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ALFRED P. SLOAN SCHOOL OF MANAGEMENT

A STRATEGIC PLANNING MODEL

FOR THE MANAGEMENT OF A FAMILY PLANNING SYSTEM

Glen L. Urban

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ABSTRACT

This paper describes a strategic planning model designed to
be used by managers of family planning systems to improve understanding,
forecasting, and planning. The macro-flow model describes the patient
movement through post partum and non-post partum programs. The flows
model the phenomena of: outreach, continuance, post partum check ups,
switching methods, referral, migration, contraceptive use experience,
private protection, method effectiveness, follow up, and abortion. Stra-
tegic variables can be linked to the flow parameters to produce capacity
requirements and budgetary implications. The model output includes ben-
efit measures of total actives, couple years of protection, "births pro-
tected", and unwanted births prevented. The fertility aspects of births
prevented are modeled through a non-stationery Markov process submodel which
considers demographic phenomena without burdening the basic flow struc-
ture. The input procedures used to process service statistics, outreach,
clinic survey, and experimental data are discussed. The combination of
data based estimates and subjective judgment is done by "fitting" the
model to past observed data.Testing is done by "tracking" model perfor-
mance through conditional prediction, diagnosis, and updating.

The model is programmed on a soft ware system called EXPRESS so
that evolutionary model building can take place. A simple model with two
contraceptive methods, two agencies, and a homogeneous target group
can be structurally modified on-line to have, for example four methods, five

agencies, and two target group segments. Evolution also allows new
phenomena such as abortion, advertising, or private protection to be
added on-line. The concept is to build a "decision calculus" that is
understandable to managers, complete, evolutionary, easy to use, easy
to control, robust, and adaptive.

The paper includes a discussion of how the model could be
used in goal setting, policy determination, and budgeting and alloca-
tion. An application and testing of the model to the Atlanta Area Family Planning
System is discussed and the experiences of managers in using the model
to gain new insights, forecast, budget, and plan are reported.

ACKNOWLEGEMENTS

A STRATEGIC PLANNING MODEL
FOR THE MANAGEMENT OF A FAMILY PLANNING SYSTEM

by Glen L. Urban

INTRODUCTION

From a macro point of view, the question in population is, "What should
the population growth rate be?" Current growth rates in the U.S.A. imply our
population will double each 70 to 80 years -- a rate considered excessive by
many. At the micro level, the question a family faces is, "How can we have the
number of children we want and at the times we want them?" Families are not
very successful in planning births. Fifty percent of births do not occur when
wanted (i.e., timing failures) and twenty percent are unwanted births.[1] In
the poor and near poor groups where private medical care and contraceptives are
generally not available, the problem is more severe with forty percent of
births being unwanted.[2] These births can and usually do produce undesirable
sociological, psychological, or medical effects on the child or mother. This
paper will address the problem indigent families face in planning their
families.

Since the micro problem is solved by aiding families in preventing
births, the model is operating to achieve a lower population growth rate. But
the thrust of this work is towards a model for management of a system designed
to deliver contraceptive care to indigent families so that they can prevent
unwanted births, rather than towards the problem of population control.

The need for family planning has been recognized by Congress and
and the President. Over four hundred million dollars have been made available
through the Tydings bill in order to serve the contraceptive needs

of this country. The National Center for Family Planning Services of the Department of Health, Education, and Welfare is granting money to metropolitan and rural areas to affect local family planning services. In addition, state health departments, county health departments, hospitals, and private groups, such as Planned Parenthood, provide services at the local level.

The purpose of this paper is to describe a model designed for managers of a local family planning system. The model is designed to be used by managers to help them better understand their systems, to enable them to make better forecasts, and to provide them with a tool for planning. This paper will begin with a brief introduction of the patient and management environment in family planning. Then the model structure will be defined, input procedures will be specified, and evolutionary implementation of the model will be discussed. An application of the model to the Atlanta Area Family Planning System will be presented and the paper will close with a consideration of future evolution of the model and the use of the model in the international settings.

MODEL DEVELOPMENT CONSIDERATIONS

MODEL BUILDING ENVIRONMENTS

The patient environments in which family planning systems work can be appreciated by the following brief patient case history. Sally Nelson is black, twenty three years old, and has two daughters. Her husband died in Vietnam; she is on welfare and lives in a one room apartment. Sally delivered her first baby at the charity hospital. While she was in the maternity ward she was visited by a family planning worker who explained contraceptives

and the ability to prevent unwanted births. Sally decided to come to a six week post partum check-up and learn more about family planning. Sally initially did not come to her appointment, but after a reminder she came to the post partum check-up. At the visit she received a medical examination, and after a talk with a nurse, she selected the pill as her contraceptive method and left with a three month's supply and a return appointment date. Sally took the pills for two months, but then became less interested and did not take them regularly. She forgot about her appointment and soon ran out of the pills altogether. One month after she missed her appointment, an outreach worker called on Sally and they discussed her desire not to have more children. With this reinforcement, Sally returned and picked up another supply of pills. Again, however, after a couple of months she missed taking the pills for a few days and soon found herself pregnant. Since she had no desire for another child, she went to a man in the neighborhood, named Al, to have the pregnancy terminated. The abortion was not successful and Sally carried the baby to term and delivered at the hospital. This time she selected the loop (IUD). After her six week check-up she was referred to a Planned Parenthood clinic in her neighborhood where she received yearly medical checkups and regular loop checks. For the last two years, Sally has not been pregnant.

Sally is but one example of the many combinations of ways in which patients can behave in a family planning system. As in most human phenomena, the motivations and choices are complex. Specifically in planning a family, people accept family planning, choose one of several methods,

develop a commitment to regularly use the method, and return for subsequent appointments. Observed behavior is complex since patients frequently change methods and/or clinics and because they are heterogeneous in terms of acceptance behavior, attitudes, and fertility.

Faced with such dynamic and intricate behavior patterns, the management has the task of planning and controlling a system which best serves the needs of its clientele who wish to prevent unwanted births. Managers plan post partum and non-post partum programs and specify the capacity levels of each. They allocate resources for recruiting new patients through outreach workers and advertising, but trade off this allocation against resources used to maintain high rates of continuing contraceptive usage. They decide methods to use and set policies on such matters as abortion and sterilization.

It is important to realize that in family planning systems "the management" is actually a semi-autonomous group of people who head various agencies, i.e. hospitals, county health departments or Planned Parenthood organizations. In some cases management functions have been coordinated by a family planning council, but rarely is there a formal hierarchal organization structure.[3] The diffuseness of the decision making is an important characteristic to be considered in building a model for family planning.

MODEL GOALS AND DEVELOPMENT CRITERIA

The first goal of the model reflects the complexity of the patients and management environment. The model should aid managers in understanding patient acceptance and continuance processes. The model should represent an

enlargement of the manager's implicit models and should enable all managers
to view system behavior through a consistent and comprehensive structure.
If all managers have a common view of the system behavior, coordinated and
complementary actions can be facilitated even though the managers are not
in a formal structure. The second goal of the model is that it utilize past
system data and judgments in order to produce improved forecasts. Thirdly,
the model should represent a structure that can entertain the strategic
issues of allocating resources and setting policy indicated earlier.   The
fourth and most important goal is that managers actually use the model in
their decision making. Models have been built for family planning but in
general they have not been directed at the management problem or have not
impacted at the decision level.[4] The lack of implementation of models is a
common problem in management science. Perhaps the best method for overcom-
ing this problem is the "decision calculus" approach articulated by Little.[5]
The decision calculus criteria of a model are that it be: (1) understand-
able, (2) complete, (3) evolutionary, (4) easy to use, (5) easy to control,
(6) robust, and (7) adaptive. These seven criteria are primary considera-
tions in the development of the model described in this paper.

MODEL STRUCTURE

MACRO PROCESS MODEL

The basic approach of this work is to build a macro
process model. This type of model is a deterministic flow model that allows
an effective evolutionary approach to implementation and a reasonable trade-
off between the richness of behavioral content and the difficulty of model

estimation and testing. [6] The process notions are particularly attractive in this setting since the basic clientele behavior can be represented by a patient flow that managers can understand and internalize. The process model traces movement from the target group population through post partum and non-post partum family planning program events. It links strategic resource and policy variables to the flow so that after data basing the model parameter's overall acceptance and birth rate effects can be encompassed. The event structure is utilized in preference to the demographers life table approach which characterizes continuance as a time phenomenon (e.g. active in system after 9 months). [7] The reason for the event structure is that managers perceive their systems in this manner and it is easier to model detailed strategic alternatives as affecting event flow rates rather than time based retention rates. The basic structure will be discussed in terms of the target group, non-post partum program, post partum program , and pregnancy, abortion, and birth flows.

TARGET GROUP STRUCTURE

The model begins with the concept of a target group. This is the population that managers define for program development and attempt to serve. For example, the target group may be all fertile women ages 15 to 45 who live in a specific metropolitan area and are poor by O.E.O. standards. The model divides the target group into two basic sections: (1) those active in the family planning system and (2) those not active in the family planning system. "Active" is defined as those who accepted contraceptive supplies at their last visit (e.g. accepted a three month sup-
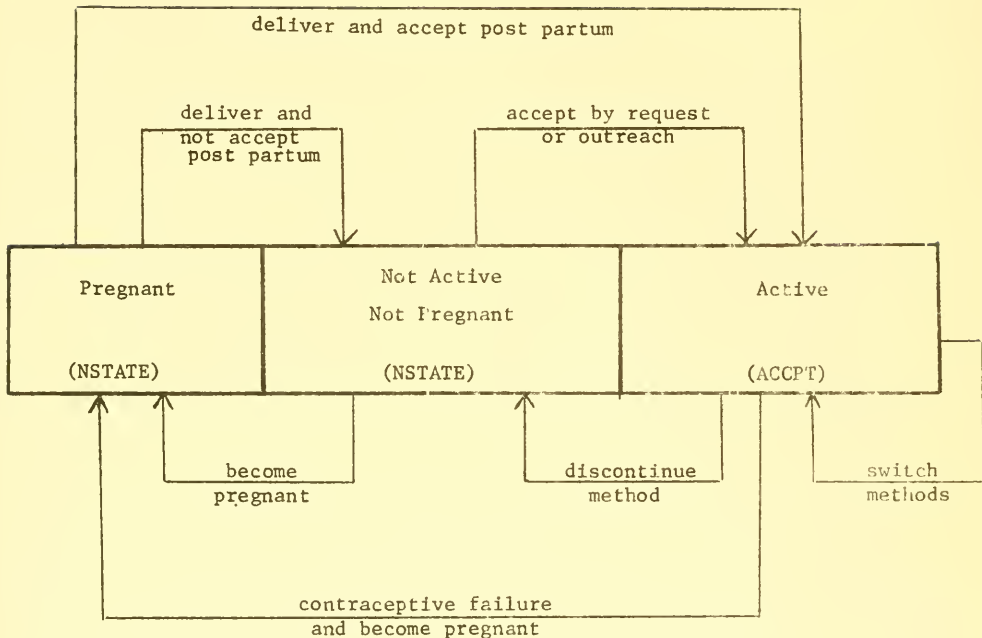
FIGURE ONE: Target Group Sections and Interaction

ply of pills or retained their IUD) and have not missed their next appoint-
ment. The not-active group is further divided into pregnant and not pregnant.
The flow between target group sections that occur within one period are
shown in figure one.

People flow from pregnant to active or not-active by acceptance
or non-acceptance of family planning upon delivery at a hospital with a
post partum program. Movement from not-active/not-pregnant to active occurs
due to new patient requests for contraceptives or outreach generated accep-
tance. Actives return to the non-active class by discontinuing contraception
(not returning for an appointment) or by becoming pregnant. Likewise, not-
active/not-pregnant people may become pregnant. The final flow is within
the active class by switching contraceptive methods.

In addition to the basic sectioning of the target group as shown in
figure one, overall segments of the target group may be defined. For
example, segments may be delineated on the basis of race (black and white)
or age (adolescent 15-18 and non-adolescent 19-45) so that specific programs
can be designed for each segment. The target group partitions shown in
figure one exist in each segment.

Before discussion in detail of the non-post partum, post partum,
and pregnancy flows, some basic notation will be defined and the effects
of migration on the total target group will be considered. The notation
that defines the total target group size is:

$\text{TARGP}_{t,g}$ = Number of people in target group - segment g at month t

The active section is populated by acceptors defined by:

$\text{ACCPT}_{t,m,a,d,g}$ = number of people who <u>accept</u> in month t method m at agency a for the "d"th time and who are from target group segment g

t = <u>t</u>ime subscript

t = 1,2,3,..., NT, where NT = the number of months to be considered

m = the <u>m</u>ethod subscript and is defined as:

m = 1 for loop
m = 2 for pill
m = 3 for another method
.
.
.
m = NM for sterilization
and NM = the number of methods to be considered

a = the <u>a</u>gency subscript

a = 1,2,..., NA, where NA = the number of agencies to be considered

When a spans a = 1,2,..., NPP, where NPP is the number of <u>p</u>ost <u>p</u>artum agencies, a will be denoted by a.

When a spans a = NPP + 1 to NPP + NNPP where NNPP is the <u>n</u>umber of <u>n</u>on <u>p</u>ost <u>p</u>artum agencies, a will be denoted by $\hat{a}$. Note: NA = NPP + NNPP.

d = the subscript to reflect the <u>d</u>epth of experience a person has had in the system and is equal to the number of consecutive times a person has accepted contraceptives.

d = 1,2,..., ND. At ND the number of people accepting are accummulated under ND for d ≥ ND.

g = the <u>seg</u>ment subscript

g = 1,2,3,..., NG, where NG = the number of segments to be considered

This basic variable (ACCPT) is used throughout the model in controlling the continuance flow. Actives are defined as all acceptors who have not yet missed their next appointment.[8]

$$\text{ACTIVE}_{t,m,a,d,g} = \sum_{T=t-A+1}^{t} \text{ACCPT}_{T,m,a,d,g}$$

$\text{ACTIVE}_{t,m,a,d,g}$ = number of <u>actives</u> as of end of time t who accepted method m at agency a for the dth time and are in target group segment g.

$A = \text{APT}_{m,a,d}$ = time interval between <u>appointments</u> for method m at agency a for those who have accepted d times. For convenience $\text{APT}_{m,a,d}$ will be denoted only by A in future equations.

The summation is from $T = t-A+1$ to t since at the end of period t, those who accepted in t-A have either missed their appointment or returned. The appointment time interval (A) is subscripted by method since contraceptive methods usually have different appointment intervals (e.g. loops 6 months and pill 3 months) and these intervals may vary by agency. The d subscript is used since the interval between the first and second visit is usually shorter than subsequent visits (e.g. one month loop check or a return visit for pills at two months due to minor side effects). In the macro flow model the appointment interval (A) is the empirical average number of months between visits.

The not-active section of the target group is denoted by NSTATE and further divided into subsections as follows:

$\text{NSTATE}_{t,s,g}$ = <u>number</u> of people at time t in <u>state</u> s who are in target group segment g.

     s=1   Pregnant

     s=2   Never active in system

     s=3   Ever active (where active at one time but not now) and have no negative attitude towards contraception

     s=4   Indirect outreach (visited by outreach worker but did not accept an appointment or did not appear for an appointment)

s=5 Advertising aware (aware of appeal of message)

s=5 + m Ever active and have a negative attitude with respect to method m (m=1,2...NM)

NS is defined as the last state and NS = 5 + NM

In this notation s=2 to s= 5+ NM is the not-active/not-pregnant group. The division into these additional states is done since people who have had differential experience in the system will behave differently in terms of acceptance and continuance. For example those never in tne system (s=2) may respond differently to a visit from an outreach visitor than those who nad been in the system and dropped out (s=3) or those who had negative experience with a method (s=5+m). Those who are aware of advertising (s=5) may be more likely to request an appointment at a family planning clinic. Likewise, those who are visited by an outreach worker and did not accept an appointment (s=4) may be more likely to request an appointment. This is an indirect outreacn effect due to the receipt of communication, but the reluctance to commit to an appointment at that time. The state of being pregnant is s=1 and it contains all people currently pregnant.

With these basic definitions the model formulation can be defined. Consider in and out migration as changing the target group size.

(1) $TARGP_{t,g} = TARGP_{t,g} (1 - PMIGO_g + PMIGIN_g)$

$TARGP_{t,g}$ = number of women in <u>target group</u> segment g at month t

$PMIGO_g$ = percent of target group segment g who <u>mig</u>rate <u>o</u>ut in a month

$PMIGIN_g$ = percent of target group segment g who **migrate in** in a month

Then each component section of the target group is modified. The non-active states are changed.

(2) $$NSTATE_{t,s,g} = NSTATE_{t,s,g} - NSTATE_{t,s,g} \ PMIGO_g + TARGP_{t,g} \ PMIGIN_g \ PMIGIS_{s,g}$$

$NSTATE_{t,s,g}$ = <u>n</u>umber of people at time t in <u>state</u> s of target group segment

$PMIGIS_{s,g}$ = <u>p</u>ercent of people who <u>mig</u>rate who are <u>in state</u> s and segment g

This equation reflects through PMIGIS that those who migrate in are more heavily concentrated in the never state (s=2). However, it is possible that migration of pregnant women from rural areas to cities may occur since these women may desire the services of a hospital.

    Finally, the active group is modified:

(3) $$ACCPT_{t,m,a,d,g} = ACCPT_{t,m,a,d,g} \ (1-PMIGO_g)$$

$ACCPT_{t,m,a,d,g}$ = number of people who <u>accept</u> in month t method m at agency a for dth time and who are in target group segment g

This equation is rather trivial but is included to reflect the necessity to conserve patients. In the remainder of this paper such trivial equations will not be included, but those who endeavor to build a macro process model should be aware of the necessity to conserve people as phenomena are modeled.

To simplify the post partum and non-post partum exposition
the segment subscript will be surpressed in further notation, but it
should be remembered that all inputs and outputs can vary by segments.

NON POST-PARTUM FLOW

The non post-partum flow is represented in figure two. New
patients enter from the not-active/not-pregnant group as the result
of a call from an outreach worker or a request for appointment. The
flow traces the initial acceptance and continuance process.

Outreach Recruitment: Outreach workers are usually women who are
similar to the members of the target group, but who have been trained
in family planning. These women work in the community.

For example, they may go door to door in a low cost housing develop-.
ment If they find someone home who is in the target group, they talk to
them about family planning. The number of people seen by outreach who
are in an eligible state s (s=2, 3,..NS) (see box 1 in figure two) is;

(4) $\text{OUTSEE}_{t,\hat{a},s} = \text{NRCALL}_{t,\hat{a}} \; \text{PRFIND}_{\hat{a}} \; \text{NSTATE}_{t,s} / \text{TARGP}_{t}$

$\text{OUTSEE}_{t,\hat{a},s}$ = number of people in state s that outreach workers
from agency $\hat{a}$ see in month t

$\text{NRCALL}_{t,\hat{a}}$ = number of recruitment outreach calls made in month t
by agency $\hat{a}$

$\text{PRFIND}_{\hat{a}}$ = percent of outreach calls of agency $\hat{a}$ that result in
finding a person in target group
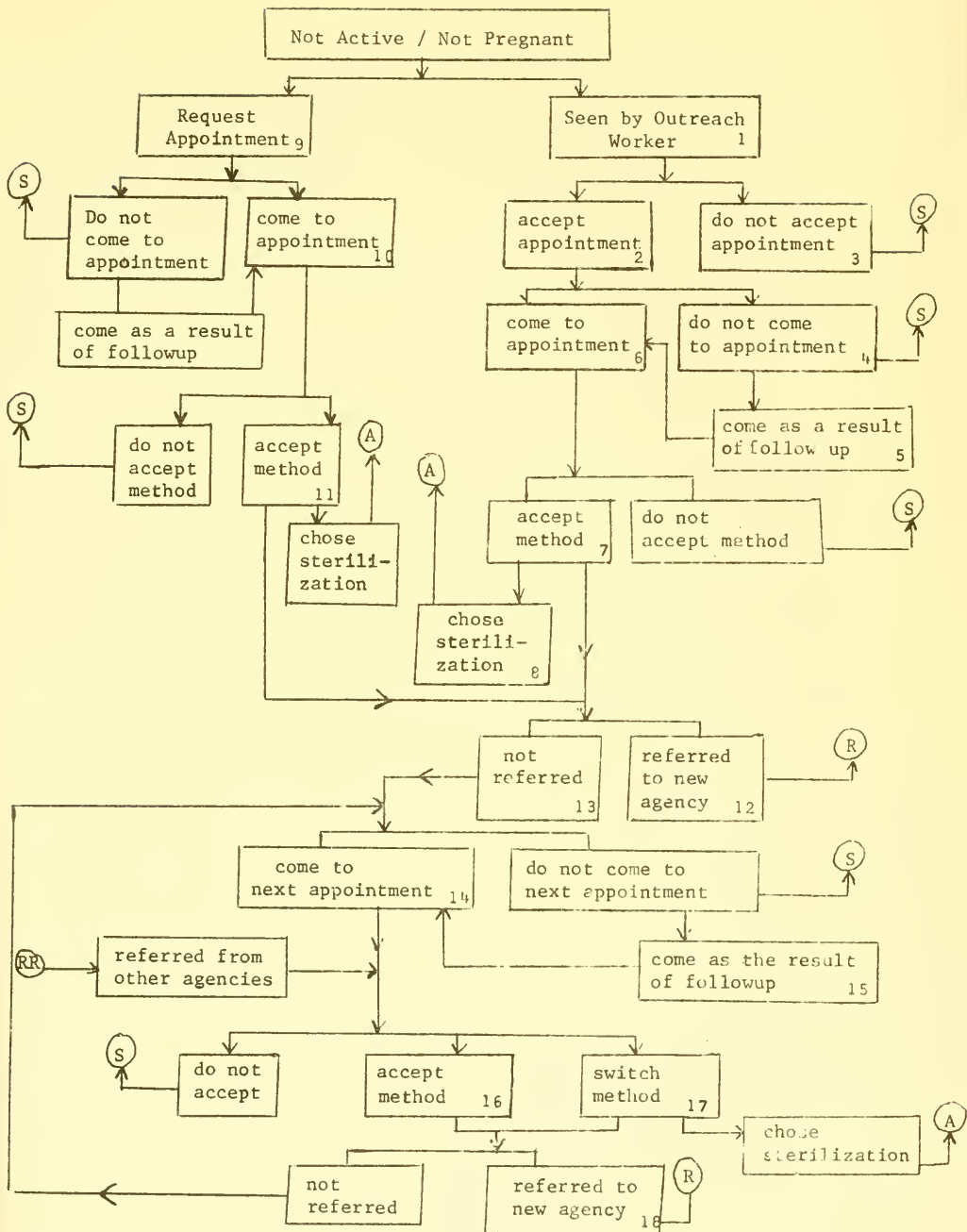
(A) Return to active group as sterilized
(S) Return to states in not-active/not-pregnant group
(R) To another agency clinic because of referral (RR) Come to agency because of referral

FIGURE TWO: Non-Post Partum Agency Flow Structure

The number of calls are reduced by the percent of people found that
are in the target group (PRFIND). The states of those called upon are
determined in proportion to the number of people in each state relative
to the target group (see third term of equation 4). This assumes a
random calling pattern with respect to states within each target group
segment. Equation 4 also reduces effectiveness by the fraction of ineligible
people (active or pregnant) since $NSTATE_{t,s}$ over $s = 2,3,\cdots$, NS does not
include the active or pregnant sections of the target group.

After removing those seen from each state (NSTATE), the number
who make an appointment with the outreach worker (see box 2 in figure 2)
is specified as :

$$(5) \quad OUTAPT_{t,\hat{a}} = \sum_{s=2}^{NS} OUTSEE_{t,\hat{a},s} \; PDESIR_{\hat{a},s}$$

$OUTAPT_{t,\hat{a}}$ = number of people visited by <u>out</u>reach worker who
make an <u>app</u>ointment in month t at agency â

$PDESIR_{\hat{a},s}$ = <u>p</u>ercent of people visited who are in state s and
who <u>desir</u>e an appointment at agency â

PDESIR is subscripted by state, since people may respond differently
based on their past experience (see p. 10 to review state definitions)
and is subscripted by agency to allow a comparision between outreach
workers and agencies.

