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STUDY ON
LOCATION OF HEALTH SERVICES

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summary

I - Scientific antecedents :

On the one hand , there is a wide spread belief that precise insight and the use of effective techniques in the organization, implementation, and evaluation of health services, is very essential if higher standards of health care are to be achieved. Meanwhile, the need for multidisciplinary studies, making use of progress attained in knowledge and technology , both medical and general, is unquestioned .

On the other hand, concerning their role in prevention, diagnosis, treatment, rehabilitation and sanitary teaching , health service facilities could be considered as the symbol of health care , and the physical means or workshops for the entire health care delivery system. And though they are not ends in themselves health facilities represent - from the investment , and planning points of view - a capital item that has a long physical life . And ignoring the planning for it , would not only affect the effectiveness and efficiency of care presented, but also would lead to serious economical losses .

Up to the time of this research , no complete work has been done in the field of health service location. Most of authors in literature dealt with planning for health service have not paid attention at all to this side . Exceptionaly , came the swedish group of researchers in Göteborg Center /1966/(1), and Schneider from the USA /1967/(2) , who separately tried to predict future hospitals utilization , operating costs , and requirements of an area , by the use of population and/or facility centered approaches . In their works , they have correlated between number of attendants to services from certain area , or for a group of hospitals, and bed turn-over data or number of patients discharges. As a matter of fact, their works -though could be considered as the earliest in the field of distributing health facilities geographycaly- have failed to represent a systematic scheme for analysis, decision making, and evaluation .

That is why, herein, accelerated efforts have been spent by the author to represent a general systematic exposition to the locational choice problem of health services on the settlements' level,i.e. problem of distributing health facilities available at present or in the future among urban and/or rural agglomerations: cities, towns,.etc fulfilling maximal geographical accessibility to the clients in a given region.§ And in order to limit the scope of this broad topic of "where" , it has been assumed -for health services- that answers have been previously given to the "what", "to whom" , "how" and "who" . Hence the objectives of this study have been put as follows :

1. to expose the locational pattern of health services .
2. to define in general , factors influencing the locational decision .
3. to present a general and applicable mathematical formulation to the problem of distributing health facilities among different settlements of a region .
4. to search for new location-oriented indicators and evaluating techniques for health services distribution .
5. to test the validity of the suggested models through their application on simplified examples from the reality .

II - Methodology and subject studied :

According to the broadness of the subject and multivariable have to be coped with , a multidisciplinary approach has been adopted by the author /Figure 1/ .

