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A MODEL FOR THE MANAGEMENT OF

A FAMILY PLANNING SYSTEM

613 - 72

Glen L. Urban
Revised June, 1973

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ABSTRACT

This paper describes a planning model designed to be <u>used</u> 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 recruitment, continuance, post partum checkups, switching methods, referral, migration, contraceptive use experience, private protection, method effectiveness, advertising response, follow up, abortion, and medical services. Strategic variables can be linked to the flow parameters to produce capacity requirements and budgetary implications. The model output includes benefit measures of total active patients, couple years of protection, "births protected", and unwanted births prevented. The fertility aspects of births prevented are modeled through a non-stationary Markov process submodel which considers demographic phenomena without burdening the basic flow structure. The input procedures used to process patient visit, outreach, clinic survey, and experimental data are discussed and some empirical results are reported. The combination of data based estimates and subjective judgment is done by "fitting" the model to past observed data. Testing and control are done by "tracking" model performance through conditional prediction, diagnosis, and updating.

The model is implemented in an on-line, conversational program that facilitates evolutionary model building by allowing the user to specify his model options. The application and testing of the model in the Atlanta Area Family Planning System are discussed and the experiences of managers in using the model to gain new insights, forecast, budget, and plan are reported.

A 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?" Growth rates in the U.S.A. in the last five years 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 in the United States.

The need for family planning has been recognized by Congress and the President. Over one hundred million dollars per year have been appropriated through the Tydings bill in order to make contraceptives available to the indigent. The National Center for Family Planning Services of the Department of Health, Education, and Welfare grants money to metropolitan and rural areas to develop local family planning services. In addition, state health departments, county health departments, hospitals, and private groups, such as Planned Parenthood, provide funds and services

at the local level.

The recipients of the grants have the task of planning and control-ling a system which best serves the needs of its clientele who wish to prevent unwanted births. Managers plan and budget for post partum and non-post partum programs. They allocate resources for recruiting new patients through outreach workers, but trade off this allocation against resources used to maintain high rates of continuing contracep-tive usage. They determine the contraceptive methods to be used and imple-ment policies on such matters as abortion and sterilization.

The purpose of this paper is to describe a model designed to be used by managers of family planning delivery systems to: help them better understand their systems; enable them to make better forecasts; and, provide them with a tool for planning. The paper will begin with a description of the model structure, output, and input procedures. Then the evolutionary implementation of the model will be discussed and an application of the model to the Atlanta Area Family Planning System will be presented. The paper will close with a discussion of future work and the applicability of the model methodology to developing countries.

MODEL STRUCTURE

The basic approach of this work is to build a macro process model.[3] 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.[4] 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. This type of model is feasible since in most U.S. family planning programs, a record is made of each patient visit and therefore, detailed flow parameters can be estimated. 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 parameters, overall acceptance and birth rate effects can be encompassed.

OVERALL FLOWS

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

supply of pills or retained their IUD) and have not missed their next appointment. The not-active group is 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 acceptance. Actives return to the not-active class by discontinuing contracepion (not returning for an appointment) or by becoming pregnant. Likewise, not-active/not-pregnant people may become pregnant. The final flows are actives switching methods, referral between agencies, and migration rates into and out of the target group.

For purposes of model development, the not-active section of the target group is denoted by NSTATE and further divided into mutually exclusive and collectively exhaustive subsections as follows:

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

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	Outreach exposure (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 are the not-active/not pregnant group. The division into these additiona
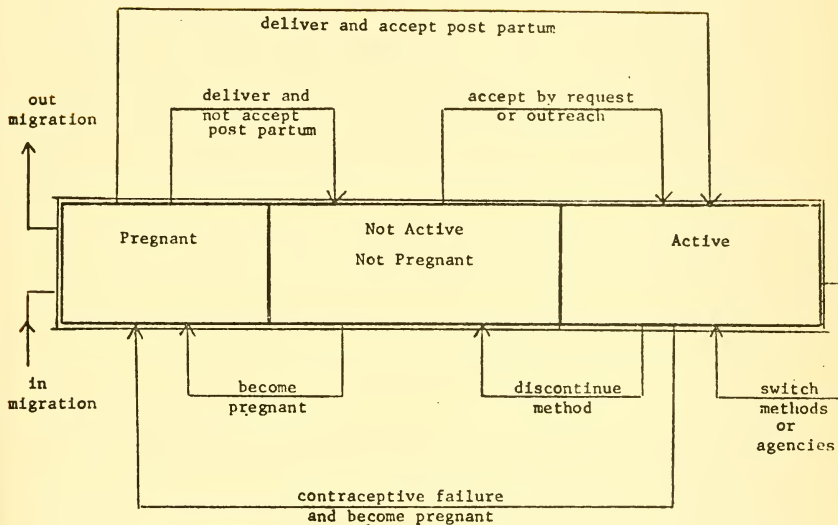
FIGURE ONE: Target Group Sections and Interaction

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 the system (s=2) may respond differently to a visit from an outreach visitor than those who had 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 outreach 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.