The number who came to the appointment made through the out-
reach worker before any follow up effort(see box 6) is:

(6) $\text{COMO}_{t,\hat{a}} = \text{OUTAPT}_{t,\hat{a}} \quad \text{PCOMO}_{\hat{a}}$

$\text{COMO}_{t,\hat{a}} =$ number of people who <u>come</u> in month t to <u>o</u>utreach generated appointment at agency $\hat{a}$ before follow up effort

$\text{PCOMO}_{\hat{a}} =$ <u>p</u>ercent of people who will <u>come</u> to their appointment made with <u>ou</u>treach worker from agency $\hat{a}$

Those who do not come may receive another outreach visit so the number who came is adjusted for follow up (see box 4-5) as:

(7) $\text{COMOFU}_{t,\hat{a}} = (\text{OUTAFT}_{t-1,\hat{a}} - \text{COMO}_{t-1,\hat{a}}) \ (\text{NFCALL}_{t,\hat{a}}/\text{TNCOM}_{t-1,\hat{a}}) \ \text{PFFIND}_{\hat{a}} \ \text{PCOMFU}_{\hat{a}}$

$\text{COMOFU}_{t,\hat{a}} =$ number of people to <u>come</u> to <u>o</u>utreach generated appointment after <u>fo</u>llow <u>up</u> in month t and agency $\hat{a}$

$\text{NFCALL}_{t,\hat{a}} =$ <u>n</u>umber of <u>fo</u>llow up <u>call</u>s by outreach workers of agency a in month t

$\text{TNCOM}_{t-1,\hat{a}} =$ <u>t</u>otal number of people who did <u>n</u>ot <u>come</u> to a scheduled appointment in month $\overline{t}$ in agency $\hat{a}$ (see equation 34)

$\text{PFFIND}_{\hat{a}} =$ <u>p</u>ercent of <u>fo</u>llowup visits that result in <u>find</u>ing the person who did not come

$\text{PCOMFU}_{\hat{a}} =$ <u>p</u>ercent who <u>come</u> of those contacted by a <u>fo</u>llow <u>up</u> visit

The first term of the equation is the number who did not come last month. The second term is the percent of all people who did not come to a scheduled appointment last month who received a follow up visit. Lags are specified since follow up does not occur until the list of people who missed their appointment last month is known. Those who missed last month are called on this month. The first terms in equation seven reflect the ability to find the person again (PFFIND) and their response in terms of coming to the appointment. Follow up visits are explicitly

modeled, but the basic rates of coming to an appointment (e.g. PCOMO
in equation 6) may reflect mail, phone reminders, or other non-outreach
followup. Those who do not come to their appointment are returned to
state four – the state defined to include people who had some outreach
experience but did not come.

Those who came decide to accept or reject family planning
and those who accept select a specific method (see box 7).

(8) $\text{ACCPTO}_{t,m,\hat{a}} = \text{OUTCOM}_{t,\hat{a}} \ \text{PACPTO}_{\hat{a}} \ \text{FACPTO}_{m,\hat{a}}$

$\text{ACCPTO}_{t,m,\hat{a}}$ = number of people in month t who <u>accept</u> method m at
agency $\hat{a}$ as a result of recruitment <u>out</u>reach

$\text{OUTCOM}_{t,\hat{a}}$ = $\text{COMO}_{t,\hat{a}}$ + $\text{COMOFU}_{t,\hat{a}}$ (see equations 6-7)

$\text{PACPTO}_{\hat{a}}$ = percent of people who <u>accept</u> a contraceptive method
after visit from <u>out</u>reach worker of agency $\hat{a}$

$\text{FACPTO}_{m,\hat{a}}$ = <u>f</u>raction of those who <u>accept</u> after <u>out</u>reach who
accept specific method at agency $\hat{a}$

The percent who accept a method may be less than one because (1) the
person learns something about contraception that she views negatively,
(2) the person is treated poorly and does not receive quality care, (3)
the clinic surroundings are not acceptable, or (4) the wait for service
is intolerably long. The first three effects can be encompassed in the
reference acceptance value (PACPTO). The waiting time phenomena is
modeled by making the reference fraction that accept a function of
the degree of capacity utilized.

(9) $\text{PACPTO}_{t,\hat{a}} = \text{PACTOC}_{\hat{a}} \; \overline{\text{RCAP}_{\hat{a}}} \; (\text{UCAP}_{t,\hat{a}}/\text{TCAP}_{t,\hat{a}})$

> $\text{PACTOC}_{\hat{a}}$ = percent of people who would accept a contraceptive method after a visit from an outreach worker at agency $\hat{a}$ if the service was convenient.
>
> $\overline{\text{RCAP}_{\hat{a}}}$ = response function for capacity at agency $\hat{a}$
>
> = defines an index between zero and one dependent on the percent of capacity utilized at agency $\hat{a}$.
>
> $\text{UCAP}_{t,\hat{a}}$ = utilized capacity in month t at agency $\hat{a}$ (see equation 69)
>
> $\text{TCAP}_{t,\hat{a}}$ = total capacity in month t at agency $\hat{a}$

For example the response fraction may be as shown in figure three.

Those people who do not accept are returned to state 2 in

the not-active/not-pregnant group. If some people choose steriliza-

tion as a method, the acceptance class for m=NM is simply updated for d=1 by:

(10) $\text{ACCPT}_{t,NM,\hat{a},d} = \text{ACCPTO}_{t,NM,\hat{a}} + \text{ACCPT}_{t,NM,\hat{a},d}$

Request for Service: Requests for an appointment may be due to adver -

tising, the indirect effects of outreach, word of mouth-communication,

or spontaneous action. These are modeled by assigning a request rate

to each state so that the number of people requesting (see box 9) is:

FIGURE THREE:

Capacity Response Function

(UCAP/TCAP) = PERCENT OF CAPACITY UTILIZED
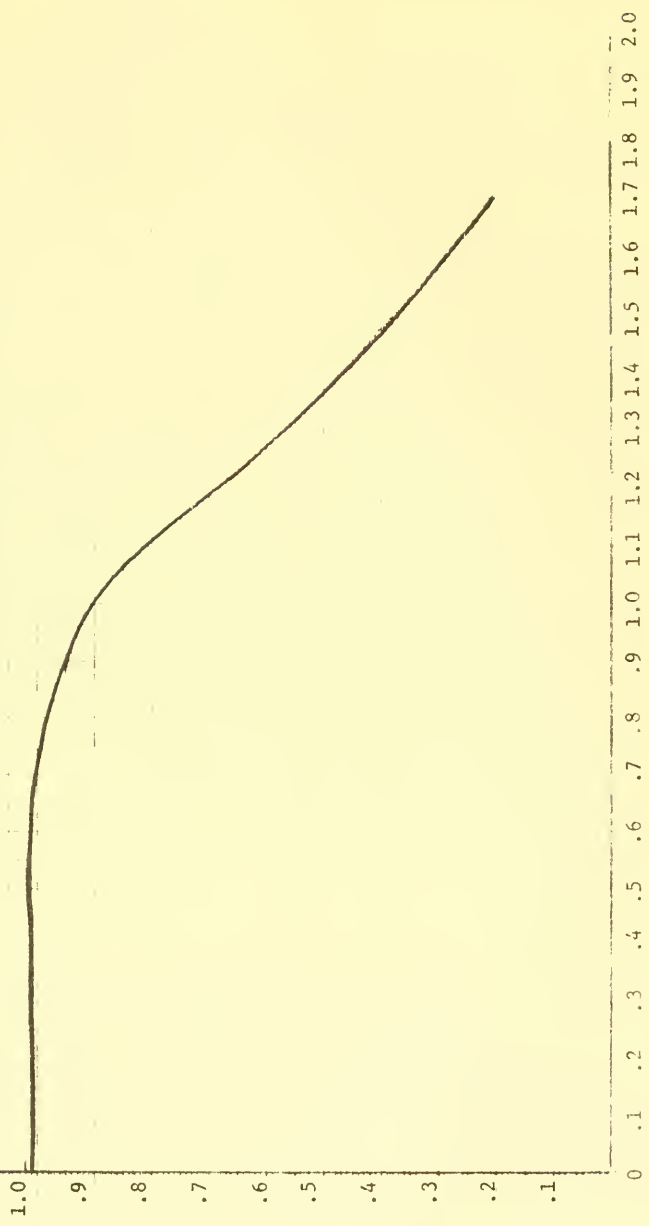
RCAP = INDEX OF ACCEPTANCE

(11) $\quad REQ_{t,\hat{a},s} = NSTATE_{t,s} \ PREQ_{\hat{a},s}$

$\qquad REQ_{t,\hat{a},s}$ = number of people from state s who <u>req</u>uest an appoint-
$\qquad\qquad\qquad\qquad$ ment at agency $\hat{a}$ in month t

$\qquad PREQ_{\hat{a},s}$ = percent of people in state s who <u>req</u>uest an appoint-
$\qquad\qquad\qquad\qquad$ ment at agency $\hat{a}$ in month t.

$\qquad$ Recall that state five (s=5) was defined as awareness so that

a higher request rate, due to media expenditures, could be considered. The

gain of awareness is modeled as a movement from other states to state

five as a fraction of the advertising expenditure. The number of people

in state 5 is:

(12) $\quad NSTATE_{t,5} = \sum_{\substack{s=2 \\ s \neq 5}}^{NS} NSTATE_{t,s} \ \overline{RADV}_s \ (ADV_t) + NSTATE_{t,5}$

$\qquad \overline{RADV}_s$ = <u>r</u>esponse function to <u>adv</u>ertising expenditure (ADV_t). It
$\qquad\qquad\qquad$ is the percent of people in state s who become aware of
$\qquad\qquad\qquad$ the advertising in a month with advertising expenditure
$\qquad\qquad\qquad ADV_t$.

A decay of awareness is specified to reflect forgetting. For states s=2 to NS:

(13) $\quad NSTATE_{t+1,s} = NSTATE_{t,s} \ ADFGET_s + NSTATE_{t,s}$

$\qquad ADFGET_s$ = percent of <u>adv</u>ertising aware people who <u>forget</u> from
$\qquad\qquad\qquad$ state 5 to s in a month

A similar function is applied to the population of state 4 (indirect

outreach) since the outreach impact will decay over time.

$\qquad$ The number of people who came to the requested appointment (see

box 10) is:

(14) $\quad COMR_{t,\hat{a},s} = REO_{t,\hat{a},s} \ PRCOM_{\hat{a}}$

$\qquad COMR_{t,\hat{a},s}$ = number of people in state s who <u>come</u> in for <u>requested</u>
$\qquad\qquad\qquad\quad$ appointment in month t at agency $\hat{a}$

$REQ_{t,\hat{a},s}$ = number of people from state s who <u>req</u>uest an appointment at agency â in month t.

$PRCOM_{\hat{a}}$ = <u>p</u>ercent of those who <u>r</u>equest an appointment who <u>com</u>e without follow up at agency â

The number who accept a method after coming (see box 11) is:

$$(15) \quad ACCPTR_{t,m,\hat{a}} = \sum_{s=2}^{NS} REQCOM_{t,\hat{a},s} PACPTR_{\hat{a},s} \overline{RCAP}_{\hat{a}} (UCAP_{t,a}/TCAP_{t,a}) \quad FACCPT_{m,\hat{a},s}$$

$ACCPTR_{t,m,\hat{a}}$ = number of people in month t who <u>accept</u> method m after <u>r</u>equesting an appointment at agency â

$REQCOM_{t,\hat{a},s}$ = $COMR_{t,\hat{a},s}$ if there is no outreach follow up of requests for appointment or $COMR_{t,\hat{a},s}$ adjusted for follow up as in equation 7 if there is outreach follow up.

$PACPTR_{\hat{a},s}$ = <u>p</u>ercent of people in state s who would <u>accept</u> a contraceptive method after coming to <u>requested</u> appointment if service was convenient at agency â

$\overline{RCAP}_{\hat{a}}$ = <u>r</u>esponse function for <u>capacity</u> at agency á (see equation 9 for further explanation)

$FACCPT_{m,\hat{a},s}$ = <u>f</u>raction of people in state s who will <u>accept</u> a method who accept specific method m at <u>agency</u> â

<u>Referral:</u> Referral in family planning systems usually operates on the total first time acceptors (d=1). This is the sum of those due to outreach and requests. For d=1:

$$(15-A) \quad ACCPT_{t,m,\hat{a},d} = ACCPTO_{t,m,\hat{a}} + ACCPTR_{t,m,\hat{a}}$$

$ACCPT_{t,m,\hat{a},d}$ = number of people who <u>accept</u> in month t method m at non-post partum agency â for the first time (d=1).

$ACCPTO_{t,m,\hat{a}}$ = <u>acceptance</u> from <u>o</u>utreach (see Eq. 8)

$ACCPTR_{t,m,\hat{a}}$ = <u>acceptance</u> from <u>r</u>equest (see Eq. 15)

Referral may take place because the patient lives near a clinic or be-
cause the capacity of a particular clinic is stressed. For example, a
post partum hospital may refer patients to a local county health depart-
ment. The referral process is modeled by a referral rate between agencies
and a percentage of the patients who will go to the new agency. In the
model, patients are not moved from one agency to another when referred,
but rather when they appear at that new agency. The equation to update
acceptance for referral (see box 13) is:

$$(16) \quad ACCPT_{t-A,m,a,d} = ACCPT_{t-A,m,a,d} + ACCPT_{t-A,m,a,d} \sum_{\substack{aa=1 \\ aa \neq a}}^{NA} PREF_{a,aa} PRCOM_{a,aa}$$

$$- ACCPT_{t-A,m,a,d} \sum_{\substack{aa=1 \\ aa \neq a}}^{NA} PREF_{aa,a} PRCOM_{aa,a}$$

$A = APT_{m,a,d}$ = interval between appointment d and d+1 for
method m at agency a

$PREF_{a,aa}$ = percent of initial acceptors referred to
agency a from agency aa in a month

$PRCOM_{a,aa}$ = percent of those referred to agency a from agency
aa who come to new agency

Although referral usually takes place at the initial visit,
equation 16 can be used to refer people of any depth when PREF is further
subscripted by d. Such alternative on-line subscripting will be discussed
later in this paper.

Continuance: At a patient's first visit she is given a return appoint-
ment. The number of people who return (see box 14) is:

(17) $COMC_{t,m,A,d} = ACCPT_{t-A,m,a,d} \ PCOMC_{m,a,d}$

   $COMC_{t,m,A,d}$ = number of people coming to their continuing appointment
   in month t having last accepted method m d times at agency a

   $ACCPT_{t-A,m,a,d}$ = number of people who accepted in month t−A
   method m at agency a for the dth time

   $PCOMC_{m,a,d}$ = percent of people who come for continuing ap-
   pointments for method m at agency a after d
   visits if service is convenient

   $A=APT_{m,a,d}$ = interval between appointment d and d+1 for
   method m at agency a

This number is then updated to reflect follow up (see box 15) in

similar manner to equation 7 to define:

   $CONCOM_{t,m,a,d}$ = after outreach follow up the number of people
   with continuing appointments coming in month t
   to agency a having accepted d times and using
   method m

Those who do not come may have lost interest in contraception or they

may have had a negative experience with their method. Those who do

not come are divided into not negative and negative groups and returned to the

appropriate states. The updating for state 3 which has been defined as "ever

in system but not negative" is:

(18) $NSTATE_{t,3} = (ACCPT_{t-A,m,a,d} - CONCOM_{t,m,a,d}) \ (1-PERNEG_{m,d}) + NSTATE_{t,3}$

   $PERNEG_{m,d}$ = percent of people who have accepted d times and
   last accepted method m who have a negative experience

The first term defines those due for an appointment in month t $(ACCPT_{t-A,m,a,d})$

less those who came (CONCOM), while the second term defines the non-negative

percentage.

For the negative states (s=5+m, m=1, $\cdots$, NM, where NM is the number of methods):

(19) $NSTATE_{t,5+m} = (ACCPT_{t-A,m,a,d} - CONCOM_{t,m,a,d})\ PERNEG_{m,d} + NSTATE_{t,5+m}$

Returning to consideration of those who did come (see box 14), the number who accept again (see box 16) is:

(20) $ACCPT_{t,m,a,d+1} = CONCOM_{t,m,a,d}\ PACPTC_{m,a,d}\ \overline{RCAP}_a\ (UCAP_{t,a}/TACP_{t,a})$

$PACPTC_{m,a,d}$ = percent of people using method m who have accepted a method d times who will <u>accept</u> a method again at agency a if the service is <u>c</u>onvenient

$\overline{RCAP}_a$ = <u>r</u>esponse function to <u>cap</u>acity (see equation 9 and figure 3)

<u>Switching:</u> The acceptance of method at a return appointment is modified for switching between methods at that visit (see box 17). A simple Markovian matrix is used to update the number of acceptors for d > 1 as:

(21) $ACCPT_{t,m,a,d} = ACCPT_{t,m,a,d} + \sum\limits_{\substack{mm=1 \\ mm\neq m}}^{NM} \sum\limits_{d=2}^{ND} ACCPT_{t,m,a,d} PSWITCH_{m,mm,a}$

$-\sum\limits_{\substack{mm=1 \\ mm\neq m}}^{NM} \sum\limits_{d=2}^{ND} ACCPT_{t,m,a,d}\ PSWITCH_{mm,m,a}$

$PSWITCH_{m,mm,a}$ = percent of actives who <u>switch</u> to method m from mm at a visit to agency a

The final step in the continuance flow is referral (see box 18). This is modeled as in equation 16 if referral takes place at repeat visits in an agency.

This completes the discussion of the first major patient flow of non-post partum entry and continuance. Next new patient arrival and retention based on phenomena that occur after delivery of a child will be considered. This post partum flow is the second major section of the model.

POST PARTUM FLOW

After delivering at a hospital with a post partum family plan-
ning program, women may accept contraception immediately or at a subse-
quent six week post partum checkup. See figure four. The post partum
flow traces these two classes of people separately through two accep-
tances and then considers their combined continuing contraceptive usage.

Immediate Acceptors: First, the post partum acceptors of sterilization
are considered (see box 1, figure 4). The number of women sterilized
post partum:

(22) $\text{STERPP}_{t,\bar{a}} = \text{DELIVS}_{t,\bar{a},s} \ \text{PDSTER}_{\bar{a},s}$

> $\text{STERPP}_{t,\bar{a}}$ = number of women sterilized post partum in month t
> at agency $\bar{a}$

> $\text{DELIVS}_{t,\bar{a},s}$ = number of women who <u>deliver</u> from <u>s</u>tate s in month
> t at post   partum agency $\bar{a}$ (see equation 65)

> $\text{PDSTER}_{\bar{a},s}$ = <u>p</u>ercent of women who <u>deliver</u> and were in state s at post
> partum agency a that request a <u>ster</u>ilization

The percent who request sterilization (PDSTER) is subscripted by state
since sterilization rates may be higher for those who had previously
been in the system or had method failures. These sterilized women are de-
ducted from DELIVS. Those who were not sterilized may be visited by a
family planning nurse while at the hospital. The number seen immediately
post partum (see box 2) is specified as:

(23) $\text{SEEPP}_{t,\bar{a},s} = \text{DELIVS}_{t,a,s} \ \text{PSEE}_{\bar{a}}$

> $\text{SEEPP}_{t,\bar{a},s}$ = number of women in state s <u>seen</u> immediately <u>p</u>ost
> partum in month t at agency $\bar{a}$.

> $\text{PSEE}_{\bar{a}}$ = <u>p</u>ercent of women <u>seen</u> by family planning worker
> in the hospital ward in agency $\bar{a}$

The percent seen (PSEE) reflects the coverage by family planning workers and the quality of the message they deliver is reflected in the acceptance rate (PACPTI) used to define the number of immediate acceptors (see box 3).

(24) $ACCPIP_{t,m,\bar{a},s} = SEEPP_{t,\bar{a},s}\ PACPTI_{\bar{a},s}\ FACCPT_{m,\bar{a},s}$

$ACCPIP_{t,m,\bar{a},s}$ = number of acceptors immediately post partum in month t who accept method m at agency $\bar{a}$ and who are in state s

$PACPTI_{\bar{a},s}$ = percent of people in state s who accept a method immediately post partum at agency $\bar{a}$

$FACCPT_{m,\bar{a},s}$ = fraction of people in state s who accept some method who accept specific method m at agency $\bar{a}$

The acceptance rate (PACPTI) and method selecting (FACCPT) are subscripted by state since those with method experiences may behave differently. For example, those who had negative experience with a method (S=5+m, see page 10-11) are not likely to select that method again.

The number of these immediate acceptors who return for their six week post partum check up (see box 4) is:

(25) $ICOMS_{t,m,\bar{a}} = \sum_{s=2}^{NS} ACCPIP_{t-2,m,\bar{a},s}\ PICOMS_{\bar{a}}$

$ICOMS_{t,m,\bar{a}}$ = number of immediate acceptors of method m who come for six week post partum appointment at agency $\bar{a}$ in month t before follow up

$PICOMS_{\bar{a}}$ = percent of immediate acceptors at agency $\bar{a}$ who come to six week post partum check

This number is updated for follow up to define:

(25A) $ISXCOM_{t,m,\bar{a},} = ICOMS_{t,m,\bar{a}}$ adjusted for follow up as in equation 7.

= number of immediate acceptors who in six weeks come to the post partum check up.

Those who do not come are returned to states as in equations 18 and 19.

The number of immediate acceptors who accept for a second time at the six week post partum check up (see box 5) is:

$$(26) \quad ACCPIS_{t,m,\bar{a}} = ISXCOM_{t,m,\bar{a}} \quad PACPIS_{\bar{a}} \quad \overline{RCAP}_{\bar{a}} \quad (UCAP_{t,\bar{a}} \quad / \quad TCAP_{t,\bar{a}})$$

$ACCPIS_{t,m,\bar{a}}$ = number of people who accepted immediately who come to their six week appointment and accept method m at agency $\bar{a}$ in month t

$PACPIS_{\bar{a}}$ = percent of people who accepted immediately who come to their six week appointment and accept method again at agency $\bar{a}$

$\overline{RCAP}_{\bar{a}}$ = response function to capacity (see equation 9 for more explanation)

Switching may occur and is modeled in a manner similar to equation 21. The degree of switching depends on how the immediate acceptance by method (FACCPT) is defined. Usually the method selection fractions in equation 24 are based on six week appointment data since the immediate post partum method selection in many cases are temporary. For example, foam instead of a loop, since it is too early to insert a loop. Rather than modeling and para-meterizing this additional switching, six week method selection data can be used and little loss of quality of output occurs since only the two months from immediate acceptance to the six week appointment are affected.

Non-Immediate Acceptors: Those who do not accept immediately, but who re-ceived a visit from a family planning worker usually accept the six week post partum appointment (see box 6). The number who accept the six week appoint-ment of those seen (ACCPSP) is:

$$(27) \quad ACCPSP_{t,\bar{a},s} = (SEEPP_{t,\bar{a},s} - \sum_{m=1}^{NM} ACCPIP_{t,m,\bar{a},s}) \quad PACPTA_{\bar{a},s}$$

$ACCPIP_{t,m,\bar{a},s}$ = number of <u>accep</u>tors immediately post partum (see equation 24)

$PACPTA_{\bar{a},s}$ = <u>p</u>ercent of those women in state s seen post partum who did no accept immediately but who <u>accept</u> a six week <u>ap</u>pointment

The number of these who come to the six week appointment (COMPS) is:

(28) $COMPS_{t,\bar{a},s}$ = $ACCPSP_{t-2,\bar{a},s}$ $PSCOMS_{\bar{a},s}$

$PSCOMS_{\bar{a},s}$ = <u>p</u>ercent of those with <u>six</u> week post partum appointment (but who did not accept immediately) who <u>come</u> to <u>six</u> week appointment

After an adjustment for follow up

$PPSCOM_{t,a,s}$ = $COMPS_{t,a,s}$ adjusted for follow up as in equation 7 = the number of <u>p</u>ost <u>p</u>artum people <u>seen</u> by a worker who <u>come</u> to the six week appointment after follow up

In addition to these people, some of the women who were not seen may come to the six week appointment since they either automatically receive an appointment as they are discharged or they learn about its availability from other people. The number of women not seen by a worker who come for an appointment (see box 7) is:

(29) $COMNS_{t,\bar{a},s}$ = $DELIVS_{t,\bar{a},s}$ $(1-PDSTER_{\bar{a},s})(1-PSEE_{\bar{a}})$ $PCOMNS_{\bar{a},s}$

$COMNS_{t,\bar{a},s}$ = number of women who <u>come</u> to six week appointment of those <u>not seen</u>

$DELIVS_{t,\bar{a},s}$ = number of women who <u>deliver</u> in month t from <u>states</u> at agency $\bar{a}$

$PDSTER_{\bar{a},s}$ = <u>p</u>ercent of women who <u>d</u>eliver who are <u>sterilized</u> in month t at agency $\bar{a}$

$PSEE_{\bar{a}}$ = percent of people <u>seen</u> immediately post partum by a family planning worker

$PCOMNS_{\bar{a},s}$ = <u>p</u>ercentage of women who <u>come</u> to six week check up of those <u>not seen</u> post partum

The total number of people who did not accept immediately, but who come to the six week appointment (COMSIX) is:

$$(30) \quad COMSIX_{t,\bar{a},s} = COMNS_{t,\bar{a},s} + PPSCOM_{t,\bar{a},s}$$

The number of these who accept (ACPTS) is:

$$(31) \quad ACPTS_{t,m,\bar{a},s} = COMSIX_{t,\bar{a},s} PACPTS_{\bar{a},s} \overline{RCAP}(UCAP_{t,\bar{a}}/ TCAP_{t,\bar{a}}) FACCPT_{m,\bar{a},s}$$

$ACPTS_{t,m,\bar{a},s}$ = number of women in state s who <u>accept</u> for the first time at the <u>six</u> week post partum check-up method m in month <u>t</u> and agency <u>a</u>.