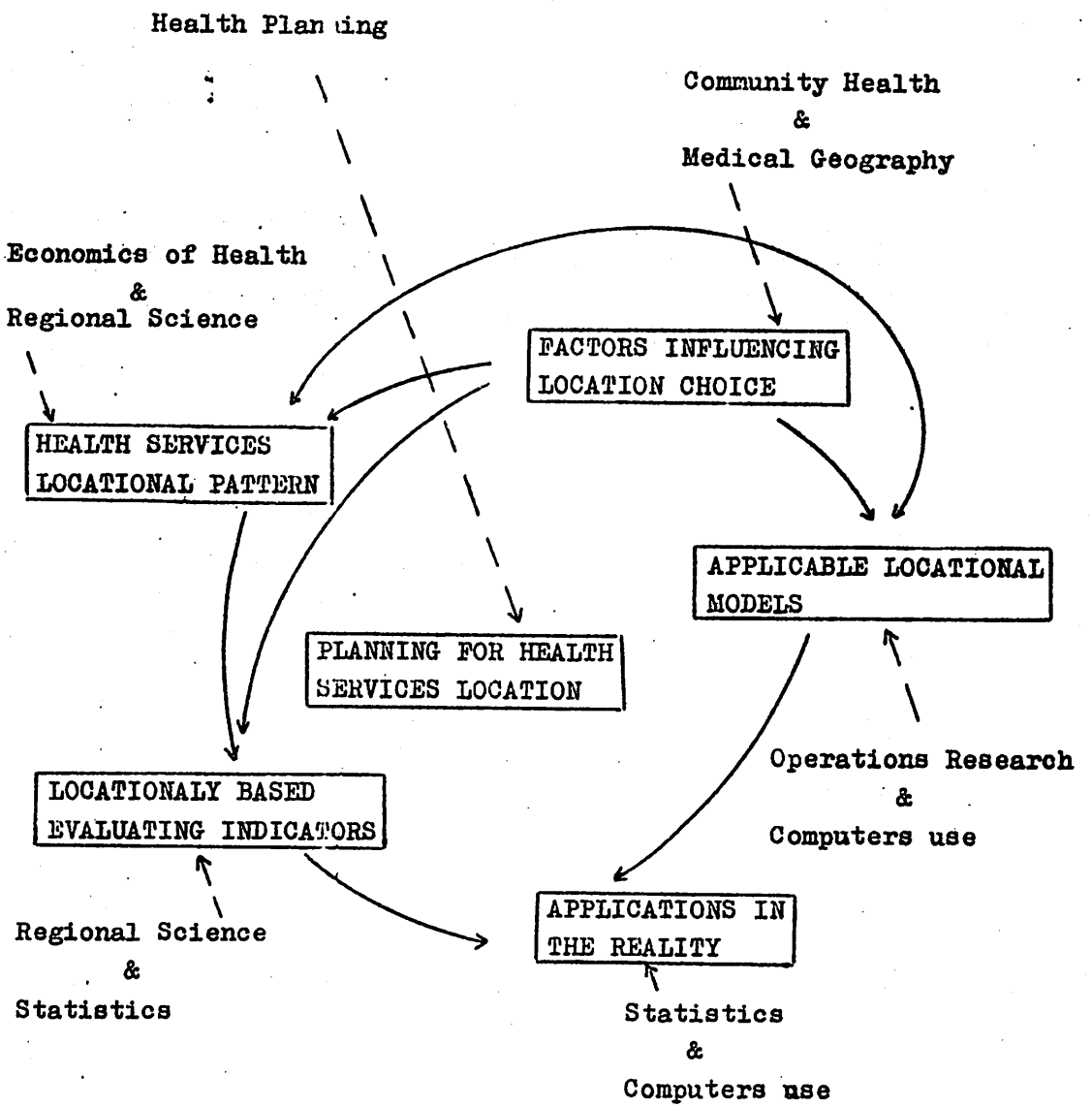
Herein , health and disease have been assumed as reflections to the degree of adjustment between man and the environment, that is why , theoretical study has been carried out to expose man's position in the ecosystem , and reflections on him due to his interaction with environment.The works of Savgent,Bur, Dubos (3) and W.H.O. publications, were very helpful in this field .

Similarly,assuming that health services,being special type of industry,aiming to facilitating care to people at risk,in an economicaly balanced cost with benefits or better state of health ,

§Given that the choice is going to be matched with the acceptability of the clients .

FIGURE : 1 .

THE DISCIPLINES ADOPTED BY THE AUTHOR WHILE DEALING WITH THE HEALTH SERVICES LOCATION STUDY OBJECTIVES



analysis has been made to reveal the socioeconomical specifications of health care.Where the works of V. Djukanovic (4), H. R. Bowen (5), and P. Rudermann (6)were very useful .

Also,making use of regional science, and medical geography - mainly the works of W. Isard(7),(8) , M. Beckmann (9), and R.W. Armstrong(3)- locational pattern of health service system , and factors influencing location and site selection, have been searched for . A matter which has been concluded after interrogation and interviewing with experts in Egypt, Hungary, England and the W.H.O.H.Qs.

Accordingly, two multifactorial locational models, have been suggested by the author to help in defining a highly good solution to the problem of distributing health facilities under some given constraints :

1. The first -SMSAHL mathematical locational model[§]-has been tested in a simple test example , where computer program written by the author in FORTRAN IV language, has been used to check the outcome got when the problem has been solved with a pocket electronic calculator .

