APPENDIX 1

LISTING OF THE COMPUTER PROGRAM GCCONT

00100 REM THIS PROGRAM, GCCONT, FINDS PREVALENCE AND INCIDENCE OF GONORRHEA FOR SEVERAL CONTROL SITUATIONS. TO MAKE A RUN, ENTER PARAMETERS WHEN THEY ARE REQUESTED.

00180 REM THE MODEL EQUATIONS ARE COMPUTED IN THE 'RATE' SUBROUTINE AND THE 'CONTROL' SUBROUTINE, USING THE CONTACT MATRIX WHICH THE 'PATTERN' SUBROUTINE CALCULATED.

00280 REM THE PROGRAM IS ORGANIZED AS FOLLOWS:

00300 REM AFTER WE ENTER DATA, THE PROGRAM MAKES PRELIMINARY CALCULATIONS WHICH INCLUDE CALLING THE PATTERN SUBROUTINE TO FORM THE CONTACT MATRIX.

00340 REM THEN THE MAIN PROGRAM LOOP BEGINS: DURING A RUN THE LOOP VARIABLE R1 STEPS THROUGH THE FOLLOWING VALUES:

00380 REM R1=1 FOR THE UNCONTROLLED CASE

00400 REM R1=2 FOR POPULATION SCREENING (WOMEN)

00420 REM R1=3 FOR POP SCREENING PLUS SUPPLEMENTARY POP SCREENING

00440 REM R1=4 FOR POP SCREENING PLUS SUPPLEMENTARY INFECTEE TRACING

00460 REM R1=5 FOR POP SCREENING PLUS SUPPLEMENTARY INFECTOR TRACING

00480 REM

00500 REM FOR EACH CASE, THE MAIN PROGRAM CALLS THE 'SOLVER' SUBROUTINE WHICH USES ITERATION PROCEDURES TO FIND PREVALENCES. THE MAIN PROGRAM ALSO MAKES SUMMARY CALCULATIONS FOR EACH CASE AND PRINTS OUT A TABLE OF RESULTS. THE 'SOLVER' SUBROUTINE ORGANIZES THE ITERATION PROCESS.

00580 REM THE 'RATE' SUBROUTINE ACTUALLY COMPUTES THE DIRECTION FIELD V(I,1): IT CALLS THE 'CONTROL' SUBROUTINE TO FIND THE CONTROL RATE PORTION.

00600 REM RATE ALSO STORES THE PREVIOUS VALUE OF THE DIRECTION FIELD IN V(I,2) AND COMPUTES THE DIFFERENCE V(T,3)=V(I,1)-V(I,2). (OTHER NUMERICAL METHODS MIGHT REQUIRE MORE BACK VALUES WHICH COULD BE STORED IN OTHER COLUMNS OF V.) 'SOLVER' USES AN EULER STEP METHOD TO BEGIN, THEN CALLS THE 'NEWTON' SUBROUTINE FOR NEWTON'S METHOD. THE MATRIX OF PARTIAL DERIVATIVES IS FOUND BY THE 'FDERIV' SUBROUTINE. WHEN THE RMS RATE IS SMALL ENOUGH, 'SOLVER' STOPS THE ITERATION PROCESS, AND THE MAIN PROGRAM SUMMARIZES RESULTS, THEN STEPS TO THE NEXT CONTROL CASE.

00780 REM

00820 REM DIMENSIONS OF VECTORS AND MATRICES:

00840 REM IF THE NUMBER OF GROUPS G IS NOT 4, REPLACE 4 BY G IN DIM STATEMENTS AND ALSO MODIFY PRINT LINES IN WHICH WE LABEL 4 GROUPS EXPLICITLY.