$PACPTS_{\bar{a},s}$ = percent of those in state s who come to the six week appointment and did not <u>accept</u> immediately, who accept a method at agency $\bar{a}$ at <u>six</u> weeks appointment

$\overline{RCAP}_{\bar{a}}$ = <u>r</u>esponse to <u>ca</u>pacity (see equation 9)

$FACCPT_{m,\bar{a},s}$ = <u>f</u>raction of those in state s who <u>accept</u> a method that accept specific method m at agency $\bar{a}$

The fraction that accept (PACPTS) is subscripted by state since women who have had negative experience with methods (s = 5+m) may come to the six week check up for medical reasons, but have a low acceptance rate. After initial acceptance, referral may take place as in equation 16.

The second acceptance of non-immediate acceptors is modeled separately (boxes 9 and 10) so that when immediate and non-immediate acceptors are pooled in the flow model, they will have the same number of acceptances. The number of people who accepted for the first time at six weeks, who return for their next appointment (COMPSR) is (see box 9):

$$(32) \quad COMPSR_{t,m,\bar{a}} = \sum_{s=2}^{NS} ACPTS_{t-A,m,\bar{a},s} PSCOMN_{\bar{a}}$$

$PSCOMN_{\bar{a}}$ = percent of those who accepted for the first time at the <u>six</u> weeks who <u>come</u> to their <u>next</u> appointment at agency $\bar{a}$

The number accept again (see box 10) is:

$$(33) \quad ACPTSR_{t,m,\bar{a}} = NSCOMR_{t,m,\bar{a}} \; PACTSR_{\bar{a}} \; \overline{RCAP}_{\bar{a}} \; (UCAP_{t,\vec{a}} \; / \; TCAP_{t,\bar{a}})$$

$NSCOMR_{t,m,\bar{a}}$ = $COMPSR_{t,m,\bar{a}}$ adjusted for follow up (see equation 7)

= number of people who accepted first at the six week appointment who come to their scheduled revisit

$PACTSR_{\bar{a}}$ = percent of those who accept for the first time at six weeks and who return for next visit that accept a method again at agency $\bar{a}$

$\overline{RCAP}_{\bar{a}}$ = response to capacity (see equation 9)

The immediate (ACCPIS, equation 26) and non-immediate acceptors (ACPTSR, equation 33) have each accepted twice and are pooled in $ACCPT_{t,m,\bar{a},d}$ where d=2 and their continuance is modeled as in equations 17-21.

The final variable needed in the flow equations is the number of people who do not come to their scheduled appointment. This is needed in the follow up response equation number 7. The number of people who fail to come to their appointment at non-post partum agencies is:

$$(34) \quad TNCOM_{t,\hat{a}} = (OUTAPT_{t,\hat{a}} - COMOFU_{t,\hat{a}}) + \sum_{s=2}^{NS} (REQ_{t,\hat{a},s} - REQCOM_{t,\hat{a},s})$$

$$+ \sum_{d=1}^{ND} \sum_{m=1}^{NM-1} (ACCPT_{t-A,m,\hat{a},d} - CONCOM_{t,m,\hat{a},d})$$

$OUTAPT_{t,\hat{a}}$ = number of those who make an outreach appointment (see equation 5)

$COMOFU_{t,\hat{a}}$ = number who come to their outreach appointment (see equation 7)

$REQ_{t,\hat{a},s}$ = number who request an appointment (see equation 11)

$REQCOM_{t,\hat{a},s}$ = number who come to their requested appointment (see equations 14-15)

$ACCPT_{t-A,m,\hat{a},d}$ = number who <u>accep</u>ted contraceptive and are due to return in t (see equation 20)

$CONCOM_{t,m,\hat{a},d}$ = number of <u>con</u>tinuing acceptors who <u>come</u> to their appointment (see equation 17)

$A = APT_{m,\hat{a},d}$ = time interval between appointments for method m at agency â for those who have accepted d times.

The number of people who fail to come to their <u>appointm</u>ents at post partum agencies is:

$$(35) \quad TNCOM_{t,\bar{a}} = \sum_{m=1}^{NM-1} (\sum_{s=2}^{NS} ACCPIP_{t-2,m,\bar{a},s} - ISXCOM_{t,m,\bar{a}}) + \sum_{s=2}^{NS} (ACCPSP_{t-2,\bar{a},s}$$

$$- COMSIX_{t,\bar{a},s}) + \sum_{n=1}^{NM-1} (\sum_{s=2}^{NS} ACPTS_{t-A,m,\bar{a},s} - NSCOMR_{t,m,\bar{a}})$$

$$+ \sum_{d=1}^{ND} \sum_{m=1}^{NM-1} (ACCPT_{t-A,m,\bar{a},d} - CONCOM_{t,m,\bar{a},d})$$

$ACCPIP_{t,m,\bar{a},s}$ = number of people who <u>accept</u> <u>im</u>mediately post partum (see equation 24)

$ISXCOM_{t,m,\bar{a}}$ = number of <u>im</u>mediate acceptors who <u>come</u> to their <u>six</u> week post partum appointment (see equation 25 -29)

$ACCPSP_{t-2,\bar{a},s}$ = number of people who do not <u>accept</u> immediately but accept a <u>six</u> week <u>p</u>ost partum appointment (see equation 27)

$COMSIX_{t,\bar{a},s}$ = number of non-immediate acceptors who <u>come</u> to <u>six</u> week appointment (see equation 30)

$ACPTS_{t-A,m,\bar{a},s}$ = number of people who first <u>accept</u> at <u>six</u> week post partum visit (see equation 31)

$NSCOMR_{t,m,a}$ = <u>n</u>umber of people who first accepted at <u>six</u> weeks who <u>come</u> to their next visit (see equations 32-33)

This concludes the specification of the post partum and non-post partum flows. The output of these flows is the number of acceptors (ACCPT)

at each point in time and the specifications of the number of people
in each non-active state (NSTATE).

PREGNANCY - ABORTION - BIRTH FLOW

With the populations of actives and non-actives determined,
the next step in the model is to: (1) specify the pregnancy rates based
upon demographic fertility data, (2) model the effects of abortion, and
(3) define the number of deliveries and live births in the target group.
This flow is described in figure five.

Pregnancy: Actives may become pregnant due to method failures and non-
actives become pregnant at rates dependent upon whether they used pri-
vate (non-system dispensed) contraceptives.

For non-actives, the number who use private contraceptives
(see box 1,figure five) is:

$$(36) \quad NPVCON_t = \sum_{s=2}^{NS} NSTATE_{t,s} \; PPVCON$$

$NPVCON_t$ = number of people privately contracepting in month t.

$PPVCON$ = percent of not active not pregnant people who use private contraceptive

$NSTATE_{t,s}$ = number of people in state s at time t

The pregnancy rate for these women depends on the effectiveness of pri-
vate methods. Since private methods include the use of rhythm, foam, and
douche, the effectiveness is usually not high. The number of women private-
ly protected who became pregnant is (see box 2):

FIGURE FIVE: Pregnancy and Birth Flows

(37) $\text{PREGPV}_t = \text{NPVCON}_t \quad \text{AFERNA}_t \ (1-\text{EFFPV})$

> $\text{PREGPV}_t =$ number of people who become <u>preg</u>nant in month t while using <u>priv</u>ate contraceptive

> $\text{EFFPV} =$ <u>eff</u>ectiveness of <u>priv</u>ate contraception

> $\text{AFERNA}_t =$ <u>a</u>verage <u>fer</u>tility of <u>n</u>ot <u>a</u>ctive not pregnant people=uncontracepted pro<u>b</u>ability of pregnancy in a month (see Eq. 42A)

The effectiveness (EFFPV) is the probability of preventing pregnancy in target group women using private methods during an average month.

The average fertility of non-actives (AFERNA) is a function of the demographic composition of non-actives and the uncontracepted fertility of each demographic cohort. The modeling of this phenomena is discussed in equation 42-50 where the demographic effects are combined with the patient flow in a non-stationary Markovian formulation to produc an appropriate average fertility for non-actives in each month. Uncontracepted fertility is considered here as the rate of recognized pregnancy.

The pregnancies that occur to non-actives who are not protected are simply the average fertility times the non-actives not using private contraception. The total number of pregnancies among non-actives in a month is (see box 3) :

(38) $\quad \text{PREGNA}_t = \text{PREGPV}_t + \displaystyle\sum_{s=2}^{NS} \text{NSTATE}_{t,s} \ (1-\text{PPVCON}) \ \text{AFERNA}_t$

> $\text{PREGNA}_t =$ number of people who become <u>preg</u>nant in month t and are <u>n</u>ot <u>a</u>ctive

> $\text{NSTATE}_{t,s} =$ number of people in <u>n</u>on-active <u>state</u> s at time t

> $\text{PPVCON} =$ <u>p</u>ercent of not active not pregnant people who use <u>priv</u>ate <u>cont</u>raception

In considering the active group, first recall the basic definition of actives for m=1 to NM-1:

$$(39-A) \quad ACTIVE_{t,m,a,d} = \sum_{T=t-A+1}^{t} ACCPT_{t,m,a,d}$$

$ACCPT_{t,m,a,d}$ = number of people who in month t accepted method m at agency a for the dth time

$A=APT_{m,a,d}$ = number of months between appointments for method m at agency a for those who have accepted d times.

Note that for sterilization (method NM) the sum is overall time periods. This definition needs ellaboration for post partum agencies on the first visit. When $a = \bar{a}$ and $d = 1$:

$$(39-B) \quad ACTIVE_{t,m,\bar{a},d} = \sum_{T=t-1}^{t} \sum_{s=2}^{NS} ACCPIP_{t,m,\bar{a},s} + \sum_{T=t-A+1}^{t} \sum_{s=2}^{NS} ACPTS_{t,m,\tilde{a},s}$$

This revision is necessary since immediate post partum acceptors (ACCPIP, equation 24) have two month appointments for a post partum check-up while six weeks first acceptors (ACPTS, equasion 31) have a revisit appointment based on regular appointment intervals (A). This difference of lags in post partum agencies of depth one is important to recall in determining the total number of people in the system.

The pregnancy rate from actives depends upon the fraction of people who are using the method properly (e.g., taking pill each day) and the effectiveness of methods, given that they are used properly. The number of actives who become pregnant in a month is (see box 5):

$$(40) \quad PREGA_{t,m} = \sum_{a=1}^{NA} \sum_{d=1}^{ND} ACTIVE_{t,m,a,d} \, (1-EFFMTH_m) \, EFFUSE_{m,d} \, AFERA_t \, ILF$$

$$+ \sum_{a=1}^{NA} \sum_{d=1}^{ND} ACTIVE_{t,m,a,d} (1-EFFUSE_{m,d}) \, AFERA_t \, ILF$$

$EFFUSE_{m,d}$ = percent of actives of method m who have accepted d times who effectively use method.

$EFFMTH_m$ = effectiveness of method m. Probability of pre-
venting a pregnancy in a month of fecund women
properly using method m

$AFERA_t$ = average fertility of actives - probability of
pregnancy in a month (see equation 43)

$$ILF = \begin{cases} \simeq \text{ index value to reflect lower fertility during amenorrhic post partum period when d=1, a=$\bar{a}$} \\ \simeq 1.0 \text{ otherwise} \end{cases}$$

The first term in equation 40 reflects actives properly using methods and
the second term defines those not properly using methods.

The rate of proper usuage (EFFUSE) varies by method.[8] For example,
a loop is properly used if it is in place, while pills must be taken every
day. EFFUSE is also subscribed by the number of times the method has been
accepted since, particularly for the first acceptance, contraceptives can
be obtained with little commitment to regular usuage. For example, a
woman at the post partum check up may accept pills but not have as great
desire to use them as a woman who has returned for her second supply and
proven her commitment to contraception. The method effectiveness (EFFMTH)
required in equation 40 is the probability of preventing a pregnancy in
a woman who is active and would have become pregnant without contraception.
Since most experimental effectiveness is in terms of gross failures among
a sample, the base of such statistics must be modified by:

$EFFMTH$ = 1.0 - (GINEFF/AFERS) where

GINEFF = gross ineffectiveness in sample(percent of sample
who become pregnant per month)

AFERS = monthly average uncontracepted fertility in sample

For example, if GINEFF is 1% and AFERS is 20%, the clinical effective-
ness to be used by the model is 95% (1-1/20). This adjustment is also

important since the clinic sample probably did not have the same fertility as the actives or non-actives in the actual system to be considered by the model. ILF is included in equation 40 to reflect lower fertility immediately post partum.

The total number of pregnancies in a month (TPREGS) is total active (PREGA) and non-active (PREGNA) pregnancies (see box 6):

$$(41) \quad TPREGS_t = PREGNA_t + \sum_{m=1}^{NM-1} PREGA_{t,m}$$

This number is placed in $NSTATE_{t,1}$ − the non-active but pregnant state.

Average fertility: The average fertility of actives (AFERA) in a family planning system will be higher than the non-active rate (AFFRNA) since many actives enter through the post partum program. The fertility of women varies by parity (i.e., the number of births). After one birth, fertility is approximately seventy five percent greater than no births, so actives will have a higher fertility than non-actives.[9] In addition to parity differences, other demographic effects may cause the average fertility of actives to be different than non-activies. For example, actives may tend to be older so that age and parity cohorts might need to be considered.

There are two possible ways to encompass demographic effects on fertility in this model. One is to define each demographic cohort as a segment of the target group (see pp. 6 to 13) and specify different fertility, acceptance, and continuance responses for each. Although this is possible, it is an expensive procedure in terms of input needs, computer run times (multiplied by the number of segments), and storage costs if many demographic groups might be considered. For example, four age groups and four parity groups

produce sixteen cohorts within each program segment such as black and white.

In order to include demographic effects and still maintain the efficiency necessary for on-line use and managerial acceptance, a submodel is used to specify appropriate average fertilities for actives by considering the demographic composition of the active and non-active groups, the fertility of each demographic cohort, and the acceptance and continuance response of each cohort.

The basic approach is to define demographic units and track the number of people in each demographic cohort in the active and non-active group each month. Given these compositions, the appropriate fertility is a weighted average of the uncontracepted fertility rates for each demographic cohort. The average fertility for non-actives (AFERNA) is:

$$(42\text{-}A) \quad AFERNA_{t+1} = \sum_{c=1}^{NC} NA_{t,c} \; FERTIL_c / \sum_{c=1}^{NC} NA_{t,c}$$

$NA_{t,c}$ = number of not active people in cohort c at time t

c = 1,2, ..., NC, where NC = number of demographic cohorts to be considered

$FERTIL_c$ = uncontracepted monthly fertility rate for women in cohort c

The average fertility for actives is:

$$(42\text{-}B) \quad AFERA_{t+1} = \sum_{c=1}^{NC} A_{t,c} \; FERTIL_c / \sum_{c=1}^{NC} A_{t,c}$$

$A_{t,c}$ = number of actives in cohort c at time t

Recall that these two average fertilities are used in equations 38 and 40 to determine pregnancies.

The number of people from each cohort in the active (A) and non-active (NA) groups in each period is specified by a non-stationary Markov process where the transition probabilities are specified by aggregations of the

model flow parameters (equations 1 to 35). The Markovian states will be
denoted by k where

$$k = 1, NC \qquad \text{for not-active in each cohort}$$

$$k = NC + 1 \text{ to } 2NC \quad \text{for active in each cohort}$$

$$k = 2NC + 1 \text{ to } 3NC \quad \text{for pregnant in each cohort}$$

The number in each Markovian state at time t is:

$$(43) \quad N_{t,k} = \sum_{kk=1}^{3NC} N_{t-1,kk} \, P^t_{k,kk}$$

$N_{t,k}$ = $\underline{\text{number}}$ of people in Markovian state k at month t

$P^t_{k,kk}$ = transition $\underline{\text{probability}}$ to state k from state kk in month t

A simple example of a transition probability matrix is given in figure six for NC = 2 and where c = 1 denotes zero parity and c = 2 is parity one or greater. k = 1 and 2 reflect non-actives. k = 3 and 4 are actives, and k = 5 and 6 are pregnant states. The specific transition probabilities reflect movement from : (1) non-actives to active (G) or pregnant (PRN), (2) active to non-actives (L) or pregnant (PRA), and (3) pregnant to active (DA) or non-active (DNA). Non-program generated flow between cohorts is allowed by the Z probabilities. Residuals (R) are defined so the probabilities in each row sum to one.

The gain probability is the fraction of not actives who accept for the first time this month. For d=1 and non-post partum agencies,

$$(44) \quad G_{c,t} = \left[\sum_{m=1}^{NM} \sum_{\hat{a}=1}^{NNPP} ACCPT_{t,m,\hat{a},d} \bigg/ \sum_{s=2}^{NS} NSTATE_{t-1,s} \right] \quad IACPT_c \bigg/ \sum_{c=1}^{NC} IACPT_c$$

$G_{c,t}$ = percent gain of actives from non-actives from cohort c in month t

$ACCPT_{t,m,\hat{a},d}$ at d=1 = number of acceptors in month t of method m at agency a for the first time

$NSTATE_{t,s}$ = number of people in non active state s in month t

$IACPT_c$ = index of non-post partum acceptance of cohort c relative to average (e.g., 1.1)

The first term defines the percent of non-active last period (NSTATE) who accept (ACCPT) for the first time in month t, the second term is an index that can be used to reflect the differential trial propersities of cohorts. For example, non-active women of parity one may accept more readily after an outreach visit than those of parity zero. Similar indices are provided for other transition probabilities.

time t

	$\dot{P}t$	NOT ACTIVE		ACTIVE		PREGNANT	
		Cohort 1 (k=1)	Cohort 2 (k=2)	Cohort 1 (k=3)	Cohort 2 (k=4)	Cohort 1 (k=5)	Cohort 2 (k=6)
NOT ACTIVE — Cohort 1 (k=1)		$R_{1,t}$	Z_1	$G_{1,t}$	0	$PRN_{1,t}$	0
Cohort 2 (k=2)		Z_2	$R_{2,t}$	0	$G_{2,t}$	0	$PRN_{2,t}$
time t-1 ACTIVE — Cohort 1 (k=3)		$L_{1,t}$	0	$R_{3,t}$	Z_1	$PRA_{1,t}$	0
Cohort 2 (k=4)		0	$L_{2,t}$	Z_2	$R_{4,t}$	0	$PRA_{2,t}$
PREGNANT — Cohort 1 (k=5)		0	$DNA_{1,t}$	0	$DA_{1,t}$	$R_{5,t}$	Z_1
Cohort 2 (k=6)		0	$DNA_{2,t}$	0	$DA_{2,t}$	Z_2	$R_{6,t}$

FIGURE SIX: Probability Transition Matrix
for Fertility Submodel

The indicies are normalized by the last term of equation 44 so that the user does not have to establish an arbitary reference condition.

The pregnancy rate for non-actives in each cohort depends upon the extent and effectiveness of private contraception and is:

(45) $PRN_c = FERTIL_c \ PPVCON \ (1-EFFPV) + FERTIL_c \ (1-PPVCON)$

PRN_c = percent pregnancies from not actives of cohort c in a month

$FERTIL_c$ = uncontracepted fertility rate of cohort c

$PPVCON$ = percent of non-actives privately protected

$EFFPV$ = effectiveness of private protection

The first term is those using private contraception ineffectively, and the second term is those who are not privately protected.

The loss rate from actives to non-actives is the percent of actives who do not come to their appointment or do not accept if they come:

(46) $L_{c,t} = \left[\left\{ \left(\sum_{a=1}^{NA} TNCOM_{t,a} + \sum_{m=1}^{NM-1} \sum_{a=1}^{NA} \sum_{d=1}^{ND} (CONCOM_{t,m,a,d} - ACCPT_{t,m,a,c}) \right. \right. \right.$

$\left. + \sum_{\bar{a}=1}^{NPP} (ISXCOM_{t,\bar{a}} - \sum_{m=1}^{NM} ACCPIS_{t,m,\bar{a}}) + \sum_{a=1}^{NPP} \sum_{s=2}^{NS} (COMSIX_{t,\bar{a},s} \right.$

$\left. \left. - \sum_{m=1}^{NM} ACPTS_{t,m,\bar{a},s}) + \sum_{m=1}^{NM} \sum_{\bar{a}=1}^{NPP} (NS \ COMR_{t,m,\bar{a}} - ACPTSR_{t,m,\bar{a}}) \right\} \right/$

$\left. \sum_{m=1}^{NM} \sum_{a=1}^{NA} \sum_{d=1}^{ND} ACTIVE_{t-1,m,a,d} \right] \ (ILOSS_c \ / \ \sum_{c=1}^{NC} ILOSS_c)$

$L_{c,t}$ = percent loss from active state to non active state of cohort c in month t

$TNCOM_{t,a}$ = total number of people who do not come (see equation 34 and 35)

$CONCOM_{t,m,a,d}$ = number of people who <u>come</u> to their <u>continuing</u> appointment (see equation 17)

$ACCPT_{t,m,a,d}$ = number of people who <u>accept</u> at their continuing appointment (see equation 20)

$ISXCOM_{t,\bar{a}}$ = number of immediate acceptors who in <u>six</u> weeks <u>come</u> to post partum appointment (see equation 25 and $\overline{25A}$)

$ACCPIS_{t,m,\bar{a}}$ = number who <u>accepted immediately</u> who accept again at the <u>six</u> week post partum appointment (see equation 26)

$COMSIX_{t,\bar{a},s}$ = number of people who did not accept immediately who <u>come</u> to the <u>six</u> week post partum check up (see equation 30).

$ACPTS_{t,m,\bar{a},s}$ = number of people who <u>accept</u> for first time at six week post partum check up (see equation 31).

$NSCOMR_{t,m,\bar{a}}$ = <u>n</u>umber of people who first accepted at <u>six</u> weeks who <u>come</u> to their <u>revisit</u> (see equation 32-33)

$ACPTSR_{t,m,a}$ = number of people who <u>accepted</u> first at six week appointment who <u>come</u> to their <u>revisit</u> and accept again (see equation 33)

$ILOSS_{c}$ = <u>index</u> of <u>loss</u> of cohort c relative to average

The first term is those who did not come to the appointment and the remainder of the numerator terms are those who came, but did not accept. The denominator is the total number of total actives in the system. The pregnancy rate for actives is the observed active rate of pregnancy weighted by the cohort fertility.

(47) $PRA_{c,t} = (PREGA_t \quad / \quad \sum_{m=1}^{NM} \sum_{a=1}^{NA} \sum_{d=1}^{ND} ACTIVE_{t-1,m,a,d})(FERTIL_c \quad / \quad \sum_{c=1}^{NC} FERTIL_c$

$PRA_{c,t}$ = percent <u>pregnancies</u> from <u>actives</u> of cohort c in month t

$PREGA_t$ = number of <u>pregnancies</u> by <u>actives</u> in month t (see equation 40)

$FERTIL_c$ = uncontracepted <u>fertility</u> rate of cohort c

The fraction of pregnant women who deliver is related to the number of pregnancies nine months ago. The transition probability for deliveries is for k= 2NC + c

$$(48) \quad D_{c,t} = \sum_{kk=1}^{ZNC} N_{t-9,kk} \ P_{k,kk}^{t-9} \ / \ N_{t-1,k}$$

$P_{k,kk}^{t}$ = transition probability to k from kk (see equation 43 and figure 6) in period t

$N_{t,k}$ = number of people in Markovian state k at month t (see equation 43)

$D_{c,t}$ = percent of pregnant women in cohort c who deliver in month t

The fraction of the deliveries that accept family planning is the number of post partum first acceptors (d=1) divided by the number of deliveries:

$$(49) \quad DA_{c,t} = D_{c,t} \left(\sum_{m=1}^{NM} \sum_{\bar{a}=1}^{NPP} ACCPT_{t,m,\bar{a},d} \Bigg/ \sum_{\bar{a}=1}^{NPP} \sum_{s=2}^{NS} DELIVS_{t,\bar{a},s} \right)$$

$$X \quad \left(IACPTP_c \Bigg/ \sum_{c=1}^{NC} IACPTP_c \right)$$

$DA_{c,t}$ = percent of pregnant women in cohort c who deliver in month t and accept contraception

$ACCPT_{t,m,\bar{a},d}$ at d=1 = the number of post partum first acceptors (sum of ACCPIP equation 24 and ACPTS equation 31)

$DELIVS_{t,\bar{a},s}$ = number of deliveries in month t at agency $\bar{a}$ from states s (see equation 64 and 65)

$IACPTP_c$ = index of post partum acceptance for cohort c relative to average

The precent who do not accept is the residual:

$$(50) \quad DNA_{c,t} = D_{c,t} - DA_{c,t}$$

$DNA_{c,t}$ = percent of pregnant women in cohort c who deliver in month t and do not accept contraception

Note that in figure six, when people deliver they are moved to the appropriate parity group.

The Z probabilities shown in figure 6 are equal to zero if there is no movement between cohorts except by pregnancy. Z can be set to a monthly transition rate to reflect other phenomena such as aging if cohorts were defined by age and parity.