2. The second -SMIHL.1 mathematical locational model[§§]- differs from the first in being able to define the best or optimal solution within almost similar constraints to those of the first model in a more realistic form. The model belongs to the integer branch of linear programming of operation research . A test example has been used to explain way of solving such model .

Lastly , making use of location evaluating tools - in use in general industry made by Florence, Hoover, and Duncan (8) - some have been adopted after modification, to be applied in the field

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[§]Single type Multi-constraint Searching Algorithm for Health facilities Location .

[§§]Single type Multi-constraint Integer programming model for Health services Location number 1 .

of health services locational evaluation . They have been classified under 4 categories included: distance and time shares and averages, location quotients, and coefficients of localization . Such tools have been systematicaly tested in a case study, where a scheme for locational evaluation has been established by the author .

III - New scientific results :

1. The inter-relationship between man's health and environment,in relation to the ecological system has been revealed more, giving an explanation to the W.H.O.s definition of health . As a result , NEW DEFINITION TO HEALTH has been adopted by the author in his study , stating that health is " The state of adjustment between man and environment manifested in complete physical, mental , and social well-being , and not mearly the absence of disease or infirmity. Where environment is both the external one or habitate[§] , and the internal one or body fluids,etc." .

2. The LOCATIONAL PATTERN OF HEALTH SERVICES FACILITIES which is attributed to sponsorship,financing arrangements in addition to type of service presented,has been found-by the author - to be :

2.1. COMMUNITY oriented , as it is mainly devoted to the sake of people at risk .

2.2. TIME and TRANSPORTATION oriented,or FOOT LOOSE,for the great role played by time taken to cut distances between people's residences and sites of services .

2.3. Tends to take either the FIXED PATTERN or the MOBILE FORM . The first , usually occurs when people live in fixed dwellings while the second is needed,when people are moving or migrating - nomads and gipsies .

2.4. Tends to take either the CENTRALIZED FORM, or the DECENTRALIZED one.Acute hospitals or departments and intensive care unins

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[§]The term habitate,embraces human social environment,and natural one. The last includes the physical- and bio-environments .

- for example - tend to be highly centralized to facilitate high level of multispecialized comprehensive care . While community control units, and basic care centers tend to be dispersed among people at risk, to facilitate an accessible service .

3. During the search, the author has concluded that DISTRIBUTING HEALTH FACILITIES AMONG DIFFERENT SETTLEMENTS requires the weighting of a great number of factors . These factors could be summarized as follows :

3.1. The DEMOGRAPHIC, and EPIDEMIOLOGICAL factors of community . They -in turn- are determined by the age-sex composition,as well as fertility, migration, morbidity and mortality data. They have been found to increase the locational pull of health services to where people at risk are concentrated .

3.2. The ECONOMICAL and INFRASTRUCTURAL conditions of the society . The economical school to which the society belongs would determine the concept of health service adopted . Hence , profit making services producers locate more services to extend their market areas , but they would stop when they reach points where their returns just cover the marginal costs of services.While in a command society believing in keeping health care almost absolutely free,accessibility of services are more important than just keeping them available . Moreover, transportation methods available, power,fuel,water and wast disposal have been found to influence strongly the location decision .

3.3. The GEOGRAPHICAL, and TOPOGRAPHICAL effects - including the geo-climatic conditions of an area - not only influence the morbidity structure , but also are reflected on type , size , and location of services presented .

3.4. The EDUCATIONAL , and SOCIO-CULTURAL values would not only influence manpower distribution,but to great extent would determine the sanitary behaviour of people, hence, type and distribution of disease prevalent and population at risk .

3.5. The HISTORICAL and POLITICAL influences are so important as the plan choice,and its implementation are among the politicians' tasks .