NON POST-PARTUM FLOW

The detailed non post-partum flow is represented in figure two. New patients enter from the not-active/not-pregnant group as the result of a home visit from an outreach worker or a request for an 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 development. 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 workers from agency a, who are in an eligible state s (s=2, 3,...NS) (see box 1 in figure two) is:
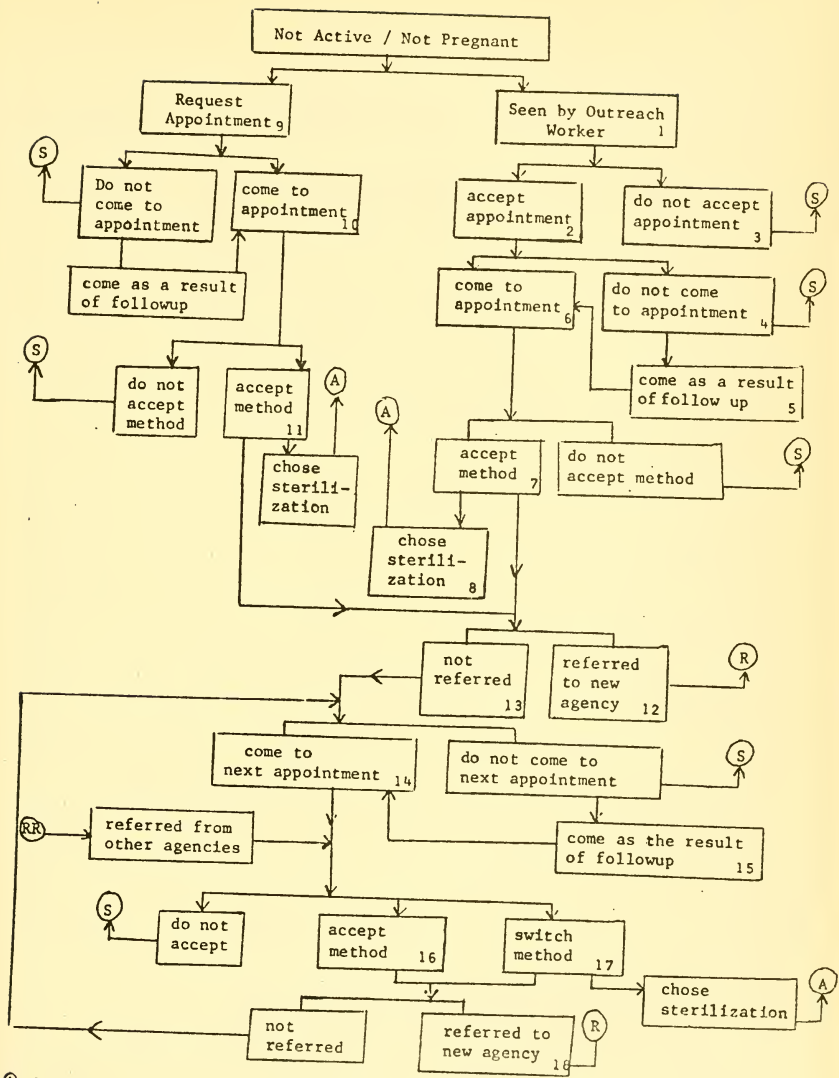
Ⓐ Return to active group as sterilized
Ⓢ Return to states in not-active/not-pregnant group
Ⓡ To another agency clinic because of referral   ⓇⓇ Come to agency because of referral

FIGURE TWO: Non-Post Partum Agency Flow Structure

(1) $\text{OUTSEE}_{t,a,s} = \text{NRCALL}_{t,a} \ \text{PRFIND}_a \ \text{NSTATE}_{t,s} \ / \text{TARGP}_t$

$\text{OUTSEE}_{t,a,s}$ = number of people in state s that <u>out</u>reach workers from agency a <u>see</u> in month t

$\text{NRCALL}_{t,a}$ = <u>n</u>umber of <u>r</u>ecruitment outreach <u>calls</u> made in month t by agency a

PRFIND_a = <u>per</u>cent of outreach calls of agency a that result in <u>find</u>ing a person in target group

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

TARGP_t = number of people in the <u>targ</u>et grou<u>p</u> at time t

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 1). This assumes a random calling pattern with respect to states within the target group. Equation 1 also reduces effectiveness by the fraction of ineligible people (active or pregnant) since $\text{NSTATE}_{t,s}$ 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 :

(2) $\text{OUTAPT}_{t,a} = \sum_{s=2}^{NS} \text{OUTSEE}_{t,a,s} \ \text{PDESIR}_{a,s}$

$\text{OUTAPT}_{t,a}$ = number of people visited by <u>out</u>reach worker who make an <u>ap</u>pointment in month t at agency a

$\text{PDESIR}_{a,s}$ = <u>per</u>cent of people visited who are in state s and who <u>desire</u> an appointment at agency a

PDESIR is subscripted by state, since people may respond differently based on their past experience and is subscripted by agency to allow differences between outreach workers of agencies.

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

$$(3) \quad COMO_{t,a} = OUTAPT_{t,a} \quad PCOMO_a$$

$COMO_{t,a}$ = number of people who <u>come</u> in month t to <u>o</u>utreach generated appointment at agency a before <u>fol</u>low up effort

$PCOMO_a$ = <u>p</u>ercent of people who will <u>come</u> to their appointment made with <u>out</u>reach worker from agency 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:

$$(4) \quad COMOFU_{t,a} = (OUTAPT_{t-1,a} - OUTCOM_{t-1,a}) \ (NFCALL_{t,a}/TNCOM_{t-1,a}) \ PFFIND_a \ PCOMFU_a$$

$COMOFU_{t,a}$ = number of people to <u>come</u> to <u>o</u>utreach generated appointment after <u>fol</u>low <u>up</u> in month t and agency a

$OUTCOM_{t,a}$ = $COMO_{t,a} + COMOFU_{t,a}$

$NFCALL_{t,a}$ = <u>n</u>umber of <u>fol</u>low up <u>calls</u> by outreach workers of agency a in month t

$TNCOM_{t-1,a}$ = <u>t</u>otal number of people who did <u>n</u>ot <u>come</u> to a scheduled appointment in month t in agency a

$PFFIND_a$ = <u>p</u>ercent of <u>f</u>ollowup visits that result in <u>find</u>ing the person who did not come

$PCOMFU_a$ = <u>p</u>ercent who <u>come</u> of those contacted by a <u>fol</u>low <u>up</u> visit

The first term of the equation is the number who did not come to their out-reach generated appointment last month. The second term is the percent of all people who did not come to a scheduled appointment last month who re-

ceived 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 last terms in equation four reflect the ability to find the person again (PRFIND) and their response in terms of coming to the appointment. Follow up out-reach visits are explicitly modeled, but the basic rates of coming to an appointment (e.g. PCOMO in equation 3) may reflect mail, phone reminders, or other non-outreach follow up. Those who do not come to their appoint-ment are returned to state four – the state defined to include people who had some outreach experience,but did not come.

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

(5) $ACCPTO_{t,m,a} = (COMO_{t,a} + COMOFU_{t,a})\, PACPTO_a\, FACPTO_{m,a}$

$ACCPTO_{t,m,a}$ = number of people in month t who <u>acc</u>ept method m at agency a as a result of recruitment <u>out</u>reach

$PACPTO_a$ = <u>p</u>ercent of people who <u>acc</u>ept a contraceptive method after visit from <u>out</u>reach worker of agency a (see equation 6)

$FACPTO_{m,a}$ = <u>f</u>raction of those who <u>acc</u>ept after <u>out</u>reach who accept specific method m at agency a

The percent who accept a method may be less than one because (1) the person learns something about contraception that is viewed 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 reference acceptance value . The waiting time phenomena is

modeled by making the reference fraction that accept a function of
the degree of capacity utilized.

(6) $PACPTO_{t,a} = PACTOC_a \; \overline{RCAP}_a \; (UCAP_{t,a}/TCAP_{t,a})$

> $PACTOC_a$ = percent of people who would accept a contraceptive
> method after a visit from an outreach worker at agency a if the
> service was convenient.

> $\overline{RCAP}_a$ = response function for capacity at agency a
> = defines an index between zero and one dependent on
> the percent of capacity utilized at agency a.