The final transition probability is the residual of the row:

R_k = residual percentage so that sum of row probabilities equals one.

In review the Markovian submodel described in equations 43 to 50 specifies the cohort composition of actives and non-actives which is used in equation 42 to calculate the average fertility for actives and non-actives. This average fertility controls the pregnancy flow in equations 37 to 41.

Abortion: Pregnancies can be terminated by legal abortion, illegal abortions, or natural causes. The abortion flow is shown in Figure five. First, those who desire abortion are specified and then legal or illegal abortions take place. The amount of illegal abortions depends upon the availability of legal abortions, since those who are not accepted for a legal abortion may seek illegal abortion.

The number of people who desire an abortion in month t (see box 6, figure five) is:

$$(51) \quad NDESA_{t,mp} = TPREGS_{t-mp} \ PDESA \ PDAP_{mp}$$

$NDESA_{t,mp}$ = number of people who desire an abortion in month t and who have been pregnant for mp months

$TPREGS_t$ = total number of pregnancies in month t (see equation 41)

$PDESA$ = percent of women who become pregnant who will desire an abortion

$PDAP_{mp}$ = percent of those who desire an abortion who will request in the mp month of pregnancy

The abortion flow is parameterized in terms of the number of months a woman is pregnant (mp) since the abortion method used, mortality, and morbidity depend on the time since pregnancy. The duration of pregnancy correlates with the abortion method and, therefore, fuctions as a rough surrogote for various methods of abortion in the model.[10] Particularly, saline procedures are used in late abortions and this procedure has the highest mortality and morbidy.

The number of people of term mp who request legal abortions (REQLA) at agency a (see box 7) is:

$$(52) \quad REQLA_{t,a,mp} = NDESA_{t,mp} \; PREQLA_a$$

$PREQLA_a$ = percent of those desiring an abortion who will request a legal abortion at agency a

Not all people who request abortions are accepted. Depending on what local conditions exist, certain eligibility rules must be satisfied. This eligibility depends on the duration of pregnancy at least in terms of a maximum acceptable duration (usually six months). The number accepted is (see box 8):

$$(53) \quad AREQLA_{t,a,mp} = REQLA_{t,a,mp} \; POKA_{a,mp} \; \overline{RACAP}_a \; (UACAP_{t,a} \, / \, TACAP_{t,a})$$

$AREQLA_{t,a,mp}$ = number of accepted requests for legal abortion at agency a in month t from woman pregnant mp months.

$POKA_{a,mp}$ = percent who desire abortion who are OK for abortion by criteria at agency a and who have been pregnant for mp months.

$\overline{RACAP}_a$ = response function to abortion capacity (analogous to equation 9) The percent of approved abortions that can be done as a function of utilized abortion capacity $(UACAP_{t,a})$ relative to total abortion capacity $(TACAP_{t,a})$

The number of people who experience morbidity (sickness or medical complications) from legal abortions (see box 9) is:

$$(54) \quad NMBLA_{t,a} = \sum_{mp=1}^{9} AREQLA_{t,a,mp} \; PMBLA_{a,mp}$$

$PMBLA_{a,mp}$ = percent morbidity in legal abortion of woman pregnant mp months at agency a

The number of mortalities (see box 10) is:

$$(55) \quad NMTLA_{t,a} = \sum_{mp=1}^{9} AREQLA_{t,a,mp} \; PMTLA_{a,mp}$$

$$PMTLA_{a,mp} = \text{percent \underline{mo}rtality in \underline{l}egal \underline{a}bortion of woman pregnant} \atop \text{mp months}$$

The morbidity and mortality depend on the months of duration of pregnancy. As the duration increases, this reflects the higher risks associated with the necessity to shift from suction and D and C to saline procedures. Mortalities are removed from the target group.

People who have successful abortions or experience morbidity may accept family planning methods. The number of those who accept (ACCPTA) family planning method m at agency a in month t (see box 11) is:

$$(56) \quad ACCPTA_{t,m,a} = (\sum_{mp=1}^{9} AREQLA_{t,a,mp} - NMTLA_{t,a}) \; PACPTA_a \; FACPTA_{m,a}$$

$PACPTA_a$ = percent <u>accept</u>ance of family planning method at agency a of those <u>a</u>borted.

$FACPTA_{m,a}$ = <u>f</u>raction of those who <u>accept</u> a method who <u>a</u>ccept specific method m at agency a of an <u>a</u>bortion

Now consider illegal abortions (see figure five). The number who undergo an illegal abortion equals the number who desire an abortion minus those who were accepted for a legal abortion, multiplied times the parameter that reflects their ability to find services for an abortion. The number who find an illegal abortion (see box 12) is:

$$(56A) \quad FINDIA_t = \sum_{mp=1}^{9} (NDESA_{t,mp} - \sum_{a=1}^{NA} AREQLA_{t,a,mp}) \; PFIA$$

$PFIA$ = <u>p</u>ercent who desire abortion that <u>f</u>ind <u>i</u>llegal <u>a</u>bortion

$NDESA_{t,mp}$ = <u>n</u>umber who <u>desire</u> an <u>a</u>bortion (see equation 51)

$AREQLA_{t,a,mp}$ = number <u>accepted requests</u> for a <u>l</u>egal <u>a</u>bortion (see equation

The number of mortalities from illegal abortion (NMTILA) is (see box 13):

$$(57) \quad NMTILA_t = FINDIA_t \; PMTILA$$

$PMTILA$ = percent <u>mo</u>rtality in <u>il</u>legal <u>a</u>bortion

The number of morbidities from illegal abortion (NMBILA) is (see box 14):

(58) $NMBILA_t$ = $FINDIA_t$ PMBILA

PMBILA = percent of morbidity in illegal abortion

Some of these morbidities require hospitalization and there may be an opportunity to accept family planning. The number of people who accept family planning after a morbidity due to illegal abortion (see box 15) is:

(59) $ACPTIA_{t,m,a}$ = $NMBILA_t$ $PHMBIA_a$ $PACTIA_a$ $FACTIA_{m,a}$

$PHMBIA_a$ = percent hospitalization at agency a of morbidities due to illegal abortion

$PACTIA_a$ = percent of hospitalized morbidities that accept family planning after illegal abortion

$FACTIA_{m,a}$ = fraction of those who accept some method that accept specific method m at agency a after an illegal abortion

Some illegal abortions are not successful in terminating pregnancy. The number of unsuccessful abortions (USILA) is (see box 16):

(60) $USILA_t$ = $FINDIA_t$ PILAUS

$FINDIA_t$ = number who find an illegal abortion (see equation 56A)

PILAUS = percent illegal abortions that are unsuccessful but did not lead to mortality or morbidity

The number of people who have a successful legal or illegal abortion are removed from the pregnant state. The updating of NSTATE for mp=1 to 9 is:

(61) $NSTATE_{t-mp,1}$ = $NSTATE_{t-mp,1}$ $- \sum_{MP=1}^{mp}$ ($AREQLA_{t,MP}$ - ($FINDIA_t$ - $USILA_t$) $PIAMP_{MP}$)

$AREQLA_{t,mp}$ = number of acceptor requests for legal abortion (see equation 53)

$FINDIA_t$ = number who find an illegal abortion (see equation 56A)

$USILA_t$ = unsuccessful illegal abortions (see equation 60)

$PIAMP_{mp}$ = per cent of illegal abortions done on women mp months pregnant

This is a cumulative update since $NSTATE_{t,1}$ is the cumulative total of women pregnant in month t. The value in $NSTATE_{t,1}$ is used to determine the number of births in nine months. (see equation 62)

After the abortion process, the Markovian fertility sub-model is adjusted to reduce the number of pregnancies by normalizing $N_{t,k}$, k= 2NC + 1 to 3NC (see equation 43) to equal the total number of pregnancies ($NSTATE_{t,1}$) in each of the last nine months [11].

Births: The number of births in a month equals the number of women who have been pregnant for nine months and not had an abortion, times the fraction that terminate with a live birth. The number of live births (BIRTH) in month t at agency a (see box 17) is:

(62) $\quad BIRTH_{t,\bar{a}} \quad = \quad NSTATE_{t-9,1} \; PLB \; PDELIV_{\bar{a}}$

$\qquad$ PLB $\qquad$ = $\;$ probability of pregnancy ending in live birth

$\qquad$ $PDELIV_{\bar{a}}$ = $\;$ percent of deliveries at agency $\bar{a}$

The probability of ending in live birth (PLB) includes the effects of miscarriage and of fetal mortality at birth. It is assumed that after a miscarriage , a woman may contact family planning and, therefore, these people are included in the number who deliver at a post partum hospital program.
The number of deliveries (DELIV) at a post partum agency is:

(63) $\quad DELIV_{t,a} \quad = \quad NSTATE_{t-9,1} \; PDELIV_{\bar{a}}$

In order to determine the state of women who were not active at pregnancy, it is assumed that their states are proportional to the non-active states when they become pregnant.

$$(64) \quad \text{DELIVS}_{t,\bar{a},s} = (\text{DELIV}_{t,\bar{a}} - \sum_{m=1}^{NM-1} \text{PREGA}_{t,m} \text{PDELIV}_{\bar{a}}) \text{NSTATE}_{t-9,s} / \sum_{s=2}^{NS} \text{NSTATE}_{t-9}$$

$\text{PREGA}_{t,m}$ = number of women who become <u>preg</u>nant while <u>a</u>ctive and accepting method m (see equation 40)

Next, those who suffered method failures (PREGA) are added to the negative method experience states. For methods m=1 to NM-1 DELIVS is updated to:

$$(65) \quad \text{DELIVS}_{t,a,5+m} = \text{DELIVS}_{t,a,5+m} + \text{PREGA}_{t,m} \text{PDELIV}_{\bar{a}}$$

The variable $\text{DELIVS}_{t,\bar{a},s}$ becomes the initial input to the post partum flow (see equation 22).

The pregnancy, abortion, and live birth flows completes the process model specification. Attention is now directed at capacity and output measures related to births prevented.

CAPACITY AND OUTPUT MEASURES

Capacity: The capacity of a family planning clinic can usually be varied quite easily. More clinic hours can generally be added, or more doctors hired. The equipment required (except for surgical sterilization and later term abortions) is not elaborate, so the physical plant can be enlarged in less than one year. But in the short run (one month or two), capacity is fixed by the physical resources and budgets.

The capacity is modeled as the weighted sum of first and second visits. The number of first visits in a non-post partum agency is:

$$(66) \quad \text{TNFVIS}_{t,\hat{a}} = (\text{OUTCOM}_{t,\hat{a}} + \sum_{s=2}^{NS} \text{REQCOM}_{t,\hat{a},s}) \overline{\text{RCAP}}_a (\text{UCAP}_{t,\hat{a}} / \text{TCAP}_{t,a})$$

$\text{TNFVIS}_{t,\hat{a}}$ = <u>t</u>otal <u>n</u>umber of <u>f</u>irst <u>vis</u>its at agency â in month t

$\text{OUTCOM}_{t,\hat{a}}$ = number of people with <u>out</u>reach generated appointment who <u>com</u>e (see equation 7 and 8)

$\mathrm{REQCOM}_{t,\hat{a},s}$ = number who request an appointment and come
(see equations 14-15)

$\overline{\mathrm{RCAP}}_a$ = response to capacity (see equation 9)

The first term is the number who come while the second term adjusts for
those who left due to intolerable delay. The number of first visit at
a post partum agency is defined as immediate post partum plus six week visits.

$$(67)\quad \mathrm{TNFVIS}_{t,\bar{a}} = \sum_{m=1}^{NM}\sum_{s=2}^{NS}\mathrm{ACCPIP}_{t,m,\bar{a},s} + (\sum_{m=1}^{NM}\mathrm{ISXCOM}_{t,m,\bar{a}} + \sum_{s=2}^{NS}\mathrm{COMSIX}_{t,\bar{a},s})$$

$$\times\ \overline{\mathrm{RCAP}}_{\bar{a}}\ (\mathrm{UCAP}_{t,a}\ /\ \mathrm{TCAP}_{t,\bar{a},s})$$

$\mathrm{ACCPIP}_{t,m,\bar{a},s}$ = number of people who accept immediately post partum
(see equation 24)

$\mathrm{ISXCOM}_{t,m,\bar{a}}$ = number of people who accepted immediately and in six weeks
come to post partum check up (see equation 25A)

$\mathrm{COMSIX}_{t,\bar{a},s}$ = number of people who come to six week appointments of
those who did not accept immediately (see equation 30)

The number of repeat visits (TNRVIS) in month t of people accepting method
m at agency a is simply:

$$(68)\quad \mathrm{TNRVIS}_{t,m,a} = \sum_{d=1}^{ND}\mathrm{CONCOM}_{t,m,a,d}\ \overline{\mathrm{RCAP}}_a\ (\mathrm{UCAP}_{t,a}\ /\ \mathrm{TCAP}_{t,a})$$

$\mathrm{CONCOM}_{t,m,a,d}$ = number of continuing acceptors who come to their
next appointment (see equation 17)

For post partum agencies, the sum is over d=3 to ND after adding $\mathrm{NSCOMR}_{t,m,\bar{a}}$:

$\mathrm{NSCOMR}_{t,m,\bar{a}}$ = number of people who first accepted at their six week
appointment who come to their revisit appointment
(see equations 32-33)

The utilized capacity is the sum of the first and second visits weighted by
the average number of minutes of clinic time or doctor's time utilized. Repeat

visits are divided into medical and non medical visits since they require
different amounts of clinic and doctor's time.

$$
(69) \quad UCAP_{t,a} = TNFVIS_{t,a} \; WTFV_a + \sum_{m=1}^{NM-1} TNRVIS_{t,m,a} \; FRACMD_{m,a} \; WTMRV_a
$$

$$
+ \sum_{m=1}^{NM-1} TNRVIS_{t,m,a} \; (1 - FRACMD_{m,a}) \; WTRRV_a
$$

$UCAP_{t,a}$ = <u>u</u>tilized <u>cap</u>acity in month t at agency a

$WTFV_a$ = resource <u>weigh</u>ting for <u>f</u>irst <u>vi</u>sit at agency a
(e.g., .45 hours of clinic time)

$WTMRV_a$ = resource <u>weigh</u>ting for <u>m</u>edical <u>re</u>peat <u>vi</u>sit at agency a

$FRACMD_{m,a}$ = <u>frac</u>tion of repeat visits that include a <u>med</u>ical checkup
for method m at agency a

$WTRRV_a$ = resource <u>weigh</u>ting for <u>r</u>egular (non - medical) <u>re</u>peat <u>vi</u>sit
at agency a

This measure of utilized capacity is included in acceptance equations during
the next period (e.g., $UCAP_{t,a}$ is used in t+1 as the capacity utilization
rate) to reduce the continuing acceptance of methods (m=1, NM-1). For
sterilization, the capacity available is used as a short run constraint and
if more requests are made for sterilization than can be accommodated, only
the maximum number implied by the capacity level are carried out. In abortion,
a capacity response function based on the number of abortions done last
month affects the acceptance rates (see equation 53). The capacity utilization
measures are important outputs for managers in their capacity planning
and budgeting.

<u>Cost</u>: Cost is modeled by establishing the following: (1) fixed costs for each
agency, (2) variable costs for each agency for each method at medical or non-
medical visits, (3) communication costs for outreach and advertising at each
agency, and (4) overall system fixed and communication costs. These can be

modified to produce changes in the model flows and the number of actives.
Advertising and outreach expenditures affect acceptance (see equations 4
and 11 to 15). Changes in fixed costs can modify capacity and affect
acceptance and continuance (see equation9). The strategic use of the
model will be discussed later, but these examples introduce the issue of
output from the model and the benefit which is obtained from additional
expenditure.

Benefit Measures: The most commonly used measures of family planning systems
performance are the number of total actives or the percent of the tar-
get group who are active and the number of new patients per period. The
model output includes these measures, as well as, the number of births (see
equation 62), the number of pregnancies (see equation 41), the capacity
utilized (see equation 69), the costs, and a detailed analysis of the source
of new patients (see equation 9 for new outreach patients, see equation 15
for new patients through requests, and see equations 24,26,31, and 33 for new
post partum patients). In addition, the actives are known by the number of
times they have accepted (see equation 20 and 39). When the number of
times accepted is multiplied with monthly appointment interval, the time
in the system for each group of actives is known. This allows an output
profile of the percent of people continuously in the system for X months
(e.g., X= 3,6,9,12,...36 months). Other outputs such as the number of
abortions and mortalities and morbidities due to legal and illegal abortion
may be displayed (see equations 54, 55, 57, 58 and 60). Also recall
that actives (ACTIVES) are subscripted in the model by time, method and
agency, so that totals can be made on any dimension to allow comparisons
between agencies, methods, or agencies and methods.

Although these outputs are valuable, they do not allow a cost/benefit trade off. Three benefit measures are defined to allow direct tradeoffs of policy, budget, and allocation changes. The first is couple years of protection. If one hundred women were sterilized they would be completely protected in each year, so one hundred couple years of protection would be generated. For other methods, the degree of protection depends upon how effectively people use the method and the underlying clinical effectiveness. The number of couple years of protection is determined by summing the actives in each month weighted by their effectiveness of use and method effectiveness and divided by 12 to convert months to years:

$$(70) \quad CYP_{y,a} = \left[\sum_{m=1}^{NM-1} \sum_{T=t-12}^{t} \sum_{d=1}^{ND} ACTIVE_{T,m,a,d} \; (EFFUSE_{m,d}) \; (EFFMTH_m) \right.$$

$$\left. + \sum_{T=t-12}^{t} ACTIVE_{T,NM,a,1} \quad + \sum_{T=t-12}^{t} \sum_{mp=1}^{9} (AREQLA_{T,a,mp} - NMTLA_{T,a}) \; MPROA \right] / 12$$

$CYP_{y,a}$ = couple years of protection in year y at agency a

$EFFUSE_{m,d}$ = fraction of acceptions effectively use method (see equation 40)

$EFFMTH_m$ = effectiveness of method m (see equation 40)

$AREQLA_{T,a,mp}$ = number of accepted requests for legal abortion (see equation 53)

$NMTLA_{t,a}$ = number of mortalities in legal abortion (see equation 54)

MPROA = months of protection from abortion

The first term is the couple years of protection produced by actives of all methods except sterilization and abortion. The second term adds the protection from sterilization (method NM). Note all people sterilized

are under d=1 . Abortion protection is included by assuming the abortion will produce protection (MPROA) at least over some number of months such as the average duration of pregnancy at the time of the abortion.

The criteria of couple years of protection should allow strategic trade-offs between methods and agencies, but it is insufficient in considering loop (IUD) protection as specified in equation 70. In the model repeat acceptors are only those who return for continuing appointments. But many loop (IUD) users may not return for an appointment since they have no side effects and still retain the loop. While a missed pill appointment means the loss of protection, a missed loop (IUD) appointment need not imply this. To include this protection due to retention loops, the model is modified to produce a new pseudo class of actives which is defined as those loop users who missed their appointments and retained their loops. See figure Seven.The entrance to the pseudo loop users class is by retention of the loop after failing to keep a repeat appointment. The pseudo loop user class decays due to loop expul- sion, pregnancy due to a method failure, or by returning to the clinic for a check up. This flow is parameterized analogously to the other flows modeled earlier in this paper. The equations will not be included here due to space constraints and since they are straight forward flows. All previous model equations in which actives are defined are also modified for the new pseudo loop user class. The couple years of protection measure defined in equation 70 is updated for the retained loop effect by adding the number of pseudo loop users to the number of loop acceptors $(\text{ACCPT}_{t,m,a,d},,m=1,d=2)$.

Although the couple years of protection is a good benefit measure and would allow comparison between methods, agencies, and systems on the basis of couple years of protection per dollar, it does not capture the prevention of unwanted births. What is needed is a measure of the incremental number of unwanted births prevented. The incremental number of births prevented by
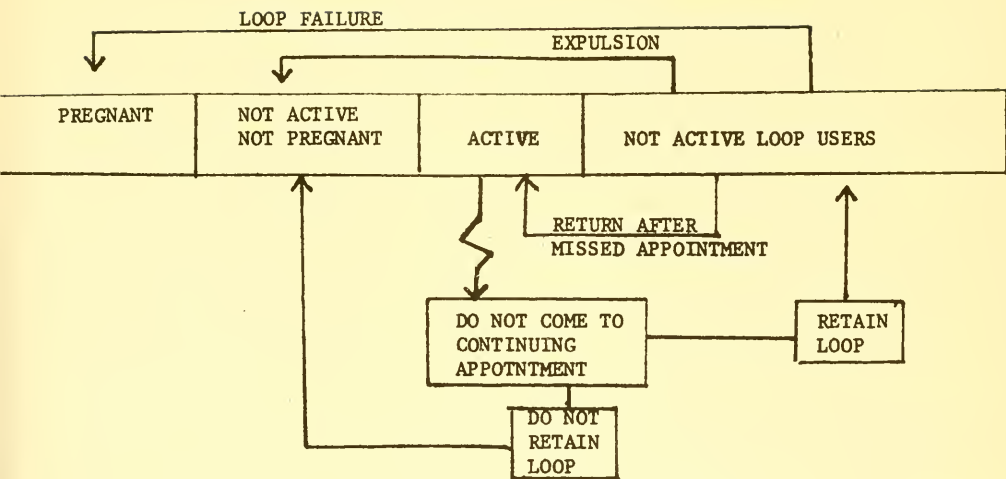
FIGURE SEVEN

FLOW FOR LOOPS RETAINED BY NON-ACTIVES

a year of protection depends upon: (1) the uncontracepted fertility of the
active group, (2) the effects of lower fertility during the amenorrhic
period immediately after birth, (3) the protection that would result
during the term of pregnancy, and (4) the practices people would have followed
to prevent or terminate pregnancy if the system did not exist.

The first two effects can be captured by a modification of couple
years of protection to produce what shall be called "births protected" (BP)
The number of births protected is the couple years of protection multiplied
by the uncontracepted ferility rate and adjusted for the amenorrhic period.

$$(71) \quad BP_{y,a} = \left[\sum_{m=1}^{NM-1} \sum_{T=t-12}^{t} \sum_{d=1}^{ND} ACTIVE_{T,m,a,d} \; ILF \quad (EFFUSE_{m,d})(EFFMTH_{m}) \; AFERA_{t} \right.$$

$$\left. + \sum_{T=t-12}^{t} ACTIVE_{T,NM,a,1} \; AFERA_{t} + \sum_{T=t-12}^{t} (\sum_{mp=1}^{a} AREQLA_{T,a,mp} - NMTLA_{T,a}) \; MPROA \; AFERA_{t} \right] \Big/ 1$$

$AFERA_{t}$ = average uncontracepted <u>fer</u>tility of <u>a</u>ctives at time t
(see equation 42B)

ILF $\begin{cases} = \text{index for lower fertility during post partum amenorrhic period for depth } d=1 \text{ and } a=\bar{a} \text{ and method m (see equation 40)} \\ = 1.0 \text{ otherwise} \end{cases}$

If it is assumed that all acceptors are in the family planning system
because they do not want any more children at a particular time, then
births protected is actually the number of unwanted births protected.

The final benefit measured is the incremental unwanted births prevented.
The number of births prevented should include the effects of protection
during pregnancy and consideration of what people would have done without

the system. This measure can be obtained by comparing two runs of the model. The first would be with the family planning system programs and flows as specified in equations 1 to 69. The second would be without any system programs (no acceptance or continuance), but with the appropriate parameters for private protection (equations 36 and 37) and abortion (equations 51 to 60). By subtracting the number of births in the first run from those in the second run, the incremental number of unwanted births prevented can be obtained.[12] When the cost for an incremental birth is calculated, realistic budgeting decisions can be made if the value of a birth prevented can be determined.[13]

The benefit measures defined here to consider unwanted birth preventions are powerful, but a difficult trade off still exists in abortion where policy must reflect mortality (equation 55 and 57), morbidity (equations 54 and 58), ethics, and birth protection (equation 71). The benefit measures defined here are not complete, but they do offer the manager a useful spectrum of system output evaluations so that the model can be used as a tool for strategic planning. Before considering use of the model in planning, attention will be directed at the problem estimating the models parameters.

MODEL INPUT

In building a large macro process model, care should be taken to structure the model to allow parameters to be data based. This empirical estimation will probably not be totally sufficient due to biases and statistical problems in the data, so managerial judgment is also necessary. The flow model described in the previous sections is designed to correspond well to the manager's basic perception of his family planning system, so the judgmental input process can be facilitated. But care also has been taken to al-

low data based estimation of each parameter. The subjective and empirical data are combined by a "fitting and tracking" procedure. The model input discussion will be oriented towards the sources of data and their subsequent use as model input. See table One.

INPUT SOURCES

Service Statistics: Service statistics are made up of an initial and repeat visit form for each person's visits. The initial forms include demographics, the method selected and date of next appointment. The initial form is usually longer and contains medical data and a record of pregnancies and births. A service statistic system specifies a longitudinal description of each patient. This service statistic '' data normally is used for follow up of patients who missed appointments and the determination of patient loads, but it is the most important set of model input data. From a model point of view, a sample of longitudinal histories is sufficient so the availability of exhaustive data is an unexpected advantage. The exhaustive data allows estimation of parameters within detailed subgroups of the model flow group (e.g. post partum immediate acceptors versus 6 week first accep-tors) and target group segments.