4. Similarly,another group of factors have been found-by the author- to influence the FINAL SITE SELECTION OF HEALTH SERVICES WITHIN GIVEN SETTLEMENT . Such factors have been found to be not only concerned with finding a quite well climatized place , easily accessible to beneficiaries, or with a fine site with attractive building for service performance , but also imply plant location engineering infleunced by:

4.1. The natural CONFIGURATION , and ELEVATIONS of LAND affected by its geographical structure and water level .

4.2. The natural or man-made WATER FEATURES , as lakes, rivers , and canals .

4.3. The makes of man, such as ROADS , DAMS , and BUILDINGS .

4.4. The relation between LOCATIONAL BUILDING CODES , and ZONING REGULATIONS from one side , and the type of building proposed to be constructed from the other side .

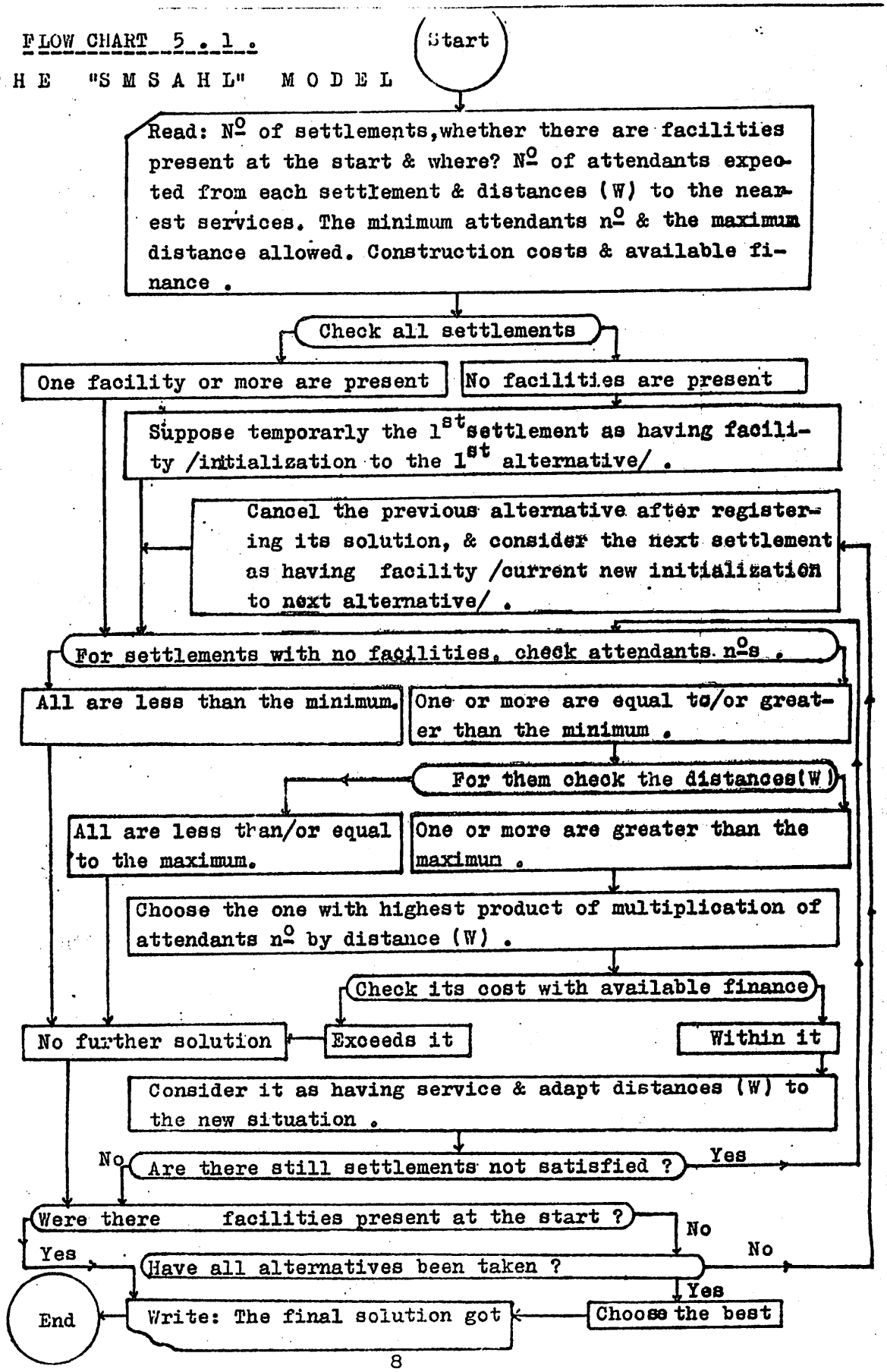
4.5. The extent of POLICE , and FIRE PROTECTION COVERAGE to the selected site .