> $UCAP_{t,a}$ = utilized capacity in month t at agency a

> $TCAP_{t,a}$ = total capacity in month t at agency a

The response function (RCAP) would usually have values near one until capa-
city is exceeded, at which point the index would drop rapidly. Those who
do not accept are returned to state 2 (never) or 3 (ever) depending upon
whether they had a previous record of acceptance.

Request for Service: Requests for an appointment may be due to advertising,
the indirect effects of outreach, word of mouth-communication, or spontaneous
action. These are modeled by assigning a request rate to each state and a
time varying index so that the number of people requesting (see box 9) is:

(7) $REQ_{t,a,s} = NSTATE_{t,s} \; PREQ_{a,s} \; INDREQ_{t,a}$

> $REQ_{t,a,s}$ = number of people from state s who request an appoint-
> ment at agency a in month t

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

> $PREQ_{a,s}$ = percent of people in state s who request an appoint-
> ment at agency a in month t

> $INDREQ_{t,a}$ = time index for requests (nominally 1.0)

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 function of the advertising expenditure. The number of people in state 5 is:

(8) $\quad \text{NSTATE}_{t,5} = \sum_{\substack{s=2 \\ s \neq 5}}^{NS} \text{NSTATE}_{t,s} \; \overline{\text{RADV}}_s \; (\text{ADV}_t) + \text{NSTATE}_{t,5}$

$\overline{\text{RADV}}_s$ = response function to advertising expenditure (ADV_t). It is the percent of people in state s who become aware of the advertising in a month with advertising expenditure ADV_t. The usual form would show decreasing returns to advertising and a saturation level.

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

(9) $\quad \text{NSTATE}_{t+1,s} = \text{NSTATE}_{t,5} \; \text{ADFGET}_s + \text{NSTATE}_{t,s}$

ADFGET_s = percent of advertising aware people who forget from 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.

The number of people who came to the requested appointment (see box 10) is:

(10) $\quad \text{COMR}_{t,a,s} = \text{REQ}_{t,a,s} \; \text{PRCOM}_a$

$\text{COMR}_{t,a,s}$ = number of people in state s who come in for requested appointment in month t at agency a

$\text{REQ}_{t,a,s}$ = number of people from state s who request an appointment at agency a in month t.

PRCOM_a = percent of those who request an appointment who come without follow up at agency a

The number who accept a method after coming (see box 7) is:

$$(11) \quad ACCPTR_{t,m,a} = \sum_{s=2}^{NS} REQCOM_{t,a,s} PACPTR_{a,s} \overline{RCAP}_a (UCAP_{t,a}/TCAP_{t,a}) \ FACCPT_{m,a,s}$$

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

$REQCOM_{t,a,s}$ = $COMR_{t,a,s}$ if there is no outreach follow up of requests for appointments or $COMR_{t,a,s}$ adjusted for follow up as in equation 4 if there is outreach follow up.

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

$\overline{RCAP}_a$ = <u>r</u>esponse function for <u>cap</u>acity at agency a (see equation 6 for further explanation)

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

<u>Referral and Switching Methods</u>: Referral in family planning systems usually operates on the total first time acceptors. This number of non-post partum acceptors is the sum of those due to outreach and requests.

$$(12) \quad ACCPT_{t,m,a,d} = ACCPTO_{t,m,a} + ACCPTR_{t,m,a}$$

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

$ACCPTO_{t,m,a}$ = <u>accept</u>ance from <u>o</u>utreach (see Eq. 5)

$ACCPTR_{t,m,a}$ = <u>accept</u>ance from <u>r</u>equest (see Eq. 11)

Referral may take place because the patient lives near a clinic or because the capacity of a particular clinic is stressed. For example, a post partum hospital may refer patients to a local county health department. 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 12) is:

$$(13) \quad ACCPT_{t-A,m,a,d} = ACCPT_{t-A,m,a,d} + \sum_{\substack{aa=1 \\ aa \neq a}}^{NA} ACCPT_{t-A,m,aa,d} \, PREF_{a,aa,m} PRCOM_{a,aa}$$

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

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

$PREF_{a,aa,m}$ = percent of initial acceptors of method m 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 (d=1),
equation 13 can be used to refer people of any depth of experience when
PREF is further subscripted by d. Such alternative on-line subscripting
will be discussed later in this paper.

Switching of methods (see box 16) is simply modeled by a first
order Markov transition from one method to another within an agency where
the rate of switching can have different values for women using different
methods and with different numbers of past acceptances of the method.

Continuance: Continuation is modeled by specifying the number of people
who will return for their next visit. The alternative would be to use
time as the basic unit of continuance (i.e., percent of patients active
n months after acceptance). In this model, visit continuation is preferred
since (1) costs and service are incurred at visits, (2) client data is

visit based, (3) phenomena such as referral and switching are visit related, and (4) managers think in terms of the visit as the underlying program event. In situations where patient visit records are not available, time dependent rates could be derived from survey data and be converted into visit to visit rates by dividing the time axis into visit intervals and calculating the percent who continue from visit d to d + 1.

The number of people who return for their next visit (see box 13) is:

$$(14) \quad COMC_{t,m,A,d} = ACCPT_{t-A,m,a,d} \; PCOMC_{m,a,d}$$

$COMC_{t,m,A,d}$ = number of people <u>com</u>ing to their <u>c</u>ontinuing appointment in month t having last accepted method m d times at agency a

$ACCPT_{t-A,m,a,d}$ = number of people who <u>acc</u>epted in month t-A method m at agency a for the dth time

$PCOMC_{m,a,d}$ = <u>p</u>ercent of people who <u>com</u>e for <u>c</u>ontinuing appointments for method m at agency a after d visits

$A=APT_{m,a,d}$ = interval between <u>ap</u>poin<u>t</u>ment d and d+1 for method m at agency a

This number is then updated to reflect follow up (see box 14) in a similar manner to equation 4 to define:

$CONCOM_{t,m,a,d}$ = after outreach follow up the number of people with <u>con</u>tinuing appointments <u>com</u>ing 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:

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

$PERNEG_{m,d}$ = <u>per</u>cent of people who have accepted d times and last accepted method m who have a <u>neg</u>ative 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,..., NM, where NM is the number of methods):

(16) $NSTATE_{t,5+m} = \sum_{d=1}^{ND} (ACCPT_{t-A,m,a,d} - CONCOM_{t,m,a,d}) PERNEG_{m,d} + NSTATE_{t,5+m}$

Those who come may accept (see box 15 and equation 7), switch methods (box 16), and be referred (see box 17 and equation 13). Those who do not come to their appointment may obtain contraceptives through private channels and they are identified as a separate group, but they are not included in the public system manager's definition of "active". At the end of the period all people are in a non-active ($NSTATE_{t,s}$) or active ($ACCPT_{t,m,a,d}$) so in the next period, equations 1 to 15 again process them through the non-post partum flow.