00860 REM

00880 REM N(8),Y(8),D(8),K(8),P(8)

00900 REM R(8),Z(8),W(8),U(8),E(8)

00920 REM H(8,8),B(8,8),T(8,8),L(8,8)
DIM A(8,8), V(8,3), F(8,1), X(8,1), H(8,1)
DIM S(5,8), Q(11,8), O(1,8)
REM
ENTER DATA
REM INDEXING: WOMEN ODD, MEN EVEN
REM ORDERING: GP1 WOMEN, GP2 MEN, GP3 WOMEN, GP4 MEN
REM G=NUMBER OF GROUPS
G=8
PRINT' INPUT G1=SELF INTERACTION FRACTION'
INPUT G1
REM G2 SELECTS PRINTOUT: G2=0 FOR SUMMARY ONLY: G2=1 FOR ITERATION INFO
G2=0
REM N(I)=RELATIVE SIZE OF GROUP I, IN ANY UNITS
PRINT' INPUT GROUP FRACTIONS N(I)'
MAT INPUT N
PRINT' INPUT ACTIVITY RATIOS OF GROUPS: WOMEN AND MEN'
INPUT R8, R9
REM Y(I)=INITIAL GUESS OF PREVALENCE, THE INFECTIVE FRACTION OF GROUP I
FOR I=1 TO G STEP 1
READ Y(I)
NEXT I
DATA
REM D(I)=DURATION OF DISEASE (AVERAGE) FOR GROUP I, IN ANY UNITS (MONTHS)
PRINT' INPUT DURATIONS D(I)'
MAT INPUT D
PRINT' INPUT PROB OF TRANS BY TNF MAN/PROB OF TRANS BY INF WOMAN'
INPUT R7
REM K(I)=NUMBER OF EFFECTIVE CONTACTS OF EACH GROUP I INFECTIVE
PRINT' INPUT K(I)'
INPUT K(1)
K(2)=K(1)/D(2)/D(1)/R7::(N(1)+N(5)+(N(3)+N(7))/R8)/(N(2)+N(6)+(N(4)+N(8))/R9)
K(3)=K(1)/D(3)/D(1)/R8
K(4)=K(2)/D(4)/D(2)/R9
K(5)=K(1)/D(5)/D(1)
K(6)=K(2)/D(6)/D(2)
K(7)=K(1)/D(7)/D(1)/R8
K(8)=K(2)/D(8)/D(2)/R9
REM PRELIMINARY CALCULATIONS
MAT A=ZER(G,G)
MAT F=ZER(G,1)
MAT X=ZER(G,1)
MAT H=ZER(G,1)
MAT V=ZER(G,3)
PRINT'### RUN NUMBER ###'
PRINT' GONORRHEA CONTROL MODEL'
PRINT' -------------------
REM GO BUILD CONTACT MATRIX B
REM MAIN PROGRAM LOOP
REM R1 INDEXES THE CONTROL METHOD: R1=1 BEFORE THE CONTROLS ARE USED
R1=1
02160 REM GO TO THE SOLVER SUBROUTINE TO FIND THE SOLUTION
02180 GOSUB 4560
02200 IF G2=0 THEN 2280
02220 PRINT Y(1),Y(2),Y(3),Y(4),N5
02240 PRINT 'SOLUTION APPROACHED IS ON ABOVE LINE',' ','RMS RATE'
02280 IF Rl.>)THEN 2680
02300 REM SAVE VALUES FROM ORIGINAL CASE, BEFORE APPLYING CONTROLS
02320 S2=0
02340 S3=0
02360 S4=0
02380 S5=0
02400 FOR I=1 TO G STEP 1
02420 S(1,1)=Y(I)
02440 S(2,1)=Y(I)*N(I)
02460 S(3,1)=D(I)
02480 S(4,1)=S(2,1)/D(I)
02500 Z(I)=S(4,1)
02520 NEXT I
02540 FOR I=1 TO G-1 STEP 2
02560 S2=S2+Z(I+1)
02580 S3=S3+Z(I)
02600 S4=S4+S(2,1+1)
02620 S5=S5+S(2,1)
02640 NEXT I
02660 REM STORE VALUES FOR PRINTING IN MATRIX Q
02680 Q2=0
02700 Q3=0
02720 Q4=0
02740 Q5=0
02760 FOR I=1 TO G STEP 1
02780 Q(1,1)=Y(I)
02800 Q(2,1)=(Q(1,1)-S(1,1))*100/S(1,1)
02820 Q(3,1)=Y(I)*N(I)
02840 Q(4,1)=(Q(3,1)-S(2,1))*100/S(2,1)
02860 Q(5,1)=D(I)
02880 Q(6,1)=1/(1/D(I)+C*R(I)/(Y(I)*N(I))+.1*C*P(I)/(Y(I)*N(I)))
02900 Q(7,1)=Q(3,1)/Q(6,1)
02920 Q(8,1)=(Q(7,1)-S(4,1))*100/S(4,1)
02940 Q(9,1)=C*R(I)+.1*C*P(I)
02960 Q(10,1)=N(I)
02980 Q(11,1)=K(I)
03000 NEXT I
03020 FOR I=1 TO G-1 STEP 2
03040 Q2=Q2+Q(7,1+1)
03060 Q3=Q3+Q(7,1)
03080 Q4=Q4+Q(3,1+1)
03100 Q5=Q5+Q(3,1)
03120 NEXT I
03160 ON R1 GOTO 3180,3220,3230,3260,3320
03180 PRINT '********** RESULTS WITH NO EXTRA CURE RATE APPLIED **********'
03200 GOTO 3340
03220 PRINT '********** RESULTS FOR POPULATION SCREENING **********'
03221 PRINT 'THE NUMBER OF WOMEN DISCOVERED BY POPULATION SCREENING IS'
03222 PRINT 'SET EQUAL TO 10% OF THE INCIDENCE AND THE EFFECTIVE CONTACT'
03223 PRINT 'NUMBER IS CHosen SO THAT THIS POPULATION SCREENING CAUSES'
03224 PRINT 'APPROXIMATELY A 20% DECREASE IN INCIDENCE IN MEN.'
03225 GO TO 3340
03230 PRINT '**********RESULTS FOR SUPPLEMENTARY POPULATION SCREENING **********'
03231 GO TO 3340
03240 PRINT '********** RESULTS FOR SUPPLEMENTARY INFECTEE TRACING **********'
PRINT 'TRACE WOMEN REPORTED AS CONTACTEES OF DIAGNOSED MEN'