The first parameters estimated from service statistic data are the visit intervals (A) for each method, agency, and first and subsequent visits. This is the basic periodicity of the model and is used to put events such as a visit and acceptances on a time scale. Next, continuance rates are estimated by examining a set of people who have accepted method m at agency a for the dth time. Empirically it is determined how many came back for their $d + 1^{th}$ appointment. Likewise, classification analysis can be used to find the fraction of women who accepted again (PACPT C) or switched to an-other method (e.g. PSWITCH). Since service statistic systems contain tens of

TABLE ONE: Input Sources

Data Source   Parameter Estimated

Service Statistics   PCOMC(17), PACPTC(20), PSWITCH(21),
                                           PACPTI(24), PICOMS(25), PACPIS(26), PACPTA(27),
                                           PSCOMS(28), PCOMNS(29), PACPTS(31), PSCOMN(32),
                                           PACTSR(33), IACPT(44) ILOSS(46), IACPTP(49),
                                           PACTIA(59), FACTIA(59), FACCPT(15,24,31),
                                           FACPTA(56), PACPTA(56)

Outreach Worker Records   PRFIND(4), PDESIR(5), PFFIND(7)

Non Post Partum Clinic Records   PCOMO(6), PCOMFU(7), PACTO(9) PACPTO(8),
                                           FACPTO(8), PREQ(11), PRCOM(14), PACPTR(15),
                                           PREF(16), PRCOM(16)

Post Partum Clinic Records   PISTER(22), PSEE(23), PACPTI(24), POKA(53),
                                           RACAP(53), PMBLA(54), PMTLA(55), PACPTA(56),
                                           FACPTA(56), PHMBIA(59)

Observational Clinic Study   RCAP(9,20,26,31,33), WTFV(69), WTMRV(69),
                                           WTRRV(69)

Survey of Discontinuers   PERNEG(19)

Survey of Method Failures   EFFUSE(40), EFFPV (37), PPVCON (36)
and Interview Post Partum

Survey of Target Group
   Contraception   PPVCON(36)
   Abortion   PDESA(51), PDAP(51), PREQLA(52), PFIA(56)
                                           PIAMP (61), PILAUS (60)

   Awareness to Advertising   RADV(12), ADFGET(13)
   Migration   PMIGI(1), PMIGIS(2)

Demographic Data
   Census   PMIGO(1), PMIGIN(1)
   Pregnancy   FERTIL(42,43), ILF(40,71)
   Abortion Studies   PMTILA(57), PMBILA(58), PHMBIA(59), PALTIA(59),
                                           FACTIA(59), PILAUS(60), PIAMP(61), MPROA(70)

Experiments   RADV(12), ADFGET(13)

thousands of histories, the detailed classification still leads to reasonable
sample sizes. The classification procedures allow, in addition, the estima-
tion of the initial acceptance rates and the method selection composition
(e.g.,PACPTI and FACCPT).

The greatest problem with estimation based on service statistics is
the end effect due to having at any given time a number of people due to
come to appointments (called "prospectives") or slightly late for an ap-
pointment (called"delinquents"). The question is what fraction of these
people will come? This is important since at any time a number of the re-
levant longitudinal histories may not be complete. For example,in examining
the data for last year we may find that 1000 people accepted pills for the
second time at a specific agency. But in looking for third acceptances we
find 600 accepted for a third time in the year, 100 did not return, 200
are not due yet for their third appointment, and 100 are less than one
month late for their third appointment. We could estimate the continuation
rate (1) based on those of the total who came to their appointment ($60\% = \frac{600}{1000}$),
(2) based on completed appointments only ($85\% = \frac{600}{700}$), (3) assuming prospec-
tives will come, but delinquents will not($80\% = \frac{600 + 200}{1000}$), (4) by empir-
ically estimating the probability that prospectives or delinquents will come
(e.g., $83\% = (600 + 200 (.9) + 100 (.5)/ 1000)$. This problem is greatest
when long appointment intervals are present and non-stationarity is suspec-
ted. An example is the use of loops that have a six month visit inter-
arrival time and in a system in which follow-up is improving. Only the last
year's data would be examined and probably fifty percent of the people would
be prospective or delinquent. The approach used for the model is to estimate
the continuance rates by several procedures in order to get a range of

possible values. Then the model is run for each value and the best value is the one which causes the model to best fit a past set of data on active patients.

Outreach Worker Records: Outreach workers usually maintain call records with the name of each person where a visit was attempted and the result of the visit (e.g., not eligible, pregnant, active or made an appointment). These basic records can be classified by recruitment or outreach calls and the fraction who are found (e.g., PRFIND and PFFIND) and who make appointments (PDESIR) can be determined.

To determine how many outreach appointments are kept, the non-post partum clinic register book can be examined by name to see if a particular person came (PCOMO, PCOMFU). If the clinic records also include a roster of requests for appointments and a designation of the source of knowledge (e.g., advertsing) about family planning, the requests rates for each state can be estimated (PREQ). Clinic records and service statistics can provide the information needed to estimate the flows due to referral (PREF, PRCOM).

Post partum records indicate the number of births and the number of visits and their results, so the immediate acceptance process can be follow- ed (PDSTER, PSEE, PACPTI). Likewise, clinical abortion records are needed to follow the legal abortion process (e.g.,POKA, PMBLA). After the first acceptance, the service statistics system contains the data needed to parameterize continuance.

Observational Clinic Study: In order to determine the resource utilization of first and second visits, a time analysis study of clinic operations is necessary. This type of study also is needed to estimate the fraction of people who will leave the clinic because of excessive delay (RCAP).

Survey Data: Several parameters can be estimated best by special inter-
views. For example, an attitude questionnaire administered to people who
have discontinued can estimate the fraction with negative views (PERNEG).   Surveying
the women who had method failures and post partum women to determine what
contraception they were using and how it was used could help estimate what
fraction of women were properly using their methods (EFFUSE and EFFPV).
Surveys of the target group can lead to data on private contraception
(PPVCON), advertising, and migration. The most difficult inputs relate to
abortion, but a properly executed behavioral research instrument might help
supply information on abortion practices.

Demographic Studies: Secondary data related to demographics are useful in
estimating migration from census data, pregnancy rates, and abortion. The
fertility rates in the model can not be obtained from birth records since
an explicit intervening structure of abortion exisits. What is needed is
the rate of pregnancy measured at four weeks. For example, work by Tietze[14]
and James[15] helps to estimate these rates. The live birth fraction (PLB,
equation 62) can also be estimated from demographic studies.[16] After the
initial estimates of the flow of parameters on fertility and abortion are
made, the parameters are adjusted until the model predicted live births (see
equation 62) fit the observed live birth rate.

Experiments: The final empirical data source is experimentation. This is
most important if advertising is to be considered since then a response
function (RADV) is needed. A changeover experimental design and data on
awareness and requests for appointments can estimate the request rate,
awareness response, and forgetting associated with advertising.

FITTING AND TRACKING

When all these data sources are exhausted, an initial estimate of each parameter is obtained. This can then be checked against managerial subjective estimates of the parameters. This checking of subjective and empirical estimates helps managers learn about their systems, identifies biases in the data, and provides a basis of defining "best" estimates. These best estimates are inserted in the model and the model output is compared to a historical set of data on total active patients, new patients, births, and actives by method and agency. If the model does not fit as well as desired, parameters are adjusted until a best fit is obtained. This is a non-linear estimatio procedure that forces a best fit to the historical data and it is called "fitting".

"Tracking" is then used to test the estimates and identify dynamics in the system. The best fitting parameters are used to make a conditional prediction of system performance. As the new data is obtained, the predicted and actual values are compared. If they differ, an attempt to find out why is made. This problem finding is an important managerial act. For example if the number of actives are lower than expected, is it because acceptance rates fell, continuance rates decreased, or initial parameter estimates were wrong? If after an attempt to find the problem, no reasons for system non-stationarity are discovered, parameters are updated to best fit the new data and new predictions are made. If a problem is found (e.g., the number of outreach calls below expected) the input is adjusted and the model re-fitted to the data. This adaptive procedure continues along with changes in strategy and planning.

In addition to the straight forward estimation and adaptive procedure, another method of resolving the input issues is to aggregate the model. For example, aggregation could occur by ignoring all non-active state distinctions. If advertising were not considered, this would remove the need for experimentation and awareness surveys. Abortion and demographic cohort

fertility effects could be ignored so that only the direct hospital birth

rate would be needed. These aggregations reduce the input burden and simplify

the model. The underlying philosophy of the model is evolutionary. It

is visualized that application of the model would begin at a very simple

level where data was available, then the model would be elaborated as

managers desired more detail and input data became available. This

evolutionary implementation of the model will be discussed after the uses

of the model in planning are discussed.

USE OF THE MODEL IN STRATEGIC PLANNING AND CONTROL

Anthony has defined strategic planning as:

> "the process of deciding on objectives of the organization,
> on changes in these objectives, on the resources used to attain
> these objectives, and on the policies that are to govern the
> acquisition, use, and disposition of these resources."[17]

The use of the model to carry out each of these component functions

will now be discussed. The first use of the model in planning is to aid in setting

goals for the family planning system and its component agencies. The pre-

dictive capability of the model helps assure that goals will be established

that are reasonable. If the model prediction is for a growth rate of three

percent per year in actives, it may be reasonable to set a goal of ten per-

cent per year. If a goal of twenty-five percent was set, it might become

obvious that it is an impossible achievement and loose its relevance as a

motivator. If the model predicts growth at twenty-five percent growth

rate, a goal of less than twenty-five percent would not have the affect

of pushing performance to its best level.

The use of the model to produce reasonable system goals is supple-
mented by the models use by agencies to set their goals. If the agency in-
puts its flow parameters, obtains its prediction, and then commits to a set
of goals, the over-all system goal can be the sum of agency goals adjusted
by the model for inter-agency interdependencies. The interaction between
system and agency simulations can lead to shared goals that are meaningful
in motivating system growth.

In addition to goals reflecting over-all growth of actives, more macro
goals of couple years of protection per dollar or births prevented per
dollar can be set. These goals will add the factor of efficiency to the
planning. More micro goals could also be set. For example, continuance
(e.g., PCOMC, equation 7) and acceptance rates (e.g., PACPTC, equation 20)
could be set that reflect a high quality level for service. Finally, goals
could differ by segments of the target group. For example, the goal for
cost of a birth prevented in a high medical risk segment may be higher than in
a low medical risk segment. This would reflect the differential commitment
to prevent births in segments where infant and mother mortality are likely
to occur.

The goal setting process is an exercise of managerial perogatives,
but the model allows the goals to be compared to realistic predictions,
encourages shared goals between agencies and the system, and helps to produce
reasonable goals that motivate system growth, quality, and efficiency.

A given set of goals are achieved within a set of policies.   In
the model, policy issues such as: (1) Should we allow abortion? (2) Should
sterilization be available? (3) Should advertising be utilized? (4) Should
outreach be used? or (5) Should a referal system be instituted? Can be en-
tertained. The effects on the goal related outputs can be obtained and the

trade off in setting a policy can be obtained. For example, with a set of response estimates for outreach, the growth rate and cost per year of protection that results from hiring an outreach group of ten women can be determined. The issue of abortion would require many non-model considerations, but the model would predict the effects of legalized abortion on mortality, morbidity, and the acceptance of family planning (see equations 51 to 60). The model is useful in setting policy since it allows the effects of policy on goal achievement to be considered and since it helps managers to understand the nature of their systems better.

To achieve the system goals within the policy guide lines, programs budgets, and allocations have to be established. If the input when processed through the model fit and tracked real performance, reasonable confidence can exist for predictions implied by alternate programs and allocation. For example, outreach changes reflected in the number of outreach workers (NCALL, equation 4) can be directly assessed. The allocation between recruitment (NCALL, equation 4) and follow-up (NFCALL, equation 7) can be examined. Advertising expenditures effect on actives and cost per birth prevented can be determined (RADV equation 12 and 13). Capacity issues can be raised since capacity affects acceptance (RCAP, equation 9). In addition, the direct model output of utilized capacity (UCAP, equation 69) leads managers to take steps to assure adequate supply. The sensitivity to basic process inputs can suggest strategies. For example, if continuance rates are low, but the model shows significantly better achievement with reasonable improvement in the rates, buses to bring patients to the clinics or baby sitting services could be considered. Another example is the use of visual aids to improve the immediate post partum acceptance rate (PACPTI,

equation 24). If a sensitive flow point is found strategies to change the parameter can be considered.

Allocation between agencies and between segments can be simulated by changing variables or flow parameters. The number of strategic planning alternatives is large and the model is structured so that nearly every included flow parameter could be influenced by program changes or budget allocations. One final example will suffice. If a new method was introduced (e.g., prostaglandins) the effects in terms of active load, births, and cost per birth percent could be obtained if the basic acceptance (e.g., FACCPT, equations 15,24,31) and continuance parameters could be specified.

Although the model addresses itself towards strategic planning, it does have some implications for managerial control.[18] After strategies have been determined, steps must be taken to assure that the detailed implementation of them succeed. For example, a decision to use outreach would be implemented by allocating effort between recruitment and follow-up and between segments, and setting detailed goals in terms of number of calls (NCALL, equation 4), success in finding (PRFIND, equation 4), quality of presentation (PDESIR, equation 5) , and the fraction coming for appointments (PCOMO, equation 6). If after a reasonable period of time, the number of new patients from outreach was low, the process goals would be used to help find the problem. For example, if all parameters were on target except PCOMO, this would indicate a lack of effort by outreach workers to facilitate the patients coming to the appointment.

All model flow parameters can be used in such a control or problem finding sense. It is also useful to compare agencies on the basis of re-sulting flow parameters, total actives, and cost per year of protection. It

may be clear that some agencies are becoming inefficient and this comparison could triger action to improve the performance at that agency.

The model facilitates control, but it is not a detailed control model. It does not address itself to issues such as patient scheduling and control of clinical procedures. Although long waiting times will affect the acceptance rates during the problem finding steps, the model is a medium term planning tool rather than a short term control aid.

It is hoped that the model can be understood by the manager and after he has customized it to his specifications, it can be a tool for him in setting goals, establishing policy, specifying budgets and allocation, and in finding problems.

EVOLUTIONARY IMPLEMENTATION OF MODEL

Previous sections of this paper have discussed the model structure and how, when parameterized by patient, outreach, clinic, survey, and demographic data, it could be useful in forecasting and decision making. But the model that has been described does not seem to meet some of the decision calculus criteria that a model should be understandable, evolutionary, easy to use, and easy to control. The purpose of this section is to show how the model can be used in an evolutionary manner to promote understanding, how an on-line conversational computerization of the model can make it easy to use, and how customization of the model for the manager can give him a feeling of control.

MODEL SPECIFICATION SECTION

The basic approach to evolution is through a series of one-line questions which specify the nature of the model to be considered. First the agencies are listed and then the type of program (post partum or non-post partum, or both) they offer is defined. Next the contraceptive methods

available in the system are indicated and it is noted if they are available
at all agencies. The options to be included in this version of the model
are then selected. See table two. Next, the state specification for non-actives
is begun with an initial definition of two stages: pregnant and all other non-actives
The manager can select to divide this further into never and ever in the system, or
ever can be further divided into ever with negative experience and ever but
not negative. The state specification described in the model structure section
of this paper (p. 10) can be obtained by fully dividing the non-actives and
indicating the desire for consideration of indirect outreach and advertising.
The final model specification is the segmentation of the target group. The
specification section is used to set up the model structure and generate the
conversational input questions that are required.

The specification section can be used to build a very simple mod I model.
For example, if two agencies (one post-partum and one non-post partum),
two methods (pill and loop), no options, two non-active states (pregnant
and all other non-active), and no segments are specified, the on-line
input conversation will be very short. Only the basic acceptance,
continuance, and birth rates are needed. See Appendix One for a Mod I
input dialogue. The input demands are small and the flow structure simple.
This type of model is a good first starting point for a manager.

The manager can then evolve his model. If he has more input data or
is willing to make subjective estimates, he could add options such as out-
reach, referal, or capacity. As each option is added, he can make his own
judgment about the time and cost trade offs of further elaboration. But he
certainly is in control and is building "his" model. In response to his
specifications only the necessary questions are asked and they are asked
in a convenient form.

Do you wish to consider:

A) abortion?

B) outreach?

C) cost-effectiveness?

D) agency capacity?

E) referral?

F) method switching?

G) migration?

H) non-active IUD continuance?

I) private protection?

J) demographics?

K) advertising?

TABLE TWO:

MODEL SPECIFCATION OPTIONS

Probably no user will specify all options, but each user may want depth in a different issue. For example, staff analysists may want to use the demographic option while an agency manager may be more interested in the effects of referal. The computer implementation of the model structure produces an evolutionary model building system for family planning managers.

COMPUTER IMPLEMENTATION

The answers from the specification section are used to set subscripts and flags in the computer code. For example, if only two states for not-active/not-pregnant people are defined, the state flow is automatically modified to aggregate into never and ever only. The agency subscripts are set up in response to the number and type of agencies specified. Flags are set to control execution of post partum or non-post partum code. Method subscripts are defined as specified with sterilization always being the last method if it is to be considered. If options are selected, flags are set to execute the required code.

The specification section answers also control the sequence and content of the questions flow. This is implemented through an interactive language which is part of a model building software system called "EXPRESS."[19] The questions are in a separate file rather than being a set of format statements in the code. With the interactive language, questions can be changed without re-compiling the model code and the ordering sequence can be changed easily.

The EXPRESS system also allows subscripts to be added to coded variables in response to on-line questions. For example, if more than one segment is specified, the segment subscript (g) will be added to all input variables. EXPRESS can do this since it has its own "dictionary" of variables and

"map" to define their subscripts. By updating the map, a new subscript can be added easily. The model code itself does not specify subscripts, but only contains the variable name. The EXPRESS system functions as a compiler in this sense. The advantage of such a feature is that the storage need not be allocated for the segment subscript until required and then only the necessary number of segments are dimensioned. This is in contrast to the usual procedure of fixing subscripts and dimensioning some maximum allowable number.

The model is run by a series of English language commands. "SPECIFI-CATION" asks the model specification question. "QUESTIONS" asks the input questions based on the options selected in specification section. "REPORT" prints out all the input for inspection along with the original question. "CHANGE" allows any question to be re-entered and its answer changed to correct an error or enter a new input value. "FILE" causes the input to be saved on a disk so it can be reinstated for later runs by the "USE" command. "GO" causes the model code to be executed. "RESULTS" begins the output sequence. With these commands the manager can easily enter data, inspect the input, make runs, change data, execute new runs, and see the output.

RESULTS SPECIFICATION

When the "RESULTS" command is used, a series of questions are asked to specify the desired output. Since the number of dimensions is large (e.g., five in the number of actives: $ACTIVES_{t,m,a,d,g}$) and the combinations of these dimensions for aggregation is much larger, the user specifies what aggregations he wants. If he does not want to specify the output, he can select the standard output. See Appendix Two for the standard report on patient loads. If he wants a special output he can select a previously entered format or enter a new one. The availability of special

output reports is important in encouraging agency use since it allows each agency to get the output it wants in the desired form. The special output is specified by designating the type of output (active, pregnancies, births, new patient capacity, or cost effectiveness) and then after the possible subscripts are displayed, indicating which ones will be considered separately in the output. After a report format is defined, it is stored for future use by that **par**ticular manager.

EXPERT MODE

The specification, command, and results structure described in the previous section is designed to be easy to use by managers and to promote a feeling of control over the model. In designing this ease of use, some of the power available in EXPRESS could not be utilized. Specifically it is assumed in the input that managers do not like to deal with subscripts,so all questions required only item answers. This makes a straight forward, but sometimes tedious input session. For example, if more than one segment is specified, the complete flow sequence of questions is asked again. A more complex but more efficient input, run, and output mode exists. This is called "expert mode", as opposed to the "managerial mode" indicated earlier. In expert mode a variable name is typed, its subscripts specified, and data entered for each subscript or over a range of subscripts. This allows a more technically trained user to interact efficiently.

The most powerful feature of expert mode is the ability to on-line add or drop subscripts. The model structure (equations 1 to 60) contains inputs specified on one particular dimensionality. Expert mode can change this. For example, perhaps the migration rate is changing over time so that

the percent who migrate out in a month from a segment ($PMIGO_g$ in equation 2) should be subscripted by time ($PMIGO_{g,t}$). Further, perhaps migration varies by the state of non-actives. For example, pregnant women might migrate at a lower rate, so if this is to be considered, $PMIGO$ would be subscripted by segment (g), time (t),and state (s). In some cases subscripts may be dropped. For example, if outreach records do not include the state of the non-actives (e.g., never-ever in systems), the state subscript on the percent who will make an appointment ($PDESIR_{a,s}$ in equation 5) could be dropped. Although the model structure is reasonable in its subscripting, it is fore-seeable that conditions might exist that could require consideration of new subscripts for almost any input. As a final example, it might be that the composition of method allocation is trending towards pills, so that the faction accepting each method (e.g, FACCPT in equations 15,24, and 37) would require a time subscript. The expert mode of EXPRESS allows the on-line change of subscripting. When a change is made, only the new data needs to be entered. The disk file of other data can still be used. This is important since if the re-ordering of storage by adding a subscript required entering all input again,as is usual under most on-line models, the time required would be prohibitive.

Expert mode also enables the more technically trained user to increase the power of the model by refining the initialization. All the lagged model variables (e.g., ACCPT, equation 39) must be initialized before each run. The initialization is done by defining the number of people in lagged periods based on the percent of actives of a method who have made "d" visits. For example, the number of initial actives are spread over the lagged periods of the visit interval equally. In expert mode, this lagged variable

could be accessed directly and the specific lagged values entered. This is the more accurate approach, but it was not used in managerial mode since it would decrease the ease of use of the model. It should be noted however, that in manager mode the lagged values are properly saved when tracking is done and the starting point is moved ahead in time (e.g.,first run t=1, 6, second run t=7, 12 and third run t=13, 48). The expert mode does have the capability bility of better initialization when the starting month is one.

The final capability available at expert mode relates to output. In expert mode any variable can be examined by typing its name and subscripts with the command "PRINT".Tables of output can be generated by the command "TABLE" and graphs by the command "PLOT". The capability to look at internal variables without adding special format and print statements in the code is extremely valuable since it allows for efficient debugging and the capability to understand the process flow in depth. This output capability allows the expert mode user to look at monthly or quarterly aggregations while in manager mode only quarterly data is available as output.

Expert mode is more difficult to use, but is more powerful than managerial mode. It allows the further customization of the model by adding and dropping subscripts and it adds flexibility and efficiency to model input.

In practice, agency heads and administrators will use manager mode, but staff personnel in the family planning system will probably use expert mode. The on-line implementation through these two modes allows for a smooth evolution and customization of the model to assure that a manager gets "his" flow model just as he wants it in terms of input, structure, and output reports. By the use of such a flexible on-line system and the flow model structure, the decision calculus criteria that a model should be

(1) understandable, (2) complete, (3) evolutionary, (4) easy to use, (5)
easy to control, (6) robust and (7) adaptive, are met in a model that en-
courages better understanding, forecasting, and decision making.

APPLICATION AND TESTING OF MODEL

The model described in this paper has been applied, developed, and
tested in co-operation with the Atlanta Area Family Planning System.

ATLANTA BACKGROUND

Atlanta has three basic service granting agencies: (1) Grady
Charity Hospital, (2) Planned Parenthood and World Population and (3)
the Fulton and Dekalb County Health Departments. A group called the Atlanta
Area Family Planning Council (AAFPC) acts to help in co-ordinating and
planning. The council has a full time director and three staff members.
It was formed in 1969 with funding from an OEO grant of $750,000.

Due to the fortuitous fact that the Center for Disease Control (CDC) of
HEW has its national headquarters in Atlanta and the interest of some mem-
bers of its staff,a service statistics system was instituted in Atlanta in
1968. The data was carefully obtained and processed by CDC so the model
testing could be effectively carried out.

The Atlanta system in 1970 had 15,000 actives from the metropolitan
target group of 33,000 people. Another 10,000 target group people live in
the outlying counties of Gwinnett, Cobb, Clayton, and Douglas. The system had
grown from 10,000 actives in 1968 and 25,000 people had been in the system
at one time during the 1968-1970 period.

The model application took place at two levels. At the service grant-
ing level the model was used to develop plans and forecasts for agencies
and at the AAFPC level the model was used to develop integrated plans and
budgets for the system.