POST PARTUM FLOW

Figure three describes the detailed post partum acceptance and continuance flow. If a woman delivers at a hospital with a post partum family planning program she may be seen by a family planning worker (box 2) and may accept a method immediately (box 3) or subsequently at a six week post partum check up (boxes 6, 7). If a woman is not seen immediately post partum, but comes to the six week check up, she may become an acceptor. In all cases of acceptance, except sterilization (box 1), the repeat visits (boxes 9, and 5) are modeled as in the non-post partum flows with follow

Deliver in Month t

Not Seen by F.P. Worker

Request Sterilization (A) 4

Seen by F.P. Worker 2

Do Not Come to 6 Week Post Partum Appointment (S)

Accept 6 Week Post Partum Appointment 6

Accept Immediately 3

Do Not Accept (S)

Do Not Come (S)

Come to 6 Week Appointment 4

Do Not Come (S)

Come to F. P. 6 Week Post Partum Appointment 7

Come As Result of Follow-Up

Come as Result of Outreach Follow-Up

Do Not Accept Method (S)

Accept Method 8

Choose Sterilization (A)

Do Not Accept Method (S)

Accept Method Again 5

Switch Methods

Referred to New Agency (R)

Not Referred

Chose Sterilization

Come to Next Appointment 9

Do Not Come (S)

Referred from Other Agency (RR)

Come as Result of Follow-Up

Do Not Accept Method (S)

Accept Method Again 10

Switch Methods

Chose Sterilization (A)

Referred to New Agency (R)

Not Referred

Come to Next Appointment 11

Do Not Come (S)

Referred from Other Agency (RR)

Come as a Result of Outreach

Do Not Accept (S)

Accept Method Again

Switch Methods

Chose Sterilization (A)

Not Referred

Referred to New Agency (P)

(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 clinic because of referral

FIGURE THREE

A Post Partum Agency Flow Structure

FIGURE FOUR: Pregnancy and Birth Flows

18.

up, referral, and method switching opportunities. Those who accept immedi-
ately are followed separately until they have made two visits (boxes 4, 5)
at which point they are aggregated with other people who have made two
post partum visits (box 10). The equations documenting these flows are
analogous to equations 1 to 16. Parameters are defined for each flow
rate and appointment lags are considered. Because of the similarity to
previous equations and space restrictions, these equations are not included
here.[5]

PREGNANCY - ABORTION - BIRTH FLOW

With the changes in the populations of actives and non-actives
determined by acceptance and continuance of post partum and non-post
partum patients, the next step is to specify the pregnancy rates based
upon demographic fertility data and model the effects of abortion in
order to define the number of deliveries and live births in the target
group. This flow is described in figure four.

Actives become pregnant due to method failures (boxes 4, 5)
and non-actives become pregnant (boxes 1, 2, 3) at rates dependent upon
whether they use private (non-system dispensed) contraceptives. If
people drop out of the public system and use private channels of distribu-
tion, the model tracks this phenomena and its demographic impact.

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 boxes 4, 5):

$$(17) \quad PREGA_{t,m} = \sum_{a=1}^{NA} \sum_{d=1}^{ND} ACTIVE_{t,m,a,d} \, (1-EFFMTH_m) \, EFFUSE_{m,d} \, AFERA_t \, SEAFER_t \, ILF$$

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

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

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

$AFERA_t$ = average fertility of actives - probability of pregnancy in a month

$SEAFER_t$ = index of seasonality on fertility[6]

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

The first term in equation 17 reflects actives properly using methods and the second term defines those not properly using methods. The rate of proper usage (EFFUSE) varies by method.[7] 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 usage. For example, a woman at the post partum check up may accept pills,but not have as great a desire to use them as a woman who has returned for her second supply and proven her commitment to contraception.

The number of pregnancies within the non-active group is the number of not active and unprotected women times their fertility rate plus the number of non-actives using privately dispensed methods times the method ineffectiveness and their fertility rate.

The model defines two average fertility rates - one for actives and one for non-actives. The average fertility of actives (AFERA) in a family planning system will be higher than the non-active rate 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, the conditional fertility rate is approximately seventy five percent greater than no births, so actives will have a higher fertility than non-actives.[8] In addition to parity differences, other demographic effects may cause the average fertility of actives to be different than non-actives. For example, actives may tend to be older so that age and parity cohorts might need to be considered. 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 number of people from each cohort in the active (A) and non-active (NA) groups in each period used in the weighted average is specified by a non-stationary Markov process. The Markovian states will be denoted by k where

$k = 1, NC$ for not-active in each cohort (NC=total number of cohorts)

$k = NC + 1$ to $2NC$ for active in each cohort

$k = 2NC + 1$ to $3NC$ for pregnant in each cohort

The number in each Markovian state at time t is:

$$(18) \quad N_{t,k} = \sum_{kk=1}^{3NC} N_{t-1,kk} \, P_{k,kk}^t$$

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

$P_{k,kk}^t$ = transition probability to state k from state kk in month t

The transition probabilities are determined from the model flow outcomes and the cohort fertility rates. For example, the transition from non-active to active is specified by the overall non-post partum first acceptance rate of the model multiplied times an index to reflect differential acceptance rates for each cohort. Similarly, other transitions are defined by internally generated model flow rates. In this manner the cohort composition of actives and non-actives can be tracked and an appropriate average fertility for actives and non-actives can be calculated.

The abortion flows shown in Figure Four represent the desire for abortion (box 6) and the rates of legal and illegal abortion (boxes 7 and 12). They interact since if the acceptance rate (box 8) for legal abortion increases, illegal abortion may decrease. Abortion outcomes (boxes 13, 14, 16, 9, and 10) and post abortion contraceptive care (box 15, 11) flows are modeled similarily to previous equations.

The resultying pregnancies not terminated by abortion (box 17) become the input after nine months to the post partum flow described in Figure Three. This completes the model flow structure description.

MODEL OUTPUT

The most commonly used measures of family planning systems performance are the number of total active patients

and the number of new patients per period. The model output includes these measures, as well as, the number of births, the number of pregnancies, the agency visit capacity utilized, the costs, and a detailed analysis of the source of new patients.