PRINT 'RESULTS FOR SUPPLEMENTARY INFECTOR TRACING'

PRINT 'TRACE WOMEN REPORTED AS INFECTORS OF DIAGNOSED MEN'

FOR I=1 TO 11 STEP 1
    FOR I=1 TO G STEP 1
        O(I,1)=Q(I1,I)
    NEXT I
    ON TI GOTO 3560,3660,3640,3680,3720,3760,3800,3840,3880,3920,3960
    PRINT 'PREVALENCE, FRAC':
    GOTO 3980
    PRINT 'CHANGE':
    GOTO 3980
    PRINT 'PREVALENCE, POP':
    GOTO 3980
    PRINT 'CHANGE':
    GOTO 3980
    PRINT 'DURATION, ORIG':
    GOTO 3980
    PRINT 'DURATION, NEW':
    GOTO 3980
    PRINT 'INCIDENCE, POP':
    GOTO 3980
    PRINT 'CHANGE':
    GOTO 3980
    PRINT 'EXTRA CURE RATE':
    GOTO 3980
    IF R1>7 THEN 4040
    PRINT 'POPULAT. RATIOS':
    GOTO 3980
    PRINT 'CONTACT NUMBERS':
    PRINT O(I,1),O(I,2),O(I,3),O(I,4)
    PRINT O(I,5),O(I,6),O(I,7),O(I,8)
    PRINT O(1,1),O(1,2),O(1,3),O(1,4)
    PRINT O(1,5),O(1,6),O(1,7),O(1,8)
    PRINT O(I,1),O(I,2),O(I,3),O(I,4)
    PRINT O(I,5),O(I,6),O(I,7),O(I,8)