5. TWO NEW APPLICABLE , MATHEMATICAL LOCATIONAL MODELS , oriented to computer-aided solutions, have been established by the author , to define highly good distribution - for the first - or even optimal solution - for the second . In these two models , attendants number in relation tc service capacity, distances out by the attendants to get their nearest services , and number of facilities would be established , or their construction costs in relation to the available finance , have been considered by the author as the simplified practical constraints to the problem of distributing health facilities among different settlements :

5.1. The first /SMSAHL searching algorithm/ - flow chart 1 - has been made to be easily run with or even without the aid of computers , for its simplicity together with its high precision of results . Shortly, the algorithm searches for those locations - settlements- having construction costs within the available budget , and possessing the greatest products of multiplication of number of attendants by distances to the nearest services, among those having attendants number equal to/or greater than a given

FLOW CHART 5.1.

THE "SMSAHL" MODEL



minimum , and away from the nearest services by distances more than a given maximum. Both the minimum and maximum are to be defined by experts of the communities where such model would be applied . In the final solution got the set of assignments -i.e. locations-are always set in order of priority towards satisfying the best welfare of people to care, from the point of view of accessibility of services . A matter which is of great importance in cases of implementation within limited resources .

5.2. The second /SMIHL.1 mathematical model/ set by the author , utilizes zero-one integer linear programming , to increase the effeciency of the solution and to make it much realistic. It facilitates the obtainment of optimal solution to the locational problem and can be solved easily by the use of one of the integer programming techniques , like branch and bound of Land and Doig (10) and (11). The problem of location -mathematicaly- has been put by the author as follows :

Find α_j , Y_{ij} satisfying :

$$\sum_{i=1}^{n} X_i Y_{ij} \geq b_j \alpha_j \qquad \forall\ j \in J$$

$$\sum_{i=1}^{n} X_i Y_{ij} \leq C_j \alpha_j \qquad \forall\ j \in J$$

$$\sum_{j=1}^{m} \alpha_j \leq p$$

and α_j , Y_{ij} = 0 or 1

that minimize the linear form :

$$\sum_{i=1}^{n} \sum_{j=1}^{m} X_i d_{ij} Y_{ij} = Z$$

where :

$i = 1,2,\ldots,n$: Populations settlements ,

$j = 1,2,\ldots,m$: Possible sites for establishing services , / where $m \leq n$ / ,

X_i : Population at i to be served ,

d_{ij} : The shortest distance between i and j ,

b_j : The minimum number of population to be served at j if service would be established there/i.e. minimum capacity/ ,

C : Maximum number of population to be served at j if facility would be established there / i.e. Maximum capacity / ,

P : Maxi. number of facilities could be established,

α_j | 1 : If facility would be established at j ,
| 0 : Otherwise ,

Y_{ij} | 1 : If population of i move to j when service would be established there ,
| 0 : Otherwise .