Acceptors are processed to obtain active patients — those who accepted at their last visit and are not late for their next visit.

$$(19) \quad ACTIVE_{t,m,a,d} = \sum_{T=t-A+1}^{t} ACCPT_{t,m,a,d}$$

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

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

In order to compare the model output to client record system output, it is also useful to define another active measure as those who complete an appointment less than X months (usually 2 months) after the scheduled appointment date. Equation 19 is theoretically more correct since it uses actual appointment intervals, but in the real data systems scheduled appointment intervals are more operational. The model produces the number of actives by both definitions for ease of tracking actual data and planning. The number of actives are subscripted by time, method, and agency, so totals can be made on any dimension to allow comparisions between agencies, methods, or agencies and methods. Since active patients also are known by the number of times they have accepted, the number of acceptances can be multiplied by the monthly appointment interval to find the time in the system for each group of actives. 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,

mortalities, and morbidities due to legal and illegal abortion also may be displayed. The volume of medical services dispensed may be assessed. These are specified by multiplying the number of people who make a visit ($ACCPT_{t,m,a,d}$) times the percent who receive a particular service on that particular visit. Medical outputs can include the number of PAP tests, breast exams, pelvic exams, annual medical checkups, V.D. screens, and sickle cell tests.

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:[9]

$$(20) \quad CYP_{y,a} = \left[\sum_{m=1}^{NM-1} \sum_{T=t-12}^{t} \sum_{d=1}^{ND} ACTIVE_{T,m,a,d}(EFFUSE_{m,d})(EFFMTH_m) + \sum_{T=t-12}^{t} ACTIVE_{T,NM,a,1} \right] \Bigg/ 12$$

$CYP_{y,a}$ = <u>c</u>ouple <u>y</u>ears of <u>p</u>rotection in year y at agency a

$EFFUSE_{m,d}$ = fraction of acceptors <u>eff</u>ectively <u>use</u> method (see equation 17 for further discussion)

$EFFMTH_m$ = <u>eff</u>ectiveness of <u>meth</u>od m (see equation 17)

$ACTIVE_{t,m,a,d}$ = number of <u>active</u> patients in time t at agency a that have accepted method m at the dth visit

The first term is the couple years of protection produced by actives of all methods except sterilization. The second term adds the protection from sterilization (method NM, d=1). Since IUD users may be protected even if they do not return for their appointments, there is an option in the model to increment the couple years of protection by a pseudo active class of IUD users who missed appointments. The number of privately protected people could be added in equation 20 if the total couple years of protection were desired.

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. This depends upon: (1) the uncontracepted fertility of the active group, (2) the protection that would result during the term of pregnancy, and (3) the practices people would have followed to prevent or terminate pregnancy if the system did not exist. The first effect 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 a reference average fertility rate that represents the average fertility before the contraception system began to operate. All three effects are included in the incremental unwanted births prevented which can be obtained by comparing two runs of the model. The first would be with the family planning system and the second would be without any system programs (no acceptance or continuance), but with the appropriate parameters for rates of private protection and abortion. 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.[10] When

the cost for an incremental birth prevented is calculated, realistic budgeting decisions can be made if the value of a birth prevented can be estimated.[11]

MODEL INPUTS

In most family planning systems, patient visit records are maintained which longitudinally document each clinic visit. From a modeling point of view, a sample of longitudinal histories is sufficient, so the availability of exhaustive data is an unexpected advantage and it allows estimation of parameters whithin detailed subgroups of the model flow (e.g., post partum immediate acceptors versus 6 week first acceptors). This data can be processed by a large classification analysis to determine acceptance, continuance, referral, and switching rates, as well as average visit intervals. This section will present some of the results of analyzing the Atlanta client record data.

A client record includes among other data: (1) patient ID number, (2) clinic code, (3) method selected, (4) date of visit, (5) date of next appointment, (6) date of last pregnancy termination, and (7) indication of referral action, if taken.

In processing client record data, a time period must be specified over which the parameters are assumed to be stationary. In the Atlanta analysis, a sixteen month period was used since non-stationarity was expected over a longer period. At the end of this period three possible states exist for people:

> (1) Prospective - next appointment date has not yet
>   arrived.
>
> (2) Delinquent - less than two months late for appointment.
>
> (3) Inactive- more than two months late for appointment.

These end effects are critical in the estimation of continuance rates. The continuation rate in the model is the percent of people who return for their next visit ($PCOMC_{m,a,d}$ see equation 14). Calculating the continuation rate was complicated since prospectives and delinquents had not completed their next visit. One alternative was to ignore any information contained in the end of the tape. This was deemed unwise since with a visit interval of six to twelve months as occurs for IUD's, much information would be lost. Rather, estimates were made for the continuance rates of the people in the end point states.

The estimation equation for continuance rates is:

$$(21) \quad PCOMC_{m,a,d} = \frac{RETURN_{m,a,d+1} + PP_{m,d} \cdot PROSP_{m,a,d+1} + PD_{m,d} \cdot DELINQ_{m,a,d+1}}{TOTAL_{m,a,d}}$$

$PCOMC_{m,a,d}$ = percent of people who <u>come</u> for their d+1 continuing appointment for method m at agency a after completing d visits.

$RETURN_{m,a,d+1}$ = number of people using method m at agency a who return for their d+1 visit before the end of the estimation period.

$PROSP_{m,a,d+1}$ = number of people who completed visit d, but whose d+1 appointment data has not arrived by end of the estimation period. They are <u>prosp</u>ective.

$DELINQ_{m,a,d+1}$ = number of people who completed visit d and are less than two months late for their d+1 visit at the end of the estimation period. They are <u>delinq</u>uent.

$TOTAL_{m,a,d}$ = <u>total</u> number of people who completed visit d during the estimation period.

$PP_{m,d}$ = <u>p</u>ercent of <u>p</u>rospective patients who will return for their d+1 appointment after making d visit.

$PD_{m,d}$ = <u>p</u>ercent of <u>d</u>elinquent patients who will return for their d+1 appointment before their scheduled appointment date plus two months.

The best estimate of $PP_{m,d}$ is the continuation rate itself PCOMC. This is because all patients (TOTAL) were at one time "prospective." PD is estimated by examining the records of a group of delinquents and empirically finding the percent who return. Substituting PCOMC for PD, equation 21 becomes:

$$(22) \quad PCOMC_{m,a,d} = \frac{RETURN_{m,a,d+1} + PD_{m,d}DELINQ_{m,a,d+1}}{TOTAL_{m,a,d} - PROSP_{m,a,d+1}}$$

This is the equation used to estimate continuance rates.

Table One presents the visit continuation rates for each method, agency, and visit number. The continuance rates in almost all cases increased as the number of visits increased. There were real differences between agencies. The counties (Dekalb and Fulton) had the highest continuation rates. This was probably due to the good service and follow-up rendered by Public Health nurses trained in epidemiology. Planned Parenthood pill continuance was high, but IUD continuance was relatively low. Grady injection and IUD continuance rates were high, while pill rates were low.