PRINT 'WOMEN, POP PREVALENCE =',Q5,'CHANGE (%) =', (Q5-S5)/100/S5
PRINT 'MEN, POP PREVALENCE =',Q4,'CHANGE (%) =', (Q4-S4)/100/S4
PRINT 'WOMEN, MONTHLY INCIDENCE =',Q3,'CHANGE (%) =', (Q3-S3)/100/S3
PRINT 'MEN, MONTHLY INCIDENCE =',Q2,'CHANGE (%) =', (Q2-S2)/100/S2
IF R1=1 THEN 4200
PRINT 'WOMEN, DISCOVERED BY POPULATION SCREENING =', C
IF R1=2 THEN 4124
PRINT 'THE PROBABILITY THAT A WOMAN DISCOVERED BY POPULATION SCREENING IS' : R(1)
IF R1>3 THEN 4136
C1=(E7-Q5)/E7*100
C2=(E7-Q5)/E7*100
IF R1=2 THEN 4200
PRINT 'THE PROBABILITY THAT A WOMAN DISCOVERED BY THE SUPPLEMENTARY PROCEDURE IS A GPI MEMBER IS' : P(1)
IF R1>2 THEN 4136
PRINT 'THE PROBABILITY THAT A WOMAN DISCOVERED BY THE SUPPLEMENTARY PROCEDURE IS A GPI MEMBER IS' : R(1)
IF R1=2 THEN 4200
PRINT 'THE PROBABILITY THAT A WOMAN DISCOVERED BY THE SUPPLEMENTARY PROCEDURE IS A GPI MEMBER IS' : P(1)
IF R1>3 THEN 4148
C1=(E7-Q5)/E7*100
C2=(E7-Q5)/E7*100
IF R1=2 THEN 4200
PRINT 'IF THIS SUPPLEMENTARY CONTROL PROCEDURE INCREASES THE NUMBER OF DISCOVERIES OF INFECTIOUS WOMEN BY 10%, THEN THE % DECREASE IN PREVALENCE IN WOMEN IS': C2: 'WHICH IS' : C2/C1: 'TIMES THE %'
PRINT 'DECREASE IN PREVALENCE IN WOMEN DUE TO SUPPLEMENTARY POPULATION SCREENING.'
\[ E_4 = \frac{(E_2 - Q_2)}{\left( \frac{1}{1 - C} \right)} \]
\[ E_5 = \frac{(E_3 - Q_3)}{\left( \frac{1}{1 - C} \right)} \]

PRINT 'THE DISCOVERY AND CURE OF ONE INFECTIOUS WOMAN BY THIS SUPPLEMENTARY CONTROL PROCEDURE PREVENTS CASES IN WOMEN AND CASES IN MEN.'

PRINT 'CASES IN WOMEN AND CASES IN MEN.'

IF R1 <> 1 THEN 4214
IF R1 <> 3 THEN 4220
R1 = R1 + 1
IF R1 > 5 THEN 4300
GOTO 2180

PRINT 'END OF PROGRAM'

REM *********** END OF MAIN PROGRAM LOOP ***********

STOP

REM SUBROUTINES

REM SOLVER SUBROUTINE

THE PROCEDURE TO FIND PREVALENCES Y(I) BEGINS HERE

J2 COUNTS THE NUMBER OF ITERATIONS MADE SO FAR
J3 SELECTS THE METHOD: J3=0 FOR EULER STEPS ALONG TRAJECTORY:
J3=1 WHEN WE USE THE NEWTON METHOD
J5=0 IF WE DON'T WISH TO COMPUTE DIFFERENCES IN THE DIRECTION FIELD

IF G2=0 THEN 5000

PRINT 'PREVALENCES, AS FRACTIONS OF EACH GROUP'

PRINT 'CORE WOMEN', 'CORE MEN', 'NONCORE WOMEN', 'NONCORE MEN', 'RMS RATE'
PRINT Y(1), Y(2), Y(3), Y(4)

GOTO 5000

THE ITERATION LOOP BEGINS HERE

IF G2=0 THEN 5000
PRINT Y(1), Y(2), Y(3), Y(4), W5

REM DECIDE WHICH SOLUTION METHOD TO APPLY NEXT

IF J3=1 THEN 5400
IF J4=G THEN 5030
GOTO 5160
J3=1
IF G2=0 THEN 5160
PRINT 'NEWTON METHOD BEGINS AFTER NEXT STEP'

THIS ITERATION PROCEDURE MAY BE USEFUL BEFORE NEWTON METHOD BEGINS:

