are strongest for blood centers smaller than 200,000 red cell units annually. Above that level, our data and national data in general are scarce.

Some of the conclusions found in this study are:

- o Centralized donor activities can smooth large fluctuations in supply and reduce competition for supply and shortages.
- o Centralized coordination of inventories can smooth demands for blood and components and reduce outdating.
- o Economies of scale can be realized for operations above 50,000-75,000 red cell units annually. Furthermore, there are economies of scale at even higher levels of operation but the rate of improvement decreases.
- o Assignment of functions to the two different hierarchical levels of operation makes an impact on the costs of operation.
- o The lowest costs are with a single RBC and no CBC's, option 6. This is followed by option 5.
- o All community blood centers in a region should operate above the 50,000 annual unit level if the region is large enough.
- o There may be diseconomies of scale in operating CBC's above 500,000 units annually but there are not enough data to permit confidence in this conclusion.

- o A transportation-location-allocation model is available to study the location of community blood centers and the transfusion services assigned to them in a minimum cost manner.
- o An assignment model is available to assign donor areas to CBC's in a minimum cost manner.