Continuance rates define if a person will return for a next visit and visit intervals describe when a person returns. Table Two describes the overall distribution of visits relative to the scheduled appointment interval. Over 80 percent of the women came early. IUDs had the longest visit interval of approximately five months. Pills had an interval value of about four months and injections had an interval of

Table One: Visit Continuation Rates - 1971 Atlanta, Georgia[*]

	VISITS			
	1 to 2	2 to 3	3 to 4	4 to 5
GRADY-Postpartum				
Pill	.59 [Δ]	.72	.76	.85
IUD	.76 [Δ]	.77	.79	.87
Injection	.76 [Δ]	.90	.89	.94
GRADY-Non Postpartum				
Pill	.59	.72	.75	.84
IUD	.71	.78	.80	.86
Injection	.78	.89	.89	.94
PLANNED PARENTHOOD				
Pill	.67	.78	.81	.89
IUD	.65	.66	.74	.78
FULTON COUNTY				
Pill	.69	.87	.90	.92
IUD	.87	.93	.90	.91
DEKALB COUNTY				
Pill	.75	.84	.87	.91
IUD	.71	.77	.78	.80

[Δ]Includes only those whose first visit was at six weeks appointment.

[*]Maximum standard deviation of estimate is .02.

(No continuation rates reported if less than 25 people.)

Table Two: Overall Distribution of Visit Intervals

<u>Class</u>

1	Less than 25% of scheduled appointments	13.1%
2	25% to 75% of scheduled appointments	22.2%
3	75% to 100% of scheduled appointments	46.5%
4	Within 2 months of appointment (delinquent)	13.3%
5	Between 2 months and 6 months after appointment	4.9%

a little under three months. These averages were substantially less than the suggested appointment intervals of twelve months for IUDs, six months for pills, and three months for shots. The mean visit intervals did not vary substantially by the number of visits. Although the model allows for variation by depth ($APT_{m,a,d}$), the Atlanta data did not indicate the need for variation over the depth subscript.

If a woman returns for a visit she can continue use of the same method or switch methods. Table Three presents the method switching rates. Over ten percent of the women using IUDs switched from IUDs to pills at each visit. These rates continued high through- out the visit sequences and reflected a continuing occurrence of side effects. The switching rate of IUDs to pills was especially high at Planned Parenthood (i.e., 25 percent). The highest rates of switching from IUDs to pills were observed for those who also switched agencies from Grady to Planned Parenthood or counties. Apparently these agencies are less loop prone than Grady. Switching from pills to IUDs was low (about one to three percent) at all agencies except Grady. At Grady the rate was ten percent on the first visit, but dropped to five percent by the fifth visit. In general, the switching rates reflected the attempts by women to find the best contraceptive method for them- selves.

In addition to continuance and switching, the client record data was used to estimate the conditional probabilities of the post partum flow. Overall, high post partum acceptance rates were found. Seventy percent of pregnancy terminations led to acceptance. Within the process of acceptance it was found that a little less than one half of the women were seen immediately post partum by a family planning worker. Seventy percent

Table Three: Method Switching Rates for Patients
Continuing from Visit d to d+1

		Planned Parenthood		Counties	
		Last Visit Planned Parenthood	Last Visit Grady	Last Visit at County	Last Visit at Grady
Visit 1-2	Grady				
IUD-Pill	10.2%	25.6%	54%	6.6%	20.5%
Pill-IUD	10.7%	2.8%	2.9%	2.6%	2.6%
Visit 2-3					
IUD-Pill	12.0%	25.1%	43%	10%	13%
Pill-IUD	8.1%	1%	3.9%	1.2%	1%
Visit 3-4					
IUD-Pill	13.9%	29.1%	35.8%	11%	33%
Pill-IUD	6.6%	.9%	2.3%	2.2%	6%
Visit 4-5					
IUD-Pill	12.6%	33%	43%	6.7%	6.7%
Pill-IUD	5.5%	1%	1.4%	1.2%	1%

of those seen immediately returned for a six week check-up. However, sixty-three percent of those not seen immediately post partum also returned. Virtually all women who returned for a visit accepted a method. The acceptance rate for those who experienced a method failure ("evers") was almost equal to the rate of new patient ("nevers") acceptance, but "evers" tended to accept more reliable methods. Referral was high at the Grady Clinic where 25 percent of the new patients were referred to the county clinics at the six week visit. Another twenty percent switched from Grady to Planned Parenthood clinics.

The analysis of the client record data yields estimates of the model's acceptance and continuance parameters. In the United States such record data is required at all agencies who receive funding from the National Center for Family Planning Services of HEW. Although the data quality may not be as high as in Atlanta, good estimation of the flow parameters can be obtained in most U.S.A. programs.[12]

In addition to client record data, outreach records, special sample surveys, demographic studies, and experiments can be used to estimate parameters of use experience (equations 15 and 16), private protection, advertising, migration, and fertility.

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 estimation 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 conditional predictions 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, outreach visits were not made, 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) corrective program action is taken, the input is adjusted, and the model refitted 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 were available, then the model would be elaborated as managers desired more detail and input data became available.

EVOLUTIONARY IMPLEMENTATION OF MODEL

The model is computerized as an on-line, conversational program so that it will be easy to use and so managers can feel in control of the system.

The basic approach to evolution is through a series of on-line questions which specify the nature of the model to be considered. First the number of agencies to be considered are identified and then the types of programs (post partum or non-post partum, or both) they offer are defined. Next the contraceptive methods available in the system are indicated. The options to be included in this version of the model are then selected. The options are: (1) outreach recruitment, (2) outreach follow up, (3) referral, (4) method switching, (5) migration, (6) private protection, (7) advertising, (8) abortion, (9) agency capacity, (10) cost-effectiveness, (11) medical services, and (12) demographics. 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 can be obtained by fully dividing the non-actives and indicating the desire for consideration of indirect outreach and advertising. The specification section is used to set up the model structure and generate the conversational input questions that are required. All inputs are requested by English language questions and only the questions relevant to the selected options are asked.

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, and two non-active states (pregnant and all other non-active) are selected, the on-line input conversation will be very short. Only the basic acceptance, continuance, and birth rates are needed. 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 outreach, referral, or capacity. As each option is added, he can make his own judgment about the time and cost trade-offs of further elaboration.