GOSUB 6880
J5=1
GOTO 5160
FOR I=1 TO G STEP 1
REM Y(I)=(W(I)-S1*R(I))/D(I)/(1+D(I)*W(I)) IS AN ALTERNATIVE
REM EULER STEPS ALONG TRAJECTORY:
Y(I)=Y(I)+.25*V(I,1)
IF Y(I)>0 THEN 5320
Y(I)=0
NEXT I
05340 GOTO 5720
05360 REM WE GO TO THE NEWTON SUBROUTINE AFTER SAVING THE OLD SOLUTION IN E
05380 REM AND THE OLD RMS RATE IN W7
05400 MAT E=Y
05420 W7=W5
05440 GOSUB 5820
05460 IF W5<W7 THEN 5720
05480 IF G2=0 THEN 5520
05500 PRINT 'USE ONLY HALF OF INCREMENT SINCE THE RMS RATE=',W5
05520 MAT Y=E+Y
05540 MAT Y=(.5)*Y
05560 GOSUB 5820
05580 IF W5<W7 THEN 5720
05600 MAT Y=E
05620 J3=0
05640 IF G2=0 THEN 5680
05660 PRINT 'USE STARTER AGAIN SINCE RHS RATE=',W5
05680 GOTO 5160
05700 REM STEP UP ITERATION COUNTER
05720 J2=J2+1
05740 IF W5>IE-06 THEN 5750
05745 RETURN
05750 IF J2<300 THEN 4900
05755 PRINT 'WARNING: 300 ITERATIONS'
05760 RETURN
05780 REM #####################################################################
05800 REM NEWTON SUBROUTINE STARTS HERE
05820 REM WE WILL SOLVE F(X)=0, WHERE X CONTAINS PREVALENCES AND F CONTAINS
05840 REM THEIR DIRECTION FIELD.
05860 REM
05880 REM FOR I=1 TO G STEP 1
05900 X(I,1)=Y(I)
05920 F(I,1)=V(I,1)
05940 NEXT I
05960 REM GO TO SUB TO FORM PARTIAL DERIVATIVE MATRIX A
05980 GOSUB 6420
06000 REM FIND NEW PREVALENCES X BY NEWTON METHOD, THEN STORE THEM IN Y
06020 GOSUB 6880
06040 RETURN
06060 REM NEWTON ALGORITHM ENDS HERE.
06080 REM
06100 REM SUBROUTINE FDERIV: FORM APPROXIMATE PARTIAL DERIVATIVE MATRIX A
06120 H9=.001
06140 J9=1
06160 Y(J9)=Y(J9)-H9
GO SUB 6880
J5=1
Y(J9)=Y(J9)+2/H9
GO SUB 6880
REM STORE PARTIALS: MATRIX A APPROXIMATES DF
FOR I=1 TO G STEP 1
A(I,J9)=V(I,3)/(2*H9)
NEXT I
Y(J9)=Y(J9)-H9
J9=.19+1
J5=0
IF J9<=G THEN 6460
RETURN
REM
REM #################################################################
REM RATE SUBROUTINE #################################################################
REM
REM WE COMPUTE THE DIRECTION FIELD V(I,1) USING THE MODEL EQUATIONS
REM
FOR I=1 TO G STEP 1
W1=0
FOR J1=1 TO G STEP 1
W1=W1+B(I,J1)*Y(J1)
NEXT J1
W(I)=W1
NEXT I
REM
REM GO TO SUB TO FORM EXTRA CURE RATES R(I)
REM
GO SUB 7580
REM
REM COMPUTE V(1,1), TIME RATES OF CHANGE OF PREVALENCES Y(I)
REM
W5=0
J4=0
FOR I=1 TO G STEP 1
MODEL EQUATIONS:
V(I,1)=(1-Y(I))*W(I)-(Y(I)/D(I))-C*R(I)/N(I)-C*P(I)/N(I)
NEXT I
WS=SQR(W5)
RETURN
REM
REM #################################################################