6. AROUND 60 NEW HEALTH SERVICES LOCATION EVALUATING TOOLS have been suggested by the author to measure the locational effects of health services distribution on the accessibility of health care presented :

6.1. The TIME and DISTANCE SHARES :

They are very simple tools that test for each time , and for one settlement the total kilometers or hours taken by all the settlements' citizens , population at risk , or attendants to reach their facilities . They could be made ,through multiplying time in hours , or distances in kilometers taken to reach the nearest services by number of citizens, population at risk,or attendants of the settlements . Weighting factors to distances , like the degree of road roughness,or cost of transportation could be used. Similarly , number of visits to the facility per year, could be used as weighting factor to citizens number, population at risk, or attendants . If (W) would refer to such weighting factors,the following could be obtained :

i. Time-citizens share .
ii. Time-citizens share (W).
iii. Time-population at risk share ,
iv. Time-population at risk share (W).
v. Time-attendants share .
vi. Time-attendants share (W).

vii. Distance-citizens share.
viii. Distance-citizens share(W)
ix. Distance-population at risk share .
x. Distance-population at risk share (W).
xi. Distance-attendants share.
xii. Distance-attendants share (W).

6.2. The TIME and DISTANCE AVERAGES :

They represent for a region-composed of group of settlements-the average time or distance taken by one of the citizens, population at risk , or attendants to reach his service . They equal to the "weighted mathematical averages" for time or distance shares for all settlements of the region i.e. summation of time or distance shares divided by total number of citizens, population at risk or attendants. Keeping (W) as in 6.1, the following could be obtained :

i. Time-citizens average.
ii. Time-citizens average(W).
iii. Time-population at risk average .
iv. Time-population at risk average(W).
v. Time-attendants average.
vi. Time-attendants average(W).
vii. Distance-citizens average.
viii. Distance-citizens average (W).
ix. Distance-population at risk average .
x. Distance - population at risk average (W).
xi. Distance-attendants average .
xii. Distance - attendants average (W).

6.3. The LOCATION QUOTIENTS :

They represent powerful tools for comparing the percentage share of a particular benefit with its percentage share of some other basic aggregate in two places : 2 settlements, or one settlement and the region it belongs to . Supposing that the suffices " a " and "b" represent these 2 places and that other symbols appearing in the R.H.S. are drived from their real notations in the corresponding L.H.S. of the equations , the following could be obtained , noting that the complete balance occurs when they equal to the unity :

i. Facility / area location quotient = $\dfrac{F_a / F_b}{A_a / A_b}$.

ii. Facility / citizens location quotient = $\frac{F_a / F_b}{C_a / C_b}$

iii. Facility / population at risk -"- = $\frac{F_a / F_b}{P_a / P_b}$

iv. Facility / attendants -"- = $\frac{F_a / F_b}{T_a / T_b}$

v. Doctors office / area -"- = $\frac{O_a / O_b}{A_a / A_b}$

vi. Doctors office / citizens -"- = $\frac{O_a / O_b}{C_a / C_b}$

vii. Doctors office / population at risk -"- = $\frac{O_a / O_b}{P_a / P_b}$

viii. Doctors office / attendants -"- = $\frac{O_a / O_b}{T_a / T_b}$

ix. Shifts / area -"- = $\frac{S_a / S_b}{A_a / A_b}$

x. Shifts/ citizens -"- = $\frac{S_a / S_b}{C_a / C_b}$

xi. Shifts/ population at risk -"- = $\frac{S_a / S_b}{P_a / P_b}$

xii. Shifts/ attendants -"- = $\frac{S_a / S_b}{T_a / T_b}$

6.4. The COEFFICIENTS OF LOCALIZATION :
Represent other powerful tools for comparing the percentage shares of a particular benefit with the percentage shares for

some other basic aggregates for 2 or more settlements , in relation to the region they belong to . Each could be made through getting the percentage of summing the positive results got from subtracting the percentage shares for one benefit from the percentage shares for another basic aggregate for 2 or more settlements each with the region they belong to . This could be represented mathematically as follows :

$$\frac{\sum_{i=1}^{n} |\beta - \gamma| / 2}{100}$$

Where i = 1,2,....,n : Regions settlements .

β : The percentage benefit of settlement to the region it belongs to .

γ : The other percentage benefit to the same settlement in relation to the region it belongs to .