MODEL EVOLUTION

The first model considered was a simple mod I flow model.[20] It did
not contain any of the options except recruitment by outreach, but
it was an understandable structure and allowed managers to begin to use a
model. It was not long before the inadequacies of the mod I model were found
and in response to managerial requests, capacity, cost effectiveness (couple
years of protection per dollar), sterilization, referral, and migration
were added in an evolutionary manner over six months. The detail of the model
also increased when it was realized that the Grady Hospital had both a
post partum and non-post partum program. Grady was modeled by two pro-
gram flows. The mod I model had only one state for not-active/not-pregnant
women. Mod I use led to elaboration of a "never" in the system and "ever"
in the system state definition. Evolution is continuing to include advertis-
ing, abortion, follow-up outreach, indirect outreach, private protection,
and demographics. The rate of evolution is less restricted by the model than
the availability of data and the managers rate of internalization and de-
sire for comprehensiveness. As the evolution proceeds, different levels of
models will exisit for different users. In Atlanta the mod I model is used
by first time users and some agency administrators, while the more elaborate
model is used by the AAFPC staff and some of the more analytical agency man-
agers. Even before the first use of mod I, a special set of training programs
were developed to help people understand models and on-line computers. This
"training aid" began with a discussion of the concept of models illustrated
by the human respiratory systems. Then it considered a simple on-line
savings account model which merely compounded interest and allowed depos-
its and withdrawals. The exercise ended with on-line use of the outreach
portion of the family planning model. This training aid was administered
to 25 people in the Atlanta system and produced positive attitude changes.[21]

MODEL INPUT AND "FITTING":

The basic source of input was the Center for Disease Control and
its service statistic system. Programs were written to estimate the
acceptance and continuance rates (see table two) and ranges of estimates
were determined to accomodate the end effects of prospective and delinquent
patients (see the service statistics input discussion to review this
problem).[22] Outreach data was collected on a sample basis and manual
tabulations were made to find the response rates (e.g., percent who make
an appointment PDESIR, equation 5). Contraceptive method failure rates
were based on a private study by Christopher Tietze of 2000 post partum
patients from 1968-1969. Since the current state of evolution at the applied
level did not include abortion, advertising, or demographics, many of the
more difficult input problems cited in the section on input did
not exist. A full input for the Atlanta model is given in Appendix Three.
The trade-off between input demands and additional detail is difficult.
For example, if demographics are not included (equations 42-50) the model
uses a surrogate birth rate of the monthly observed birth rate divided by
the non-active/not-pregnant population. The approach in Atlanta has been to add
detail as reasonable data sources can be cultivated. For example, the
outreach data is now being systematized. This will allow better data bas-
ing of the recruitment parameters and enable follow up outreach to be explicitly
modeled.

Initial data estimates were made based on the service statis-
tics data of June 1969 to June 1970. After these flow parameter estimates were
put in the model. changes were made so that the model output of active
and new patients fit the actual June 1969 to June 1970 figures. Most of
the changes were in the continuance rates. Within the tolerance of ±5 per-

cent produced by alternate end point data analysis assumptions (see input discussion) the model was very sensitive, so the estimates were "tuned" to produce the best fits. The fits for the total number of actives and actives at the Planned Parenthood and Grady Clinic are shown in figures eight, nine, and ten. Fitting was also done to assure that the model replicated the real data for each method and for new patients at each agency.

"TRACKING" RESULTS

Although the model fits to past data encouragingly well, such fits from the non-linear estimation procedure are the result of considerable massaging of the data. The testing of the model was based upon comparing actual and predicted patient flows over a period of saved data and over a real six month period.

Saved Data June 1970 to December 1970 data were not used in the data estimation procedures and were saved for predictive testing. Conditional forecasts were made for the July 1970 to December 1970 period based on the June 1969 to June 1969 to June 1970 data estimation. These initial predictions are shown in figures eight, nine, and ten.

The predictions are lower than actual. This is particularly true at Planned Parenthood where the prediction is for stable performance and the total active curve increased sharply. The Grady Clinic prediction is also low. The question to be answered is: Is the lack of accuracy due to poor input, an inadequate model structure, or changes in the real system itself? Answering this question is an exercise in problem finding, or in this case, finding the reasons for unexpected success. A detailed analysis of the July 1970 to December 1970 data showed that the number of requests (walk-in appointments) at Planned Parenthood increased from one hundred a month to about two hundred and fifty per month during this time. The initial tracking prediction was

FIGURE EIGHT: Fitting and Tracking for Total Actives in Atlanta
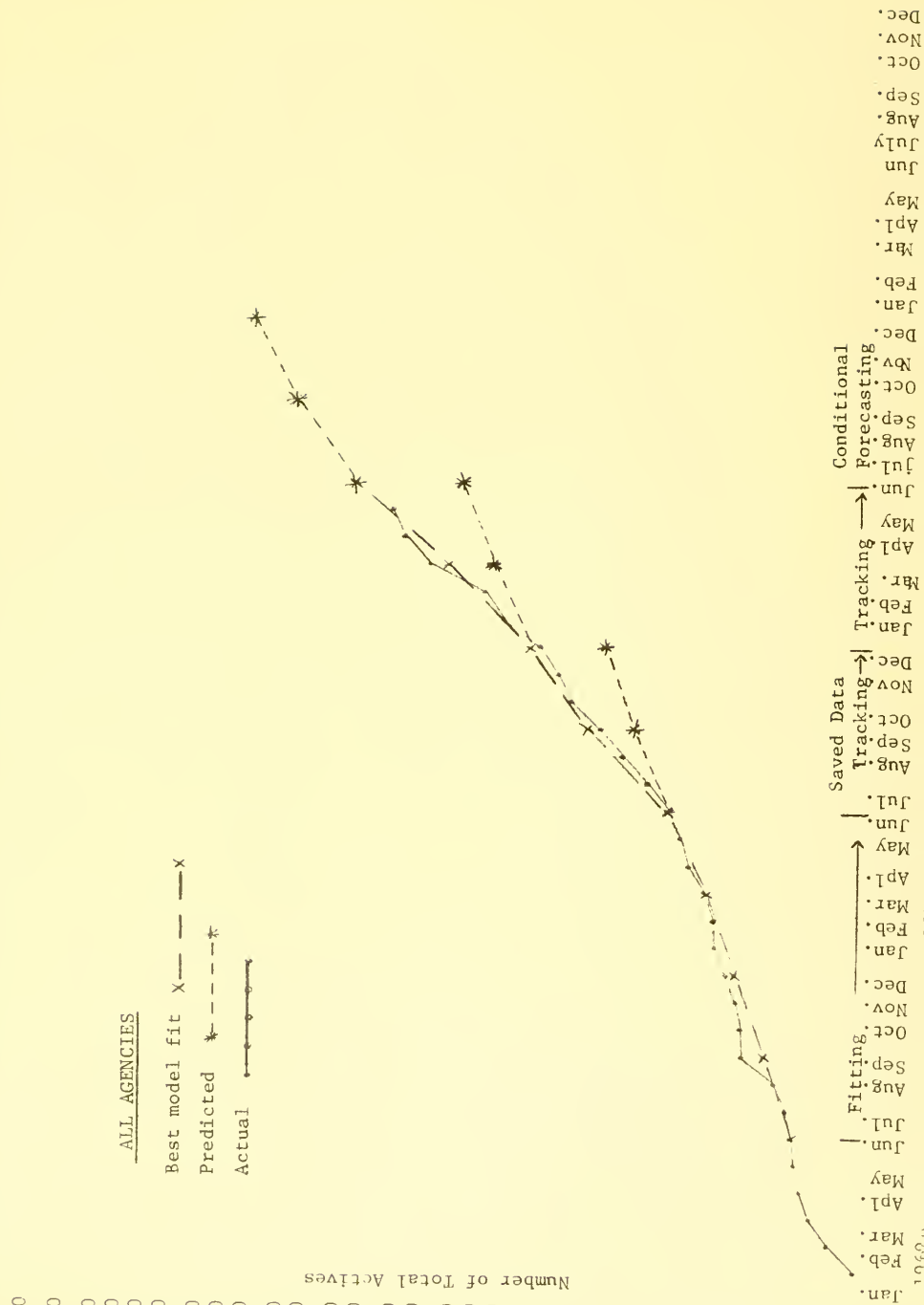
PLANNED PARENTHOOD

Actual ·—·—·—·

Best model fit ×——×
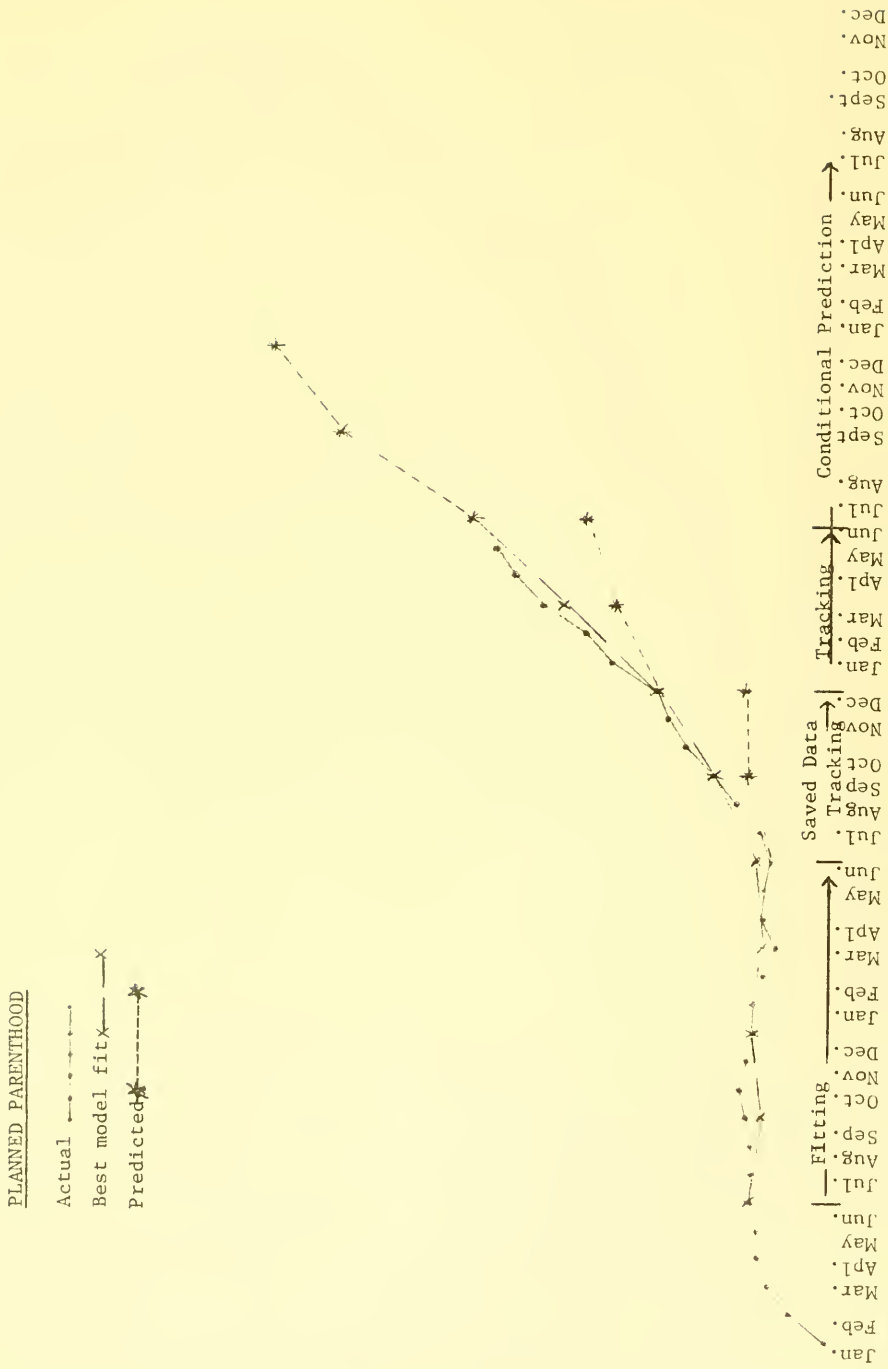
Predicted ⋆ - - - - ⋆

GRADY CLINIC

Actual ●——●——●

Best model fit ×——×

Predicted ✳——✳
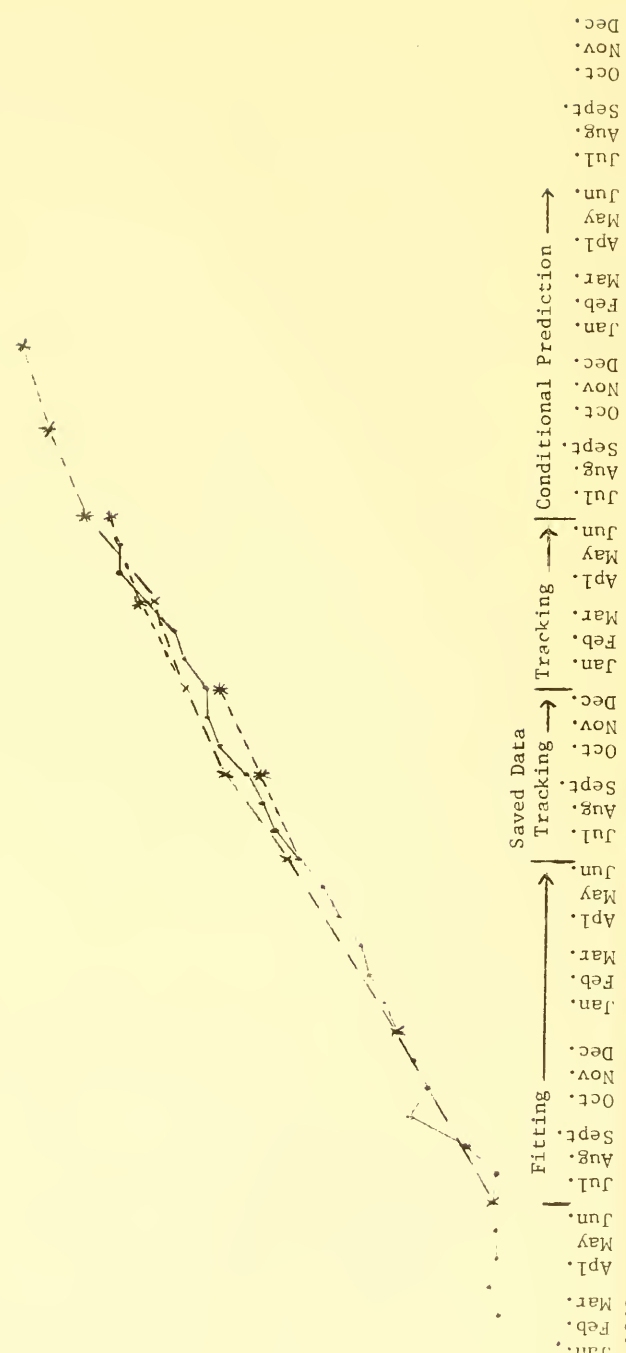
based on the past average of one hundred per month. Revising the input to reflect the actual new patient inflow produced a curve that tracked very well.   This implies that the other input were probably good and that the structure of the model is reasonably sound. The rapid increase of new pa- tients calls for diagnosis. Why did the number increase when outreach re- cords showed an increase in calls, but very few additional appointments being made with outreach workers? The hypothesis being investigated was that there was an indirect outreach effect (see equation 11). Data was collected about new patient clinic arrivals to see if outreach calls correlate with voluntary requests for appointments.   This is an example of how the model can be used adaptively to produce gains in understanding, improvement in data collection, and improved forecasting.

The lack of correspondence between actual and predicted at Grady was found to be due to a new clinic being opened to serve the hippie community and the subsequent increase of about fifty new patients per month.   After these adjustments for new patients at Planned Parenthood and Grady, the active tracking appeared good (see figure eight, nine, and ten) Grady tracking as of December 1970 was higher than actual, but this was accepted since Grady actives did not increase in December, and a reporting error was suspected.   Tracking was also carried out at the specific method level.   This tracking and a new analysis of the July 1970 to December 1970 data indicated a shift in the composition of method selection towards the pill.

Tracking 1971: The tracking over the saved data period (July 1970 to December 1970) was encouraging, but additional tracking over the period January 1971 to June 1971 allowed for additional retirements to the model input and structure.   The conditional predictions made in December 1970 are shown

in figures eight, nine, and ten. Again the predictions were low. The Planned Parenthood Agency increased its new patient rate to 450 a month or 200 more than predicted. It was found that Grady refered 50 percent more people per month to the county clinics than expected. This rate had also accounted for some of the over tracking from June 1970 to December 1970. New non-post partum clinic growth added 50 more new patients per month. Finally county health department outreach was more effective than anticipated. The volatility of the system reflected in these changes emphasize the need for tracking and an effective adaptive planning model. With the input updates the model tracked well, but again the question of why the new patient rate increased was asked. Data indicated the indirect outreach effects to be real. Four times as many people contacted by outreach workers came without an appointment than came with an appointment. There was also a supposition that some of the new patient growth was coming from outside the target group. This suggested the need for segmenting the target group in the model as soon as continuation data could be established for the new segment. Until such data became available the overall target group was increased by 10,000 people to reflect this new segment.

The fitting and tracking has increased the confidence that the model and input procedures were satisfactory. This adaptive testing has also led to new insights into the system performance and identified needs for further evolution in terms of modeling the non-post partum new patient phenomena.

MANAGERIAL USE OF THE MODEL

The model is being used on a self-sufficient basis by the Assisant
23
Director of Planning at the AAFPC. He is using it to develop an overall system plan and as a tool to aid agencies in their planning. Special planning sessions are being conducted with many agencies so that these managers

can better understand their patient response, improve forecasts, and develop goals and plans. Although formal measurement of this impact is difficult, the managers using the model have reacted positively and are beginning to use the model as a tool in their planning and control. For example, one agency used the model to determine the effects of outreach workers and were able to predict the number of new patients and the change in the cost per year of protection that would result from undertaking an outreach program. In another agency the outreach data and model runs indicated weakness in the success of outreach workers in making appointments. The process of education and usage is not yet complete at all agencies but agency level use is showing potential.

The model usage process has produced some new insights. Particuarly, the fitting and tracking exercise has been valuable since it requires a detailed analysis of why predictions are not as good as desired. The indirect outreach effect was a new insight that resulted from the model use. In tracking birth flows, it was found that twenty-five percent of the deliveries from the target group were not done at the Grady Hospital. Originally managers had believed that virtually all target group deliveries were done at Grady. This implies the need for additional post partum program planning. The analytic approach fostered by the model led to this new important insight into the system behavior.

After fitting the model for the period of January 1971 to June 1971, a conditional forecaset was made for the period July 1971 to December 1971. This is the basis for the next tracking period, but also was needed for the budget request for 1972. Due to the planning system the 1972 budget was required in September 1971. The model proved valuable to managers in generating the forecast for the remainder of 1971 so past funds could be

"accounted" for. It should also be mentioned that the environment
surrounding the 1972 budgeting was frantic due to proposal dead lines.
The on-line features of the model allowed rapid simulation and predictions
so that an effective proposal could be formulated on time. The forecast
for the proposal was for the year 1972 and is shown in figure eleven. The
first forecast was based upon a budget sufficient to meet capacity requirements.
The forecast showed 22,250 actives by December 1972 and for a cost per
year of protection of $65.64 over three years. However, the funding agency
in Washington had requested that last year's budget amount be held for 1972.
In order to show the effects of this constrained budget, the model was
re-run with the arrival rates decreased until existing capacity could
serve the active groups. This budget constrained run indicated 20 percent
fewer actives, 250 women per month being refused service and an increase
of 5 percent in the cost per couple year of protection. These forecasts were
included in the 1972 budget request and it may be the first time that an
explicit cost/benefit measure has been included in H.E.W. family planning
proposal. This may have the healthy effect of causing funding groups to
consider not just cost, but also benefits and efficiency.

In addition to an orderly forecasting procedure, various strategic
alternatives were considered. First, an outreach program to post partum
non-Grady patients was simulated. With an estimate of the number of calls
allocated to this new program and their effect (see equations 4 to 8) it
was found actives increased 1 percent over three years and the cost per year
of protection decreased slightly. The second strategy was to increase the
capacity to do sterilizations. Requests had been twice the capacity. This
strategy resulted in a small increase in actives in three years, but a
5 percent reduction in the birth rate. However, the cost per year of protection
increased since sterilizations were priced at $300 each and they did not
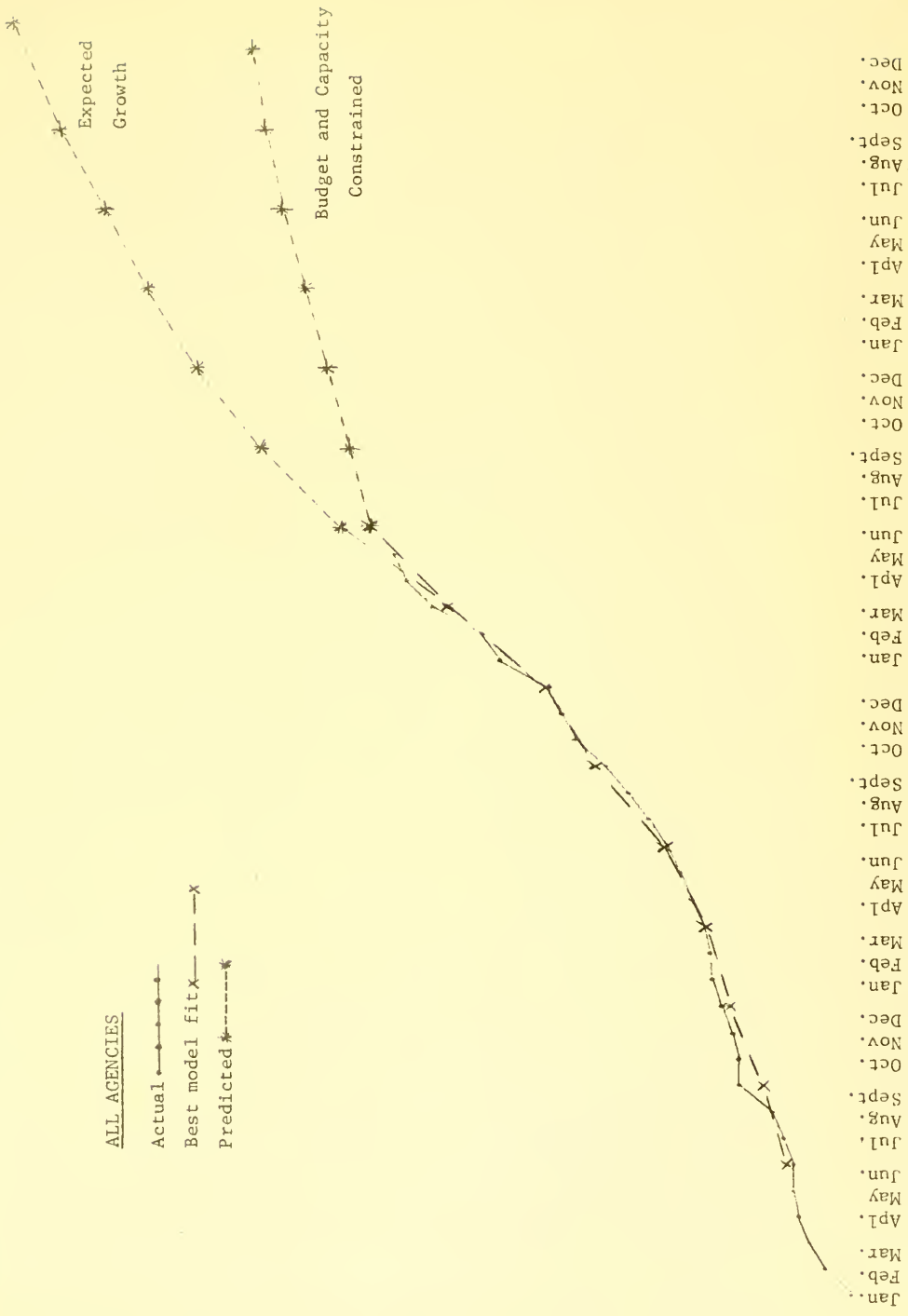
pay back in three years (recall overall $65 per year of protection.)
In fact, at this rate it would take five years to pay back. Steriliza tion
in the short run is not very attractive as a method with this cost. New technology
more efficient procedures, or negotiation could reduce the cost. Other
strategies were tried, but the gains due to the new strategies, although
significant, were small (less than 5 percent). It became clear to program
managers that the target group was being saturated. This insight has led
them to think of widening their program to include more of Georgia. The
improvements due to strategic analysis were important, but an equal
benefit of the analysis has been a better perception of the system and
how it works.