REM CONTROL SUBROUTINE #################################################################
REM
REM THESE LOOPS FORM EXTRA CURE RATES R(I) AND P(I)
REM
IF R1=1 THEN 7770
IF R1>2 THEN 7720
T1=C=G=0
FOR I=1 TO G-1 STEP 2
Z(I)=Y(I)*N(I)*(1/D(I)+T1*R(I)/(Y(I)*N(I)))
C = C + Z(I)
NEXT I
C = 1.1C
REM C IS THE DISCOVERY RATE DUE TO POPULATION SCREENING
IF R1 < 4 THEN 7880
IF R1 = 4 THEN 8080
IF R1 = 5 THEN 8360
REM UNCONTROLLED CASE
FOR I = 1 TO G STEP 1
R(I) = 0
P(I) = 0
NEXT I
RETURN
REM POPULATION SAMPLING, WOMEN
REM
A3 = 0
FOR I = 1 TO G - 1 STEP 2
A3 = A3 + Y(I) * N(I)
NEXT I
FOR I = 1 TO G - 1 STEP 2
R(I) = Y(I) * N(I) / A3
NEXT I
IF R1 = 2 THEN 8060
FOR I = 1 TO G - 1 STEP 2
P(I) = R(I)
NEXT I
RETURN
REM INFECTEE SAMPLING, WOMEN
A5 = 0
FOR I = 1 TO G - 1 STEP 2
A4 = 0
FOR I9 = 2 TO G STEP 2
A4 = A4 + M(I9, I) * (1 - Y(I9)) * N(I9) * K(I9) / D(I9)
NEXT I9
FOR I = 1 TO G - 1 STEP 2
P(I) = A4 / N(I) * Y(I) * K(I) / D(I)
A5 = A5 + P(I)
NEXT I
FOR I = 1 TO G - 1 STEP 2
P(I) = P(I) / A5
NEXT I
RETURN
REM INFECTOR SAMPLING, WOMEN
A5 = 0
FOR I = 1 TO G - 1 STEP 2
A4 = 0
FOR I9 = 2 TO G STEP 2
A4 = A4 + M(I9, I) / (1 - Y(I9))
NEXT I9
A5 = A5 + P(I)
NEXT I
FOR I = 1 TO G - 1 STEP 2
P(I) = P(I) / A5
NEXT I
RETURN
REM
MAT M = ZER(G, G)
MAT T = ZER(G, G)
MAT B = ZER(G, G)
REM SET UP PROPORTIONATE MIXING MODEL
A1=0
A2=0
FOR I=1 TO G STEP 1
U(I)=N(I)*K(I)/D(I)
NEXT I
FOR I=2 TO G STEP 2
A1=A1+U(I-1)
A2=A2+U(I)
NEXT I
FOR I9=1 TO G-1 STEP 2
FOR I=2 TO C STEP 2
M(I-1,I9+1)=U(I-1)/A1
M(I,19)=U(I)/A2
NEXT I
NEXT 19
IF G1=0 THEN 9440
MAT L=ZER(G,G)
FOR K8=3 TO 7 STEP 4
FOR K9=1 TO 2
U8=U(K9)+U(K9+4)
L(K9,K8-K9)=U(K9)/U8
L(K9+4,K8-K9)=U(K9+4)/U8
U9=U(K9+2)+U(K9+6)
L(K9+2,K8-K9+2)=U(K9+2)/U9
L(K9+6,K8-K9+2)=U(K9+6)/U9
NEXT K9
NEXT K8
MAT L=(G1)/nullL
MAT M=(1-G1)/nullM
MAT Lkl=M+L
FOR 19=1 TO G STEP 1
FOR I=1 TO G STEP 1
T(I,19)=M(I,19)/nullK(I9)
B(I,19)=T(I,19)*N(I9)/(D(19)*N(I))
NEXT I
NEXT 19
IF G1>0 THEN 9780
PRINT 'PROB. OF TRANS. BY INF. MAN/PROB. OF TRANS. BY INF. WOMAN=':R7
PRINT 'SEXUAL ACTIVITY OF GP1 WOMAN/SEXUAL ACTIVITY OF GP3 WOMAN=':R8
PRINT 'SEXUAL ACTIVITY OF GP2 MAN/SEXUAL ACTIVITY OF GP4 MAN=':R9
P1=0
P2=0
FOR I=2 TO G STEP 2
P1=P1+M(I,1)*K(I)
P2=P2+M(I-1,2)*K(I-1)
NEXT I
K4=P1*P2
PRINT 'EFFECTIVE CONTACT NUMBER=':K4
PRINT
IF G2=0 THEN 9880
PRINT 'MIXING MATRIX: M(I,J)=FRAC OF EFF. CONTACTS OF J THAT ARE WITH I'
RETURN
END