More technically trained users of the model can access variables directly and change their subscripting. For example, if outreach records do not include the state of the non-actives (e.g., never-ever in system), the state subscript on the percent who will make an appointment (PDESIR$_{a,s}$ in equation 2) could be dropped. Although the model structure is reasonable in its subscripting, it is foreseeable that conditions might exist that could require consideration of new subscripts for almost any input. As another example, it might be that the composition of method selection is trending towards pills, so that the faction accepting each method (e.g., FACCPT in equation 11) would require a time subscript. Finally, a subscript can be added to the appointment interval (APT$_{m,a,d}$) to allow specification of a distribution about the average appointment interval. This would allow the model to encompass skewed patterns of visits (e.g., very long intervals between visits for some loop users). The capabilities to change subscripting on-line allows rapid and efficient customization of the model to specific decision environments.

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-ordination and planning of the system. 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 members of its staff, a client record system was instituted in Atlanta in 1968. The data was carefully obtained and processed by CDC, so the model estimation and testing described in the previous section could be effectively carried out.

The model application took place at two levels. At the service granting 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.[13] 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 the Grady Hospital program was modeled as one post partum and one non-post partum program. 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 advertising, 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 desire for comprehensiveness. As the evolution proceeds, different levels of models will exist 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 managers.

MODEL INPUT AND "FITTING":

The basic source of input was the Center for Disease Control and its client record system. 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 2). Contraceptive method failure rates were based on a private study by Christopher Tietze of 2000 post partum patients from 1968-69. Since the current state of evolution at the applied level did not include abortion, advertising, or demographics, many of the more difficult input problems were avoided. 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 basing of the recruitment parameters and enable follow up outreach parameters to be estimated.

Initial data estimates were made based on the client record 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 produced by alternate data analysis assumptions and statistical variance, the model was very sensitive. Therefore, the estimates were tuned to produce the best fits. The fit for the total number of actives is shown in figure five. 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 fit past data encouragingly well, such fits from the non-linear estimation procedure were the result of considerable massaging of the data. The testing of the model was based upon comparing actual and predicted patient flows over a six month period of saved data and over a real twelve month period.

Saved Data   June 1970 to December 1970 data were not used in the data esti- mation procedures and were saved for predictive testing. Conditional fore- casts were made for the July 1970 to December 1970 period based on the June 1969 to June 1970 data estimation. This initial prediction is shown in figure five.

Figure Five

ACTIVE FAMILY PLANNING PATIENTS AT MAJOR SERVICE AGENCIES
IN ATLANTA, GEORGIA USING MODERN METHODS

Actual ·———·
Best model fit x —— x
Predicted *----*
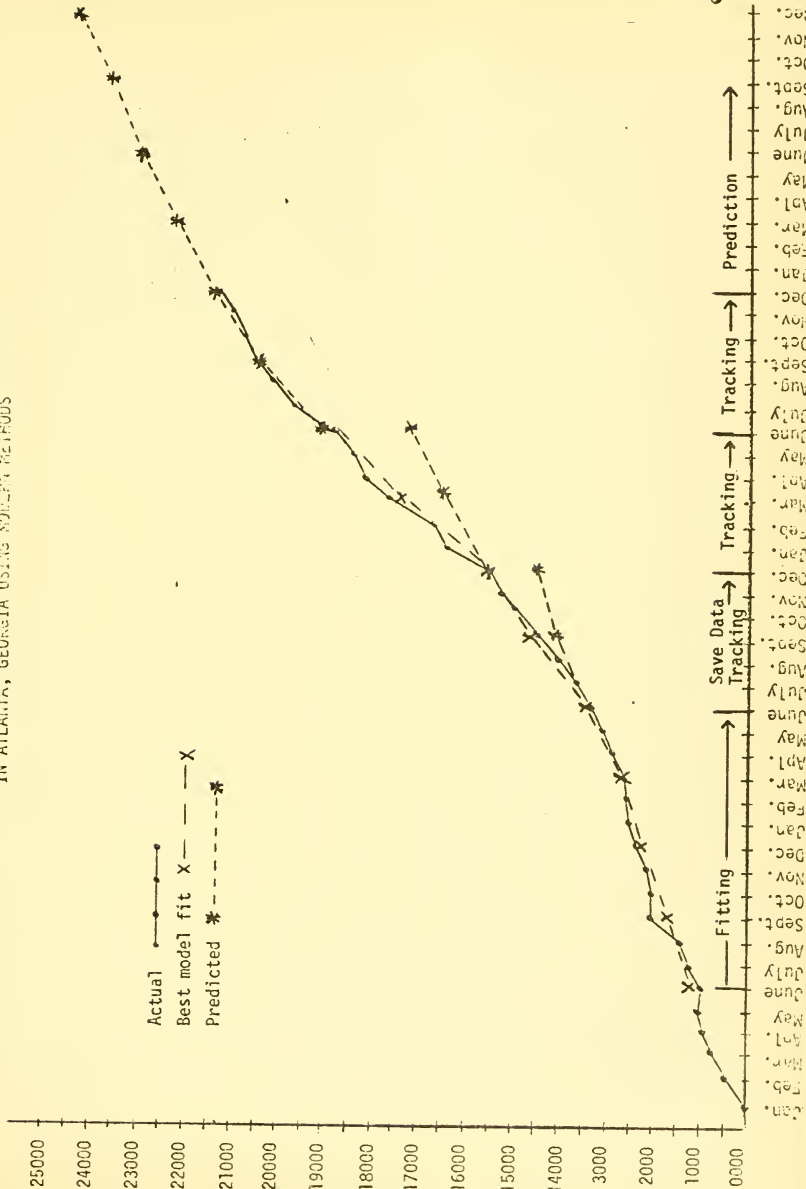
The prediction was lower than actual. This was particularly true at Planned Parenthood where the prediction was for stable performance and the total active curve increased sharply. The Grady Clinic prediction was also low. The question to be answered was: is the lack of accuracy due to poor input, random error, 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 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 inputs were probably good and that the structure of the model was reasonably sound. The rapid increase of new patients called for diagnosis. There had been an increase in the number of outreach recruitment calls, but very few additional appointments had been made with outreach workers. The hypothesis being investigated was that there was an indirect outreach effect (see equation 7). Data was collected for new patient clinic arrivals to see if outreach calls correlated with voluntary requests for appointments.

The lack of correspondence between actual and predicted patient loads at Grady was found to be due to a new volunteer run clinic 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 five). 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 December 1971 allowed for additional refinements to the model input and structure. The conditional prediction made in December 1970 is shown in figure five. Again the prediction was low. The Planned Parenthood agency increased its new patient rate to 450 a month or 200 more than predicted. It was found that Grady referred 50 percent more people per month to the county clinics than expected. New non-post partum clinic growth added 50 more 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 updated, 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. Inputs were revised and new predictions made for the last six months of 1971.