CONCLUDING REMARKS

The application and testing of the model indicate that it can
fit and track data satisfactorily and can aid managers in understanding,
forecasting, and decision making. But further evolution can take place.
More behavioral detail could be added by considering the interaction
between male and female contraceptive acceptance. As the model is now
structured, men can be viewed as a segment of the target group, but the
interaction between the male and female in family decision making is not
modeled. Behavioral depth could also be added by modeling agency switching
separately from referral. Likewise the phenomena of spacing of children
by actives could be modeled by separately following actives who become
pregnant because they have achieved their desired spacing. In the post
partum program these people could have a high acceptance rate. In the
current model structure, these people are reflected in the average
acceptance rates. The model could be extended by adding a special flow

to capture abortion prone people. In addition to behavioral phenomena, more detailed consideration of outreach could be undertaken by building priority calling policies. Now the model assumes a random call policy in each segment. It may be that within a segment, priorities could be established and outreach be carried out on a name basis. Finally, capacity feedback effects are now modeled as causing people who come to the clinic to leave without accepting. This could be extended to have capacity affect the rates of coming themselves by assuming there is a remembering of the long wait on the last visit that decreases the probability of continuing. These and many other extensions could be visualized. In fact, it is difficult to resist making an overly elaborate model. Additional detail should only be entertained if tracking indicates the need for it or managers request such extensions. Otherwise, the decision calculus criterion of understandability will not be achieved and decision impact will be lost.

The model proposed in this paper is an intermediate term planning model. Many other models such as ones for clinic location, inventory planning, work scheduling, or long term economic planning could be built. This collection of models can be called a "model bank" and care should be taken to insure that they function in a compatible manner. The planning model could specify overall capacity needs that can be converted into a specific number of clinics and locations by a detailed facilities model. The family planning model described here is a useful, but not sufficient model for the total management needs of a family planning system.

As well as interfacing this model with other models in family planning, the interaction between health services should be considered. Can

family planning systems successfully be added to comprehensive health ser-

vices? Should family planning extend to include maternal and child health

care services? These questions raise issues more macro than this planning

model can now entertain, but this interface will be explored in future

work.

A final activity envisioned for the future is the application of

this model building methodology to less developed countries.The model has

been developed for use in a metropolitan U.S.A. city, but if the flows

can be appropriately modified, the model could be used in international

settings. For example, flows to reflect the effects of midwives and

private protection (e.g., NIROHD in India) would be required. Besides

the issue of the flow compatibility, international application will repre-

sent a challenge since the management role and skills are not well

appreciated or existent in many less developed nations. But if the model

can help improve understanding, forecasting, and decision making in the

U.S.A., these potential advantages reflected in an international model may

have a significant impact on family planning in countries where population

growth is one of the most important problems.

APPENDICES

Mod 1 <u>Questions</u> input and <u>Results</u> output

All input typed in by the user has been underlined to emphasize points

of interaction.

The input/output material is for descriptive purposes and does not

represent a single set of data.

GUIDELINES FOR RESPONDING TO QUESTIONS :
     1) ALWAYS DEPRESS 'RETURN' KEY AFTER EACH OF YOUR RESPONSES
     2) WHEN A FRACTION IS ASKED FOR, TYPE A DECIMAL
        FRACTION. E.G. .35

CURRENTLY, WE CAN HANDLE 4 AGENCIES (GRADY POST PARTUM, PLANNED
PARENTHOOD, COUNTY, AND A GENERAL AGENCY -- POSSIBLY AN
INDIVIDUAL CLINIC) AND 3 METHODS.

PLEASE ENTER THE FOLLOWING SPECIFICATIONS FOR THIS PLANNING
SESSION

STARTING MONTH (1-36): <u>1</u>

ENDING MONTH: <u>12</u>

SIZE OF TARGET GROUP: <u>33000</u>

TIME (IN MONTHS) BETWEEN APPOINTMENTS FOR METHOD
1: <u>6</u>
2: <u>4</u>
3: <u>3</u>

PLEASE ENTER THE FOLLOWING GRADY POST PARTUM DATA

FRACTION OF WOMEN WHO WILL ACCEPT SOME METHOD IMMEDIATELY: <u>.48</u>

FRACTION OF IMMEDIATE ACCEPTORS WHO RETURN FOR POST PARTUM
SIX WEEK APPOINTMENT: <u>.85</u>

FRACTION OF WOMEN WHO DO NOT ACCEPT IMMEDIATELY,
WHO APPEAR FOR THEIR SIX WEEK POST PARTUM APPOINTMENT: <u>.94</u>

FRACTION OF THESE WOMEN WHO APPEAR AND ACCEPT SOME METHOD: <u>.97</u>

IN THE NEXT QUESTION, THE SET OF THREE RESPONSES
SHOULD ADD TO 1.0

FRACTION OF THOSE WOMEN WHO WILL ACCEPT SOME METHOD,
AT SIX WEEK POST PARTUM APPOINTMENT,
THAT CHOOSE SPECIFIC METHOD

1: .27
2: .66
3: .07

FRACTION OF THOSE WHO ACCEPTED FAMILY PLANNING FOR FIRST
TIME AT SIX WEEK POST PARTUM APPOINTMENT WHO APPEAR FOR NEXT
APPOINTMENT: .75

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD TWICE,
WHO WILL RETURN FOR AN APPOINTMENT: .78

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD 3 TIMES OR MORE,
WHO WILL RETURN FOR AN APPOINTMENT: .83

INITIALLY, NUMBER OF ACTIVE POST PARTUM PATIENTS USING METHOD
1: 2808
2: 3141
3: 1520

PLEASE ENTER THE FOLLOWING GENERAL AGENCY DATA

DO YOU WISH TO ENTER OUTREACH DATA FOR THIS AGENCY(6 QUESTIONS) NO

NUMBER OF WOMEN (NONUSERS, NOT PREGNANT) WHO
REQUEST AN APPOINTMENT IN AN AVERAGE MONTH: 150

FRACTION OF WOMEN WHO REQUESTED AN APPOINTMENT
WHO APPEAR FOR IT: 1

FRACTION OF WOMEN WHO HAVE APPEARED FOR AN APPOINTMENT,
WHO WILL ACCEPT SOME METHOD: .96

IN THE NEXT QUESTION, THE SET OF THREE RESPONSES
SHOULD ADD TO 1.0

FRACTION OF THOSE WOMEN WHO WILL ACCEPT SOME METHOD,
THAT CHOOSE SPECIFIC METHOD

1: .3
2: .6
3: .1

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD ONCE,
WHO WILL RETURN FOR AN APPOINTMENT: .61

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD TWICE,
WHO WILL RETURN FOR AN APPOINTMENT: .7

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD 3 TIMES OR MORE,
WHO WILL RETURN FOR AN APPOINTMENT: .76

INITIALLY, NUMBER OF ACTIVE GENERAL AGENCY PATIENTS
USING METHOD
1: 312
2: 314
3: 169

PLEASE ENTER THE FOLLOWING AGENCY DATA FOR PLANNED PARENTHOOD

DO YOU WISH TO ENTER OUTREACH DATA FOR THIS AGENCY(6 QUESTIONS)

NUMBER OF RECRUITMENT OUTREACH VISITS PER MONTH: 10000

FRACTION OF VISITS WHICH RESULT IN CONTACT: .7

FRACTION OF WOMEN (NON-USERS, NOT PREGNANT)
WHO MAKE AN APPOINTMENT: .01

FRACTION OF WOMEN WHO MADE APPOINTMENT WITH OUTREACH WORKER,
WHO APPEAR FOR APPOINTMENT: .1

FRACTION OF THOSE WOMEN WHO APPEAR FOR APPOINTMENT AS A RESULT
OF OUTREACH, WHO ACCEPT SOME METHOD: .9

NUMBER OF WOMEN (NONUSERS, NOT PREGNANT) WHO
REQUEST AN APPOINTMENT IN AN AVERAGE MONTH: 275

FRACTION OF WOMEN WHO REQUESTED AN APPOINTMENT
WHO APPEAR FOR IT: 1.0

FRACTION OF WOMEN WHO HAVE APPEARED FOR AN APPOINTMENT,
WHO WILL ACCEPT SOME METHOD: .98

IN THE NEXT QUESTION, THE SET OF THREE RESPONSES
SHOULD ADD TO 1.0

FRACTION OF THOSE WOMEN WHO WILL ACCEPT SOME METHOD,
THAT CHOOSE SPECIFIC METHOD

1: .2
2: .8
3: 0

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD ONCE,
WHO WILL RETURN FOR AN APPOINTMENT: .79

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD TWICE,
WHO WILL RETURN FOR AN APPOINTMENT: .9

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD 3 TIMES OR MORE,
WHO WILL RETURN FOR AN APPOINTMENT: .97

INITIALLY, NUMBER OF ACTIVE PP PATIENTS USING METHOD
1: 512
2: 3007
3: 0

COUNTY PUBLIC HEALTH CLINICS

DO YOU WISH TO ENTER OUTREACH DATA FOR THIS AGENCY(6 QUESTIONS

NUMBER OF WOMEN (NONUSERS, NOT PREGNANT) WHO
REQUEST AN APPOINTMENT IN AN AVERAGE MONTH: 143

FRACTION OF WOMEN WHO REQUESTED AN APPOINTMENT
WHO APPEAR FOR IT: 1.0

FRACTION OF WOMEN WHO HAVE APPEARED FOR AN APPOINTMENT,
WHO WILL ACCEPT SOME METHOD: .98

IN THE NEXT QUESTION, THE SET OF THREE RESPONSES
SHOULD ADD TO 1.0

FRACTION OF THOSE WOMEN WHO WILL ACCEPT SOME METHOD,
THAT CHOOSE SPECIFIC METHOD

1: .22
2: .78
3: 0
FRACTION OF USERS WHO HAVE ACCEPTED A METHOD ONCE,
WHO WILL RETURN FOR AN APPOINTMENT: .85

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD TWICE,
WHO WILL RETURN FOR AN APPOINTMENT: .89

FRACTION OF USERS WHO HAVE ACCEPTED A METHOD 3 TIMES OR MORE,
WHO WILL RETURN FOR AN APPOINTMENT: .96

INITIALLY, NUMBER OF ACTIVE COUNTY PATIENTS USING METHOD
1: 446
2: 1137
3: 0

DO YOU WISH TO ENTER NEW DEMOGRAPHIC DATA? yes

INITIALLY, AVERAGE NUMBER OF WOMEN IN TARGET GROUP WHO DELIVER
IN A MONTH: 510

FRACTION OF FIRST ACCEPTORS WHO BECOME PREGNANT IN ANY MONTH
USING METHOD
1: .006
2: .015
3: .002

FRACTION OF CONTINUERS (TWO OR MORE CONSECUTIVE ACCEPTANCES)
WHO BECOME PREGNANT IN ANY MONTH USING METHOD

1: .005
2: .013
3: .002

DO YOU WISH THE OUTPUT TO INCLUDE PLOTS? no

INPUT QUESTIONS ARE FINISHED,

*file best1

results

```
OVERALL | SYSTEM SUMMARY
        | THIS TABLE DESCRIBES THE GROWTH IN THE
        | NUMBER OF ACTIVES AT THE END OF EACH QUARTER AND
        | THE NUMBER OF NEW PATIENTS GAINED IN EACH QUARTER

TACTQ   | TOTAL ACTIVES BY QUARTER

TNUPQ   | TOTAL NEW PATIENTS GAINED BY QUARTER
```

QUARTER	TACTQ	TNUPQ
1.000	14290.0	3023.00
2.000	15301.0	2901.00
3.000	15989.0	2816.00
4.000	16900.0	2818.00

```
TAGENCY | TOTAL USERS BY AGENCIES
        | THE FOLLOWING TABLE DESCRIBES THE NUMBER OF ACTIVES
        | IN EACH AGENCY IN THE SYSTEM AT THE END OF EACH QUA

ACTQ1   | ACTIVES BY QUARTER AT GRADY

ACTQ2   | ACTIVES BY QUARTER AT PLANNED PARENTHOOD

ACTQ3   | ACTIVES BY QUARTER AT COUNTY CLINICS

ACTQ4   | ACTIVES BY QUARTER AT GENERAL AGENCY
```

QUARTER	ACTQ1	ACTQ2	ACTQ3	ACTQ4
1.000	7570.00	3897.00	1806.00	1017.00
2.000	7815.00	4286.00	2031.00	1169.00
3.000	7969.00	4571.00	2204.00	1245.00
4.000	8281.00	4910.00	2395.00	1314.00

```
TPREGQ  | TOTAL PREGNANCIES BY QUARTER
```

QUARTER	TPREGQ
1.000	1569.00
2.000	1521.00
3.000	1489.00
4.000	1467.00

AGENCY1 | GRADY POST PARTUM SUMMARY

ACTQP1 | ACTIVES BY QUARTER AND METHOD AT GRADY POST PARTUM

```
ACTQP1
METHOD     1.000    2.000    3.000
QUARTER
 1.000    2822.00  3426.00  1322.00
 2.000    2923.00  3722.00  1170.00
 3.000    2955.00  3956.00  1058.00
 4.000    3058.00  4256.00  967.000
```

NUPQ1 | NEW PATIENTS GAINED BY GRADY POST PARTUM IN EACH QU

```
QUARTER    NUPQ1
 1.000    1383.00
 2.000    1383.00
 3.000    1386.00
 4.000    1459.00
```

AGENCY4 | GENERAL AGENCY SUMMARY

ACTQP4 | ACTIVES BY QUARTER AND METHOD AT GENERAL AGENCY

```
ACTQP4
METHOD     1.000    2.000    3.000
QUARTER
 1.000    386.000  469.000  162.000
 2.000    450.000  568.000  151.000
 3.000    478.000  623.000  144.000
 4.000    508.000  671.000  135.000
```

NURQ4 | NEW PATIENTS GAINED BY REQUESTS IN EACH QUARTER

NUOQ4 | NEW PATIENTS GAINED BY OUTREACH IN EACH QUARTER

```
QUARTER    NURQ4    NUOQ4
 1.000    417.000  .000
 2.000    384.000  .000
 3.000    364.000  .000
 4.000    343.000  .000
```

AGENCY2 | PLANNED PARENTHOOD SUMMARY

ACTQP2 | ACTIVES BY QUARTER AND METHOD AT PLANNED PARENTHOOD

ACTQP2
METHOD	1.000	2.000	3.000
QUARTER			
1.000	634.000	3263.00	.000
2.000	753.000	3533.00	.000
3.000	838.000	3733.00	.000
4.000	927.000	3983.00	.000

NURQ2 | NEW PATIENTS GAINED IN EACH QUARTER BY REQUESTS

NUOQ2 | NEW PATIENTS GAINED IN QUARTER BY OUTREACH

QUARTER	NURQ2	NUOQ2
1.000	805.000	6.000
2.000	746.000	6.000
3.000	703.000	3.000
4.000	669.000	3.000

AGENCY3 | COUNTY CLINICS SUMMARY

ACTQP3 | ACTIVES BY QUARTER AND METHOD AT COUNTY CLINICS

ACTQP3
METHOD	1.000	2.000	3.000
QUARTER			
1.000	499.000	1307.00	.000
2.000	560.000	1471.00	.000
3.000	607.000	1597.00	.000
4.000	656.000	1739.00	.000

NURQ3 | NEW PATIENTS GAINED BY REQUESTS IN EACH QUARTER

NUOQ3 | NEW PATIENTS GAINED BY OUTREACH IN EACH QUARTER

QUARTER	NURQ3	NUOQ3
1.000	411.000	.000
2.000	380.000	.000
3.000	357.000	.000
4.000	340.000	.000
*		

ON-LINE FAMILY PLANNING MODEL

*questions
GUIDELINES FOR RESPONDING TO QUESTIONS :
    1) ALWAYS DEPRESS 'RETURN' KEY AFTER EACH OF YOUR RESPONSES
    2) WHEN A FRACTION IS ASKED FOR, TYPE A DECIMAL
       FRACTION. E.G. .35

CURRENTLY, WE CAN HANDLE 4 AGENCIES (GRADY POST PARTUM, GRADY NON-POST
PARTUM, PLANNED PARENTHOOD, COUNTY) AND 3 METHODS (4 FOR GRADY HOSP.).

PLEASE ENTER THE FOLLOWING SPECIFICATIONS FOR THIS PLANNING
SESSION

NSTART | STARTING MONTH (1-36): 1

NEND | ENDING MONTH: 36

TARGP | SIZE OF TARGET GROUP: 43000

APT | TIME (IN MONTHS) BETWEEN APPOINTMENTS FOR METHOD
1: 6
2: 4
3: 3

PLEASE ENTER THE FOLLOWING GRADY POST PARTUM DATA

ACCPTI | FRACTION OF WOMEN (WITHOUT PAST METHOD EXPERIENCE)
        | WHO WILL ACCEPT SOME METHOD IMMEDIATELY: .46

FRACTION OF WOMEN (WITH METHOD EXPERIENCE),
WHO WILL ACCEPT SOME METHOD IMMEDIATELY: .480

PSHOWI | FRACTION OF IMMEDIATE ACCEPTORS WHO RETURN FOR POST PARTUM
        | SIX WEEK APPOINTMENT: .850

PSHOWS | FRACTION OF WOMEN WHO DO NOT ACCEPT IMMEDIATELY,
        | WHO APPEAR FOR THEIR SIX WEEK POST PARTUM APPOINTMENT: .940

ACCPTC | FRACTION OF THESE WOMEN (WITHOUT PAST METHOD EXPERIENCE),
        | WHO APPEAR AND ACCEPT SOME METHOD: .963

FRACTION OF THESE WOMEN (WITH METHOD EXPERIENCE),
WHO APPEAR AND ACCEPT SOME METHOD: .975

PGNFACP | IN EACH OF THE NEXT 2 QUESTIONS, THE SET OF 3 RESPONSES
        | SHOULD ADD TO 1.0

        | FRACTION OF THOSE WOMEN (WITHOUT PAST METHOD EXPERIENCE),
        | WHO WILL ACCEPT SOME METHOD AT 6 WEEK POST PARTUM APPOINTMENT,
        | THAT CHOOSE SPECIFIC METHOD
1: .220
2: .727
3: .053

PGEFACP | FRACTION OF THOSE WOMEN (WITH METHOD EXPERIENCE),
         | WHO WILL ACCEPT SOME METHOD AT 6 WEEK POST PARTUM APPOINTMENT,
         | THAT CHOOSE SPECIFIC METHOD
1: .314
2: .582
3: .104

PSHORS | FRACTION OF THOSE WHO ACCEPTED FAMILY PLANNING FOR FIRST
        | TIME AT SIX WEEK POST PARTUM APPOINTMENT WHO APPEAR FOR NEXT
        | APPOINTMENT FOR METHOD
1: .670
2: .770
3: .870

PSHOW1 | FRACTION OF USERS OF METHOD 1, WHO WILL RETURN FOR APPOINTMENT
        | AFTER HAVING ACCEPTED METHOD 1 FOR
2 CONSECUTIVE VISITS   : .720

3 OR MORE CONSECUTIVE VISITS: .770

FRACTION OF USERS OF METHOD 2, WHO WILL RETURN FOR APPOINTMENT,
AFTER HAVING ACCEPTED METHOD 2 FOR
2 CONSECUTIVE VISITS   : .770

3 OR MORE CONSECUTIVE VISITS: .820

FRACTION OF USERS OF METHOD 3, WHO WILL RETURN FOR APPOINTMENT,
AFTER HAVING ACCEPTED METHOD 3 FOR
2 CONSECUTIVE VISITS   : .830

3 OR MORE CONSECUTIVE VISITS: .860

IACT1 | INITIALLY, NUMBER OF ACTIVE POST PARTUM PATIENTS USING METHOD
1: 2650.0
2: 3720.0
3: 878.00
4: 990.00

CAPAC1 | DO YOU WISH TO ENTER CAPACITY UTILIZATION DATA FOR
        | THE GRADY POST PARTUM AGENCY? yes.

HCCLIN | AGENCY CAPACITY IN PATIENTS PER MONTH: 1800.0

CSTER | NUMBER OF STERILIZATIONS GRADY CAN PERFORM IN A MONTH: 33.000

PSTERP | FRACTION OF POST PARTUM WOMEN (WITHOUT PAST METHOD EXPERIENCE)
        | WHO REQUEST STERILIZATION: .034

FRACTION OF POST PARTUM WOMEN (WITH METHOD EXPERIENCE)
WHO REQUEST STERILIZATION: .072

PLEASE ENTER THE FOLLOWING GRADY NON-POST PARTUM DATA

CLINSUB | DO YOU WISH TO ENTER OUTREACH DATA FOR THIS AGENCY(6 QUESTIONS no

NREQ24 | NUMBER OF WOMEN (NONUSERS, NOT PREGNANT) WHO
        | REQUEST AN APPOINTMENT IN AN AVERAGE MONTH: 150.00

PSHOWR | FRACTION OF WOMEN WHO REQUESTED AN APPOINTMENT
       | WHO APPEAR FOR IT: 1.000

ACCPTR | FRACTION OF WOMEN (WITHOUT PAST METHOD EXPERIENCE),
       | WHO HAVE APPEARED FOR AN APPOINTMENT,
       | WHO WILL ACCEPT SOME METHOD: .951

FRACTION OF WOMEN (WITH METHOD EXPERIENCE),
WHO HAVE APPEARED FOR AN APPOINTMENT,
WHO WILL ACCEPT SOME METHOD: .972

NGNFACP | IN EACH OF THE NEXT 2 QUESTIONS, THE SET OF 3 RESPONSES
        | SHOULD ADD TO 1.0

        | FRACTION OF WOMEN (WITHOUT PAST METHOD EXPERIENCE),
        | WHO WILL ACCEPT SOME METHOD, THAT CHOOSE SPECIFIC METHOD
1: .170
2: .730
3: .100

NGEFACP | FRACTION OF WOMEN (WITH METHOD EXPERIENCE),
        | WHO WILL ACCEPT SOME METHOD, THAT CHOOSE SPECIFIC METHOD
1: .420
2: .500
3: .080

PSHOW4 | FRACTION OF USERS OF METHOD 1, WHO WILL RETURN FOR APPOINTMENT
       | AFTER HAVING ACCEPTED METHOD 1 FOR
1 VISIT   : .620

2 CONSECUTIVE VISITS   : .720

3 OR MORE CONSECUTIVE VISITS: .820

FRACTION OF USERS OF METHOD 2, WHO WILL RETURN FOR APPOINTMENT,
AFTER HAVING ACCEPTED METHOD 2 FOR
1 VISIT   : .590

2 CONSECUTIVE VISITS   : .660

3 OR MORE CONSECUTIVE VISITS: .680

FRACTION OF USERS OF METHOD 3, WHO WILL RETURN FOR APPOINTMENT,
AFTER HAVING ACCEPTED METHOD 3 FOR
1 VISIT   : .680

2 CONSECUTIVE VISITS   : .800

3 OR MORE CONSECUTIVE VISITS: .820

IACT4 | INITIALLY, NUMBER OF ACTIVE GRADY NON-POST PARTUM PATIENTS
      | USING METHOD
1: 295.00
2: 414.00
3: 97.000
4: 110.00

CAPAC4 | DO YOU WISH TO ENTER CAPACITY UTILIZATION DATA FOR THE
       | GRADY NON-POST PARTUM AGENCY? yes.

PLEASE ENTER THE FOLLOWING AGENCY DATA FOR PLANNED PARENTHOOD

CLINSUB | DO YOU WISH TO ENTER OUTREACH DATA FOR THIS AGENCY(6 QUESTIONSy

NCALL | NUMBER OF RECRUITMENT OUTREACH VISITS PER MONTH: 200.00

PFIND | FRACTION OF VISITS WHICH RESULT IN CONTACT: 1.000

PCONVR | FRACTION OF WOMEN (NON-USERS, NOT PREGNANT,
        | NEVER USED A METHOD), WHO MAKE AN APPOINTMENT: .075

FRACTION OF WOMEN (NON-USERS, NOT PREGNANT,
WITH METHOD EXPERIENCE), WHO MAKE AN APPOINTMENT: .075

PSHOWO | FRACTION OF WOMEN WHO MADE APPOINTMENT WITH OUTREACH WORKER,
        | WHO APPEAR FOR APPOINTMENT: .330

ACCPTO | FRACTION OF THOSE WOMEN WHO APPEAR FOR APPOINTMENT AS A RESULT
        | OF OUTREACH, WHO ACCEPT SOME METHOD: 1.000

NREQ24 | NUMBER OF WOMEN (NONUSERS, NOT PREGNANT) WHO
        | REQUEST AN APPOINTMENT IN AN AVERAGE MONTH: 250.00

PSHOWR | FRACTION OF WOMEN WHO REQUESTED AN APPOINTMENT
        | WHO APPEAR FOR IT: 1.000

ACCPTR | FRACTION OF WOMEN (WITHOUT PAST METHOD EXPERIENCE),
        | WHO HAVE APPEARED FOR AN APPOINTMENT,
        | WHO WILL ACCEPT SOME METHOD: .975

FRACTION OF WOMEN (WITH METHOD EXPERIENCE),
WHO HAVE APPEARED FOR AN APPOINTMENT,
WHO WILL ACCEPT SOME METHOD: .990

PPNFACP | IN EACH OF THE NEXT 2 QUESTIONS, THE SET OF 3 RESPONSES
        | SHOULD ADD TO 1.0

        | FRACTION OF THOSE WOMEN (WITHOUT PAST METHOD EXPERIENCE),
        | WHO WILL ACCEPT SOME METHOD, THAT CHOOSE SPECIFIC METHOD
1: .05
2: .950
3: .000

PPEFACP | FRACTION OF WOMEN (WITH METHOD EXPERIENCE),
        | WHO WILL ACCEPT SOME METHOD, THAT CHOOSE SPECIFIC METHOD
1: .260
2: .740
3: .000

PSHOW2 | FRACTION OF USERS OF METHOD 1, WHO WILL RETURN FOR APPOINTMENT
       | AFTER HAVING ACCEPTED METHOD 1 FOR
1 VISIT   : .720

2 CONSECUTIVE VISITS   : .850

3 OR MORE CONSECUTIVE VISITS: .950

FRACTION OF USERS OF METHOD 2, WHO WILL RETURN FOR APPOINTMENT,
AFTER HAVING ACCEPTED METHOD 2 FOR
1 VISIT   : .800

2 CONSECUTIVE VISITS   : .900

3 OR MORE CONSECUTIVE VISITS: .970

FRACTION OF USERS OF METHOD 3, WHO WILL RETURN FOR APPOINTMENT,
AFTER HAVING ACCEPTED METHOD 3 FOR
1 VISIT   : .000

2 CONSECUTIVE VISITS   : .000

3 OR MORE CONSECUTIVE VISITS: .000

CAPAC2 | DO YOU WISH TO ENTER CAPACITY UTILIZATION DATA FOR THE
       | PLANNED PARENTHOOD AGENCY? yes

HCCLIN | AGENCY CAPACITY IN PATIENTS PER MONTH: 2600.0

$(ETC.)$

CLINSUB   YOU WISH TO ENTER OUTREACH DATA FOR THIS AGENCY(S QUESTIONS!