The complete balance occurs when the coefficient equals to zero. Hence, the following could be obtained :

i . Area - citizens coefficient of localization .
ii . Area - population at risk -"- .
iii . Area - attendants -"- .
iv . Area - facilities -"- .
v . Area - doctors offices -"- .
vi . Area - shifts per day -"- .
vii . Citizens - population at risk -"- .
viii . Citizens - attendants -"- .
ix . Citizens - facilities -"- .
x . Citizens - doctors offices -"- .
xi . Citizens - shifts per day -"- .
xii . Population at risk - attendants -"- .
xiii . Population at risk - facilities -"- .
xiv . Population at risk - doctors officies -"- .
xv . Population at risk - shifts per day -"- .
xvi . Attendants - facilities -"- .
xvii . Attendants - doctors offices -"- .
xviii . Attendants - shifts per day -"- .

xix . Facilities - doctors office coefficient of localization.
xx . Facilities - shifts per day -"- .
xxi . Doctors offices - shifts per day -"- .

7. Making use of the previously suggested evaluating tools , SYSTEMATIC SCHEME FOR EVALUATION has been set -by the author- to facilitate the locational evaluation and comparison between 2 or more locational situations in one or more regions . The scheme has been set as follows[§] :

7.1. Comparing numbers of facilities, doctors officies,and total number of shifts per day could be done , for the different locational situations , to see whether there are significant differences between them or not.

7.2. Measuring the effect of step "7.1." on the regions level by the use of time and distance averages .

7.3. Measuring the effect of step "7.1." on the 2 settlements,or settlement-regions level by the use of location quotients .

7.4. Measuring the effect of step "7.1." on the relation between a region and its settlements , by the use of coefficients of localizations.

7.5. Measuring the effect of step "7.1."on the settlements level by the use of time and distance shares .

7.6. Measuring the effect of step "7.1." on :

i.Area -in squ. kms- served by each facility .

ii.Numbers of citizens , population at risk , or attendants served by each facility, doctors office , and duties per day could be run at each facility .

8. The whole study could be considered as REAL INTRODUCTION TO HEALTH SERVICES LOCATION THEORY, as it has represented a systemetic exposition to the locational pattern of health services, factors influencing location decision and site selection, in ad-

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[§] t self control -one sample- test could be used for measuring the degree of significance of the differences in steps 7.1 , 7.2 , 7.4 , 7.5 ,and 7.6 . While t group control -2 sample- test could be used for step 7.3 .

dition to the establishment of two mathematical models for distributing health facilities geographically and about 60 new evaluating techniques for health services , with a systematic scheme for evaluation .

IV - PRACTICAL IMPORTANCE :

1. This work, could be considered as one of the early applicable studies tried to bring together with care the DIFFERENT ASPECTS OF HEALTH SERVICES LOCATION PROBLEM .

2. The TWO INVENTED NEW APPLICABLE LOCATIONAL MODELS -put by the author- would have a very great practical importance,as they have been made as general as possible to be easily applied anywhere. The first "SMSAHL mathematical model" could be effectively used to get a highly good solution to problem of location in developing countries, as it does not need complicated techniques and could be run with or even without the aid of computers.While highly capacitated computers are needed for the second model "SMIHL.1" for its high effeciency and ability to define an optimal solution to the location choice problem. A matter which would be suitable for the more developed countries .

3. The NEWLY SUGGESTED POWERFUL TOOLS FOR THE LOCATIONAL EVALUATION OF HEALTH SERVICES, could be of great use in practice - anywhere - not only for the locational measurement of what has been done , but also for the assignment of the best locational case among many alternatives . This has been made possible after sketching down the proposed scheme for locational evaluation.

4. The results got from applying the location evaluation techniques on one of the egyptian governorates -Damietta- would be of great practical importance in ANSWERING THE LOCATIONAL QUESTION RAISED IN THE PRESENT 5 YEARS PLAN OF THE EGYPTIAN MINISTRY OF HEALTH,included the establishment and reorganization of about 40 General Health Centers .

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