In January 1972, examination of predicted and actual values for the period June 1971 to December 1971 showed close correspondence. This was encouraging and reflected good predictive performance at the total system level. This was generally true at the agency level except at Planned Parenthood where actual was less than predicted. Refitting indicated that a decay in continuance rates could explain this. Additional diagnosis showed that the decay was due to an increasing proportion of white college girls. This raised questions of priority between college girls and indigent

mothers since clinic capacity was limited. Grady actual was 3 percent higher
than predicted due to less referral in December and more new patients in
November and December. In summary, the 1970-1971 fitting and tracking helped
diagnose problems, raised new issues, provided new insights, and improved
confidence in the model input and structure.

MANAGERIAL USE OF THE MODEL

The model is being used by the Director of the AAFPC.[14] 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
member 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. Most of the implementation has occurred at the co-ordinating council level

The model usage process has produced some new insights. Parti-
cularly, the fitting and tracking exercise has been valuable since it
required a detailed analysis of why predictions were not as good as desired.
The indirect outreach effect was one such new insight that resulted from the
model use. Another resulted from 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 insight has resulted in a new outreach program to the maternity wards of these hospitals. The analytic approach fostered by the model led to this new insight and change in the system behavior.

After fitting the model for the period of January 1971 to June 1971, a conditional forecast was made for the period July 1971 to December 1972. This was 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 first 1972 forecast was based upon a budget sufficient to meet capacity requirements. The forecast showed 24,600 actives by December 1972 and for a cost per year of protection of $69.91 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 11.7 percent fewer actives, 240 women per month being refused service, and an increase of 1.6 percent in the cost per couple year of protection. These forecasts were included in the 1972 budget request and the explicit cost/benefit justi-fication was cited as a contributing factor in the subsequent granting of

the larger budget amount. Although the larger budget was obtained for 1972, the model forecast for 1973 indicated doubt that needed funds could be obtained from existing sources. This led to more attention to generating new funding sources (welfare, Medicare), procedures for allocation between agencies, and methods of screening for only the target group members most in need.

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, it was found actives increased one 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 $70 per year of protection.) In fact, at this rate it would take five years to pay back. Sterilization in the short run was not very attractive as a method with this cost. New technology more efficient procedures, or negotiation to reduce the cost could make sterilization more attractive. 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 widen 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 macro flow model in Atlanta indicate that it can fit and track data satisfactorily and can aid managers in understanding, forecasting, and decision making. The model is now being implemented in five sites in the U.S.A. (e.g., Los Angeles, Memphis, State of Georgia) under a new contract.

The model proposed in this paper is an intermediate term planning model. Many other useful models could be built for clinic location, inventory planning, staffing, work scheduling, or long term economic planning. In building such a collection of models, care should be taken to insure that they function in a compatible manner. The planning model described in this paper could specify the overall capacity needs that could then 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 with health services should be considered. Can family planning systems successfully be added to comprehensive health services? Should family planning extend to include maternal and child health care services? These questions raise issues more macro than this planning model can entertain, but this interface will become more important as categorical funds for family planning decrease. The issues of phasing a categorical program such as family planning into the comprehensive health system will be investigated in future research.

A final activity envisioned for the future is the application of this model building methodology to developing 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. Early work with the Population Commission in the Philippines indicates that the basic flow notions are useful to managers in developing countries. In this application, attention has been focused on demographic impact, improving continuance rates, and the need for new programs. Initially, an aggregate Mod I flow model and time based continuation rates are being utilized. Although client record systems exist in several developing countries (e.g., Philippines, Taiwan, Guatemala), the Philippines experience indicates it may be more expedient to estimate time based continuance rates obtained from survey data since client records are not as complete as one would like and the concept of an appointment cycle is not as well structured as in the U.S.A. Future work in the Philippines, Korea, and Afghanistan will determine if a macro flow model can help improve managment in a developing country where population growth is one of the most important problems.

ACKNOWLEDGEMENTS

FOOTNOTES

[1] Fredrick Jaffe and Alan F. Guttmacher, "Family Planning Programs in the United States," _Demography_, V. 5, N. 2 (1968), p. 922. "Unwanted was defined by 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] Many other theoretical and conceptual planning models have been proposed but few, if any, have been applied to operating programs. Some models have reflected attempts to inappropriately cram family planning into linear programming formats. See, Hector Correa and Joseph A. Beasley, "Mathematical Models for Decision Making in Population and Family Planning," _Journal of Public Health_, V. 61, No. 1 (January, 1971), pp. 138-157, and, Charles E. Lawrence, Axel I. Mundigo, and Charles S. Revelle, "A Mathematical Model for Resource Allocation in Population Programs," _Demography_, Vol. IX, No. 3 (August 1972).

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. A.I.D. 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.

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.

[4] See, Glen L. Urban, "Sprinter mod III: A Model for the Analysis of New Frequently Purchased Consumer Goods," _Operations Research_, (Sept.-Oct. 1970), pp. 805-854; and Alfred Blumstein and Richard Larson, "Models of a Total Criminal Justice System," _Operations Research_ (March-April 1969) pp. 199-232, for examples of this type of model.

[5] A complete set of equations can be obtained from the author.

[6] Fertility rates display significant seasonality. See, _Natality Statistics Analysis_, National Center for Health Statistics, Series 21, No.1, (HEW, Public Health Service), p. 36-38. 12% more births occur in August, September, and October than in April, May and June. The seasonal pattern varies geographically.

[7] 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 17. Tietze's life table rates can be used to "fit" EFFMTH and EFFUSE .

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

[9] Note that this use of couple years of protection is based on a simulated projection forward in time. The simulated output is rather complete. This is in contrast to the demographic use of couple years of protection which is based on retrospective examination of rather incomplete past data from a real system. See, Lee L. Bean and William Seltzer, "Couple Years of Protection and Births Prevented - A Methodological Examination," *Demography*, Vol. 5, No. 2, (1968) pp. 947-959, for a description of demographic issues.

[10] 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 implies 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 6 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.

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

[12] For more detail, see Philippe A. 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, #560-71; and, Lesley E. Markman, "Management Information Systems: An Application to Family Planning," unpublished Master of Science thesis, M.I.T., 1972.

[13] See, Ronald O'Connor and Glen L. Urban, "Using a Model as a Practical Management Tool for Family Planning Programs," *American Journal of Public Health*, Vol. 62, No.11, (Nov. 1972), pp.1493-1500, for a description.

[14] See, Peter B. Tamblyn, Russell H. Richardson, and Elizabeth B. Ruyle, "Planning for Family Planning," *American Journal of Public Health*, Vol.62, No.2, (Feb.1973), pp.142-143, for the model experiences as stated by the users in Atlanta.

BASEMENT

[620 never issued]