OVERALL | SYSTEM SUMMARY
        | THIS TABLE DESCRIBES THE GROWTH IN THE
        | NUMBER OF ACTIVES AT THE END OF EACH QUARTER AND
        | THE NUMBER OF NEW PATIENTS GAINED IN EACH QUARTER

TACTQ | TOTAL ACTIVES BY QUARTER

TNUPQ | TOTAL NEW PATIENTS GAINED BY QUARTER

QUARTER	TACTQ	TNUPQ
1.000	17248.0	2925.00
2.000	18162.9	2860.00
3.000	18808.9	2807.00
4.000	19460.0	2795.00
5.000	19958.0	2742.00
6.000	20436.0	2691.00
7.000	20844.9	2656.00
8.000	21242.0	2619.00
9.000	21570.9	2582.00
10.000	21886.9	2553.00
11.000	22184.9	2530.00
12.000	22786.0	2531.00

A =
TACTQ | TOTAL ACTIVES BY QUARTER
  B =
TNUPQ | TOTAL NEW PATIENTS GAINED BY QUARTER

```
 .000                                              22786.
PER'--------------------------------------------------------'
1. '        B                             A
    '
    '
    '
2. '        B                                      A
    '
    '
    '
3. '        B                                      A
    '
    '
    '
4. '        B                                      A
    '
    '
    '
5. '        B                                         A
    '
    '
    '
6. '        B                                         A
    '
    '
    '
7. '        B                                         A
    '
    '
    '
8. '        B                                            A
    '
    '
    '
9. '        B                                            A
    '
    '
    '
10'        B                                            A
    '
    '
    '
11'        B                                              A
    '
    '
    '
12'        B                                              A
    '
```

```
TAGENCY | TOTAL USERS BY AGENCIES
        | THE FOLLOWING TABLE DESCRIBES THE NUMBER OF ACTIVES
        | IN EACH AGENCY IN THE SYSTEM AT THE END OF EACH QUARTER

ACTQ1   | ACTIVES BY QUARTER AT GRADY POST PARTUM

ACTQ2   | ACTIVES BY QUARTER AT PLANNED PARENTHOOD

ACTQ3   | ACTIVES BY QUARTER AT COUNTY CLINICS

ACTQ4   | ACTIVES BY QUARTER AT GRADY NON-POST PARTUM

QUARTER  ACTQ1    ACTQ2    ACTQ3    ACTQ4
 1.000   8085.00  4717.00  3304.00  1142.00
 2.000   8147.00  5000.00  3689.00  1327.00
 3.000   8162.00  5224.00  3983.00  1440.00
 4.000   8251.00  5426.00  4262.00  1521.00
 5.000   8295.00  5599.00  4490.00  1574.00
 6.000   8351.00  5755.00  4710.00  1620.00
 7.000   8400.00  5893.00  4903.00  1649.00
 8.000   8461.00  6014.00  5086.00  1681.00
 9.000   8502.00  6119.00  5250.00  1700.00
10.000   8554.00  6215.00  5402.00  1716.00
11.000   8610.00  6302.00  5541.00  1732.00
12.000   8758.00  6493.00  5763.00  1772.00

TPREGQ  | TOTAL PREGNANCIES BY QUARTER

QUARTER  TPREGQ
 1.000   1526.00
 2.000   1505.00
 3.000   1491.00
 4.000   1479.00
 5.000   1467.00
 6.000   1457.00
 7.000   1446.00
 8.000   1437.00
 9.000   1428.00
10.000   1419.00
11.000   1410.00
12.000   1401.00
```

AGENCY1 | GRADY POST PARTUM SUMMARY

ACTQP1 | ACTIVES BY QUARTER AND METHOD AT GRADY POST PARTUM

ACTQP1

METHOD QUARTER	1.000	2.000	3.000	4.000
1.000	2489.00	3701.00	835.000	1060.00
2.000	2444.00	3762.00	808.000	1133.00
3.000	2368.00	3795.00	789.000	1210.00
4.000	2362.00	3798.00	789.000	1302.00
5.000	2338.00	3774.00	788.000	1395.00
6.000	2331.00	3741.00	791.000	1488.00
7.000	2310.00	3709.00	798.000	1583.00
8.000	2306.00	3677.00	799.000	1679.00
9.000	2289.00	3637.00	801.000	1775.00
10.000	2281.00	3598.00	804.000	1871.00
11.000	2276.00	3560.00	807.000	1967.00
12.000	2294.00	3590.00	811.000	2063.00

NUPQ1 | NEW PATIENTS GAINED BY GRADY POST PARTUM IN EACH QUARTER

QUARTER	NUPQ1
1.000	1260.00
2.000	1259.00
3.000	1262.00
4.000	1295.00
5.000	1279.00
6.000	1266.00
7.000	1259.00
8.000	1250.00
9.000	1239.00
10.000	1233.00
11.000	1224.00
12.000	1244.00

AGENCY4 | GRADY NON-POST PARTUM SUMMARY

ACTQP4 | ACTIVES BY QUARTER AND METHOD AT GRADY NON-POST PARTUM

ACTQP4

METHOD QUARTER	1.000	2.000	3.000	4.000
1.000	358.000	547.000	111.000	126.000
2.000	430.000	632.000	124.000	141.000
3.000	475.000	676.000	133.000	156.000
4.000	520.000	695.000	135.000	171.000
5.000	557.000	693.000	138.000	186.000
6.000	594.000	688.000	138.000	200.000
7.000	622.000	677.000	138.000	212.000
8.000	653.000	664.000	140.000	224.000
9.000	677.000	648.000	139.000	236.000
10.000	699.000	633.000	136.000	248.000
11.000	723.000	617.000	132.000	260.000
12.000	752.000	616.000	132.000	272.000

NURQ4 | NEW PATIENTS GAINED BY REQUESTS IN EACH QUARTER

NUOQ4 | NEW PATIENTS GAINED BY OUTREACH IN EACH QUARTER

QUARTER	NURQ4	NUOQ4
1.000	421.000	.000
2.000	405.000	.000
3.000	391.000	.000
4.000	380.000	.000
5.000	370.000	.000
6.000	360.000	.000
7.000	356.000	.000
8.000	348.000	.000
9.000	340.000	.000
10.000	334.000	.000
11.000	332.000	.000
12.000	329.000	.000

AGENCY2 | PLANNED PARENTHOOD SUMMARY

ACTQP2 | ACTIVES BY QUARTER AND METHOD AT PLANNED PARENTHOOD

ACTQP2

METHOD	1.000	2.000	3.000	4.000
QUARTER				
1.000	713.000	4004.00	.000	.000
2.000	761.000	4239.00	.000	.000
3.000	810.000	4414.00	.000	.000
4.000	862.000	4564.00	.000	.000
5.000	914.000	4685.00	.000	.000
6.000	968.000	4787.00	.000	.000
7.000	1018.00	4875.00	.000	.000
8.000	1067.00	4947.00	.000	.000
9.000	1117.00	5002.00	.000	.000
10.000	1169.00	5046.00	.000	.000
11.000	1219.00	5083.00	.000	.000
12.000	1276.00	5217.00	.000	.000

NURQ2 | NEW PATIENTS GAINED IN EACH QUARTER BY REQUESTS

NUOQ2 | NEW PATIENTS GAINED IN QUARTER BY OUTREACH

QUARTER	NURQ2	NUOQ2
1.000	735.000	3.000
2.000	706.000	3.000
3.000	683.000	3.000
4.000	662.000	3.000
5.000	644.000	3.000
6.000	630.000	3.000
7.000	617.000	3.000
8.000	605.000	3.000
9.000	595.000	3.000
10.000	585.000	3.000
11.000	577.000	3.000
12.000	570.000	3.000

AGENCY3 | COUNTY CLINICS SUMMARY

ACTQP3 | ACTIVES BY QUARTER AND METHOD AT COUNTY CLINICS

ACTQP3

METHOD	1.000	2.000	3.000	4.000
QUARTER				
1.000	1170.00	2134.00	.000	.000
2.000	1356.00	2333.00	.000	.000
3.000	1492.00	2491.00	.000	.000
4.000	1636.00	2626.00	.000	.000
5.000	1755.00	2735.00	.000	.000
6.000	1876.00	2834.00	.000	.000
7.000	1986.00	2917.00	.000	.000
8.000	2095.00	2991.00	.000	.000
9.000	2198.00	3052.00	.000	.000
10.000	2298.00	3104.00	.000	.000
11.000	2395.00	3146.00	.000	.000
12.000	2514.00	3249.00	.000	.000

NURQ3 | NEW PATIENTS GAINED BY REQUESTS IN EACH QUARTER

NUOQ3 | NEW PATIENTS GAINED BY OUTREACH IN EACH QUARTER

QUARTER	NURQ3	NUOQ3
1.000	279.000	205.000
2.000	268.000	195.000
3.000	259.000	189.000
4.000	252.000	183.000
5.000	244.000	178.000
6.000	238.000	174.000
7.000	233.000	169.000
8.000	229.000	167.000
9.000	224.000	164.000
10.000	221.000	161.000
11.000	218.000	159.000
12.000	213.000	156.000

*

A COST BENEFIT ANALYSIS FOLLOWS

GTYPR | TOTAL YEARS OF PROTECTION GIVEN DURING THE PERIOD

GTYPR   61290.0

GTCST | TOTAL COST DURING THE PERIOD

GTCST   4.105M

SPYPRX | TOTAL COST PER YEAR OF PROTECTION DURING THE PERIOD

SPYPRX   66.977

YPRYXX | YEARS OF PROTECTION GIVEN BY THE SYSTEM IN EACH YEAR

YEAR   1.000   2.000   3.000
YPRYXX   18434.9 20684.9 22170.0

STCSTY | TOTAL SYSTEM COSTS BY YEAR

YEAR   1.000   2.000   3.000
STCSTY   1.225M   1.410M   1.470M

SPYPRY | COST PER YEAR OF PROTECTION IN EACH YEAR

YEAR   1.000   2.000   3.000
SPYPRY   66.450   68.165   66.306

YPRC | YEARS OF PROTECTION GIVEN BY EACH AGENCY DURING THE PERIOD

| CLINIC | 1.000 | 2.000 | 3.000 | 4.000 |
| YPRC | 26316.0 | 16758.0 | 13661.0 | 4555.00 |

TCSTC | COST OF EACH AGENCY DURING THE PERIOD

| CLINIC | 1.000 | 2.000 | 3.000 | 4.000 |
| TCSTC | 1.125M | 1.050M | 1.125M | 105000. |

CPYPRC | COST PER YEAR OF PROTECTION IN EACH AGENCY

| CLINIC | 1.000 | 2.000 | 3.000 | 4.000 |
| CPYPRC | 42.750 | 62.657 | 82.351 | 23.052 |

YPRYCX | YEARS OF PROTECTION GIVEN BY EACH AGENCY IN EACH YEAR

YPRYCX CLINIC	1.000	2.000	3.000	4.000
YEAR				
1.000	8590.00	4931.00	3640.00	1274.00
2.000	8755.00	5680.00	4665.00	1585.00
3.000	8971.00	6147.00	5356.00	1696.00

TCSTYC | COST OF EACH AGENCY IN EACH YEAR

TCSTYC CLINIC	1.000	2.000	3.000	4.000
YEAR				
1.000	349999.	314999.	324999.	35000.0
2.000	374999.	349999.	400000.	35000.0
3.000	400000.	384999.	400000.	35000.0

CPYPRY | COST PER YEAR OF PROTECTION IN EACH AGENCY AND YEAR

CPYPRY CLINIC	1.000	2.000	3.000	4.000
YEAR				
1.000	40.745	63.882	89.286	27.473
2.000	42.833	61.620	85.745	22.082
3.000	44.588	62.632	74.683	20.637

CAPACITY UTILIZATION ANALYSIS

TCUTLQ | TOTAL CAPACITY UTILIZATION (QUARTERLY) BY AGENCY

CLINIC 1.0		CLINIC 2.0		CLINIC 3.0		CLINIC 4.0	
QUARTER	TCUTLQ	QUARTER	TCUTLQ	QUARTER	TCUTLQ	QUARTER	TCUTLQ
1.000	1.050	1.000	.461	1.000	.356	1.000	1.369
2.000	1.022	2.000	.480	2.000	.368	2.000	1.453
3.000	1.026	3.000	.500	3.000	.407	3.000	1.574
4.000	1.014	4.000	.512	4.000	.415	4.000	1.602
5.000	1.027	5.000	.537	5.000	.456	5.000	1.675
6.000	1.010	6.000	.547	6.000	.462	6.000	1.667
7.000	1.009	7.000	.558	7.000	.489	7.000	1.693
8.000	.995	8.000	.564	8.000	.491	8.000	1.679
9.000	.998	9.000	.580	9.000	.521	9.000	1.696
10.000	.986	10.000	.585	10.000	.522	10.000	1.676
11.000	.982	11.000	.591	11.000	.542	11.000	1.681
12.000	.972	12.000	.593	12.000	.541	12.000	1.663

FVUTLQ | PERCENT OF CAPACITY USED FOR FIRST VISITS (QUARTERLY, BY AGENC

CLINIC 1.0		CLINIC 2.0		CLINIC 3.0		CLINIC 4.0	
QUARTER	FVUTLQ	QUARTER	FVUTLQ	QUARTER	FVUTLQ	QUARTER	FVUTLQ
1.000	.268	1.000	.095	1.000	.104	1.000	.732
2.000	.268	2.000	.091	2.000	.094	2.000	.703
3.000	.268	3.000	.088	3.000	.091	3.000	.680
4.000	.273	4.000	.086	4.000	.089	4.000	.660
5.000	.269	5.000	.084	5.000	.087	5.000	.644
6.000	.267	6.000	.082	6.000	.085	6.000	.629
7.000	.265	7.000	.080	7.000	.084	7.000	.616
8.000	.263	8.000	.078	8.000	.082	8.000	.604
9.000	.261	9.000	.077	9.000	.081	9.000	.594
10.000	.259	10.000	.076	10.000	.080	10.000	.585
11.000	.257	11.000	.075	11.000	.079	11.000	.576
12.000	.256	12.000	.074	12.000	.078	12.000	.568

RVUTLQ | PERCENT OF CAPACITY USED FOR REPEAT VISITS (QUARTERLY, BY AGE|

CLINIC 1.0		CLINIC 2.0		CLINIC 3.0		CLINIC 4.0	
QUARTER	RVUTLQ	QUARTER	RVUTLQ	QUARTER	RVUTLQ	QUARTER	RVUTLQ
1.000	.782	1.000	.366	1.000	.252	1.000	.637
2.000	.754	2.000	.389	2.000	.275	2.000	.750
3.000	.758	3.000	.412	3.000	.316	3.000	.894
4.000	.741	4.000	.426	4.000	.326	4.000	.941
5.000	.758	5.000	.453	5.000	.369	5.000	1.031
6.000	.743	6.000	.465	6.000	.376	6.000	1.038
7.000	.744	7.000	.478	7.000	.405	7.000	1.077
8.000	.732	8.000	.485	8.000	.409	8.000	1.074
9.000	.737	9.000	.503	9.000	.440	9.000	1.102
10.000	.726	10.000	.509	10.000	.442	10.000	1.091
11.000	.725	11.000	.516	11.000	.464	11.000	1.105
12.000	.716	12.000	.519	12.000	.463	12.000	1.094

SCUTIL | STERILIZATION CAPACITY UTILIZATION (MONTHLY) AT GRADY

TIME	SCUTIL	TIME	SCUTIL
1.000	.885	19.000	1.118
2.000	.896	20.000	1.120
3.000	.907	21.000	1.122
4.000	.918	22.000	1.124
5.000	.928	23.000	1.126
6.000	.939	24.000	1.127
7.000	.949	25.000	1.128
8.000	.959	26.000	1.129
9.000	.970	27.000	1.130
10.000	1.088	28.000	1.130
11.000	1.101	29.000	1.131
12.000	1.101	30.000	1.131
13.000	1.103	31.000	1.131
14.000	1.105	32.000	1.132
15.000	1.107	33.000	1.132
16.000	1.110	34.000	1.132
17.000	1.113	35.000	1.132
18.000	1.116	36.000	1.131

FOOTNOTES

[1]Fredricks Jaffe and Alan F. Guttmacher, "Family Planning Programs in the United States", Demography, V.5, No.2 (1968), p.922. "Unwanted was defined either the mother or father or both answering negatively to the question: "Before you became pregnant this time, did you want a (another) child?"

[2]ibid

[3]See, Joseph Beasly, "A View From Louisiana", Family Planning Perspectives I, (Spring 1969), pp.2-18, for a description of a corporate form of organization applied family planning.

[4]Models for training purposes have been reported. See R. Scott Moreland and Thomas H. Naylor, "The Carolina Population Center Family Planning Game" Carolina Population Center (June, 1970).

Many theoretical and conceptual models have been proposed but few, if any, have been applied to operating programs. See Curtis McLaughlin, "Roles for Models: As Experienced in the Design of Family Planning Programs for Developing Countries", Carolina Population Center Working Paper, No.8.

Some models have reflected attempts to inappropriately cram family planning into operations research techniques. See, Hector Correa and Joseph A. Beasley, "Mathematical Models for Decision Making Population and Family Planning", Journal of Public Health, V.61, No.1 (January, 1971), pp.138-157.

A model developed by G. E. Tempo is used at USAID and other locations, but it is directed at population policy rather than management of a Family Planning System. See,U.S. AID Contract Reports: 68TMP-119 to 121 and 70MP-87.

A model developed by Kenneth F. Smith (unpublished M.S. thesis, Massachusetts Institute of Technology, 1970) is also being used in a similar manner at AID and some universities.

In addition to policy type models many models exist for projecting population demographs. For example, see D. G. Harvity, F. G. Giesbrecht B. V. Shah, and P. A. Lachenbruch, "POPSIM, A Demographic Micro Simulation Model", Carolina Population Center Monograph Number 12 (University of North Carolina, 1971) pp.45-59.

A patient scheduling model is reported to have been used successfully in New Orleans, but no published reports exist at this time.

Recently Jack Reynolds has proposed a forecasting model for an operating system. See, Jack Reynolds "Methods for Estimating Future Caseloads of Family Planning Programs", Family Planning Perspectives, V.3 (April, 1971),pp.56-61. This is a simple model with a constant annual

discontinuance rate and a given new patient arrival input. The model is so simple that hand calculation is appropriate, but it is similar to the model proposed in this paper in its view of a patient flow. No usage experience has yet been reported.

[5]John D. C. Little, "Models and Managers: The Concept of a Decision Calculus", Management Science, (April, 1970), pp.B466-B485. Also see, Glen L. Urban, "Advertising Budgeting and Geographic Allocation: A Decision Calculus Approach", Alfred P. Sloan School of Management Working Paper, #532-71, 1971.

[6]Glen L. Urban, "Sprinter mod III: A Model for the Analysis of Frequently Purchased Consumer Goods", Operations Research, (September-October, 1970), pp.805-854, for discussion of this type of model.

[7]R. G. Poter "Application of Life Table Techniques to Measurement of Contraceptive Effectiveness," Demography 3, No.2, (1966), pp. 297-304, and C. Tietze, "Intrauterine Contraception: Research Report", Studies in Family Planning, No.18, (April, 1967), pp.1-6.

[8]The term EFFUSE should not be confused with Tietze's "use-effectiveness". Christopher Tietze and Sarah Lewit, "Statistical Evaluation of Contraceptive Methods: Use-Effectiveness and Extended Use-Effectiveness", Demography, V.5, No.2, (1968), pp.931-940. Tietze is referring to the probability of pregnancy in a group of women accepting and using supplies at a clinic. "Extended use-effectiveness" includes the pregnancies during the period of non-use that occurs at discontinuation. In the model presented in this paper, Tietze's use-effectiveness would be roughly equivalent to the total rate $((1-EFFMTH)(EFFUSE)AFERA)$ of pregnancies from actives as in equation 40. Tietze's life table rates can be used to "fit" EFFMTH and EFFUSE to failure data.

[9]Natality Statistics Analysis, National Center for Health Statistics Series 21, Number 1, (HEW, Public Health Service, 1964) pp. 54-55

[10]See, Christopher Tietze, "Early Complications of Abortions under Medical Auspices: A Preliminary Report", Studies in Family Planning, V.2, (July, 1971), pp. 138-43, and Stephen J. Williams, "National Health Planning for Abortion Services: An Operational Analysis", unpublished M.S. thesis Sloan School of Management, MIT, (1971).

[11]The Markovian population $(N_{t,k})$ are also normalized at the end of each period to that $\sum_{k=1}^{NC} N_{t,k}$ equal the total number of non-actives $(\sum_{s=2}^{NS} NSTATE_{t,s})$ and so that $\sum_{k=NC+1}^{2NC} N_{t,k}$ equal the total number of actives. This adjusts for migration and minor lagged effects.

[12] Potter has suggested the use of a stochastic model to determine births averted. See, R. G. Potter, "Births Averted by Contraception: An Approach Through Renewal Theory", Theoretical Population Biology 1, (1970), pp. 251-272. Potter models two renewal processes and uses the differences to estimate births averted. The assumptions underlying the model are significant. There must be homogeneity of women, homogeneity in time, and a long (i.e. infinity) reproductive period. The last assumption inplies births averted are due only to increased spacing and not due to reaching menopause before the desired number of children is exceeded. The homogeneity over time implies that fertility does not change with age and therefore parity and fertility are not related (see footnote 9 for contrary evidence). Homogeneity in time also applies to contraception so that second and third visit continuance must be the same. The model also does not include sterility, mortality, migration, abortion, or private protection.

[13] See, S. Enke, "The Economic Aspects of Slowing Population Growth", Economic Journal, V. 76, No. 1, (March, 1966), pp. 44-56.

[14] Christopher Tietze, "Probability of Pregnancy Resulting from a Single Unprotected Coitus", Fertility and Sterility , VII, No.5, (1960), pp. 485-488.

[15] William H. James, "The Incidence of Spontaneous Abortion", Population Studies, V. 24, No. 2, (July 1970), pp. 242-245.

[16] Sam Shapiro, Ellen W. Jones, and Paul M. Densen, "A Life Table of Pregnancy Terminations and Correlates of Fetal Loss", Milbank Memorial Fund Quarterly, V.40, No.1, (1962), pp. 8-45.

[17] Robert Anthony, Planning and Control Systems: A Framework for Analysis, Graduate School of Business Administration, Harvard University,(1965), p.16.

[18] Anthony defines: "Management Control is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives". ibid, p.17.

[19] EXPRESS was developed by Jay Wurts of Management Decision Systems, Inc., 486 Totten Pond Rd., Waltham, Massachusetts.

[20] See, Appendix One and Ronald O'Connor, "Use of a Simulation Model as a Decision-Support Tool in the Management of Metropolitan Family Planning Programs", unpublished M.S. thesis, Sloan School of Management, MIT, 1971.

[21] Perry D. Cohen and John E. Heye, "The Implementation of Management Science: An Introductory Training Program", unpublished M.S. thesis, Sloan School of Management, MIT, 1971.

[22] See, Philippe Naert, Srinivasa Murthy, "Visit Continuation Rates, Intervisit Times, and their Managerial Implications for Family Planning Administrators: A Case Study of Atlanta", Sloan School of Management Working Paper, MIT, #560-71, 1971, for a discussion of data analysis results.

[23] See, Peter B. Tamblyn, Russel H. Richardson, and Elizabeth S. Ruyle, "Planning for Family Planning", paper presented at the American Public Health Association Meeting, (Oct.1971) for the model experiences as stated by the users in Atlanta.