APPENDIX I

LINGO PROGRAMMING RESULTS

Table 1 Current Setting

Global optimal solution found.

Objective value:	4725300.
Infeasibilities:	0.000000
Total solver iterations:	0
Elapsed runtime seconds:	0.06
Model Class:	LP
Total variables:	8
Nonlinear variables:	0
Integer variables:	0
Total constraints:	17
Nonlinear constraints:	0
Total nonzeros:	20
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
NUMBER_OR	7.000000	0.000000
DAYOPEN_OR	5.000000	0.000000
OR_BLOCK_HOURS	8.000000	0.000000
NUMBER_ICU	20.00000	0.000000
DAYOPEN_ICU	7.000000	0.000000
ICU_HOURS_OPERATE	24.00000	0.000000
NUMBER_MCU	35.00000	0.000000
DAYOPEN_MCU	7.000000	0.000000
MCU_HOURS_OPERATE	24.00000	0.000000
NUMBER_NURSE	60.00000	0.000000
WORKING_SHIFT	3.000000	0.000000
HOURINSHIFT	8.000000	0.000000
DAYWORK_ICUNURSE	7.000000	0.000000
WEIGHT_WL	1.000000	0.000000
WEIGHT_OT	1.000000	0.000000
OCOST_OR	400.0000	0.000000
OCOST_ICU	15.00000	0.000000
OCOST_MCU	5.000000	0.000000
OCOST_NURSE	4.000000	0.000000
DAILY_BLOCKSUPPLY	7.000000	0.000000
WEEKLY_ORBLOCKSUPPLY	35.00000	0.000000
ICUSUPPLY	3360.000	0.000000
MCUSUPPLY	5880.000	0.000000
NURSETIMESUPPY	1120.000	0.000000
DEMAND_WEEKLY_TPT	98.00000	0.000000
TOTAL_PATIENTS_ALLDEP	5096.000	0.000000
OICU	0.000000	619.7750
OMCU	0.000000	206.5917
OOR	0.000000	16527.33
ONURSE	0.000000	165.2733
AVERAGE_CLEARINGTIME	41.31833	0.000000
TOTALBLOCK_ASSIGN	28.00000	0.000000
TOTAL_ICU_TIME	3168.600	0.000000
TOTAL_MCUDOWN_TIME	4092.000	0.000000
TOTAL_MCUUP_TIME	1188.000	0.000000
TOTAL_ICU_NURSE_TIME	1104.867	0.000000
OR_UTILIZATION	80.00000	0.000000
ICU_UTILIZATION	94.30357	0.000000
MCU_UTILIZATION	89.79592	0.000000
ONURSE_UTILIZATION	98.64881	0.000000
TOTAL_PATIENTS_ASSIGNED	121.0000	0.000000
TOTAL_WAITING_COST	4725300.	0.000000
TOTAL_OOR_COST	0.000000	0.000000
TOTAL_OICU_COST	0.000000	0.000000
TOTAL_OMCU_COST	0.000000	0.000000
TOTAL_ONURSE_NURSE	0.000000	0.000000
WAITCOST(ENT)	10.00000	0.000000

WAITCOST(OBGYN)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBGYN)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBGYN)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBGYN)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBGYN)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBGYN)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBGYN)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBGYN)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBGYN)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000
MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000

MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBGYN)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBGYN)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBGYN)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBGYN)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	5.000000	0.000000
ASSIGN(OBGYN)	3.000000	0.000000
ASSIGN(URO)	3.000000	0.000000
ASSIGN(GEN)	5.000000	0.000000
ASSIGN(VAS)	3.000000	0.000000
ASSIGN(ORT)	5.000000	0.000000
ASSIGN(NEU)	3.000000	0.000000
ASSIGN(CAR)	1.000000	0.000000
TIMEELIMINATE(ENT)	43.68000	0.000000
TIMEELIMINATE(OBGYN)	31.20000	0.000000
TIMEELIMINATE(URO)	23.11111	0.000000
TIMEELIMINATE(GEN)	57.20000	0.000000
TIMEELIMINATE(VAS)	34.66667	0.000000
TIMEELIMINATE(ORT)	59.80000	0.000000
TIMEELIMINATE(NEU)	28.88889	0.000000
TIMEELIMINATE(CAR)	52.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	4725300.	-1.000000
9	0.000000	0.000000
10	7.000000	0.000000
11	0.000000	0.000000
12	191.4000	0.000000
13	0.000000	0.000000
14	0.000000	0.000000
15	600.0000	0.000000

16	0.000000	0.000000
17	15.13333	0.000000
18	0.000000	0.000000
19	0.000000	0.000000
20	0.000000	0.000000
21	0.000000	0.000000
22	50.00000	0.000000
23	64.30357	0.000000
24	59.79592	0.000000
25	68.64881	0.000000
26	0.000000	0.000000
27	0.000000	-436.8000
28	0.000000	-530.4000
29	0.000000	-138.6667
30	0.000000	-915.2000
31	0.000000	-1560.000
32	0.000000	-1315.600
33	0.000000	-1444.444
34	0.000000	-2860.000
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	0.000000	0.000000
39	0.000000	0.000000
40	0.000000	0.000000
41	0.000000	0.000000
42	0.000000	0.000000
43	0.000000	0.000000
44	0.000000	0.000000

Table 2 Our Study

```
Local optimal solution found.
Objective value:                              4089871.
Objective bound:                              4089871.
Infeasibilities:                          0.3273435E-04
Extended solver steps:                              147
Total solver iterations:                          11898
Elapsed runtime seconds:                           0.81

Model Class:                                      MINLP

Total variables:                     36
Nonlinear variables:                 21
Integer variables:                    8

Total constraints:                   62
Nonlinear constraints:               13

Total nonzeros:                     162
Nonlinear nonzeros:                  29


                     Variable           Value        Reduced Cost
                   NUMBER_OR        7.000000            0.000000
                  DAYOPEN_OR        5.000000            0.000000
              OR_BLOCK_HOURS        8.000000            0.000000
                  NUMBER_ICU        20.00000            0.000000
                 DAYOPEN_ICU        7.000000            0.000000
           ICU_HOURS_OPERATE        24.00000            0.000000
                  NUMBER_MCU        35.00000            0.000000
                 DAYOPEN_MCU        7.000000            0.000000
           MCU_HOURS_OPERATE        24.00000            0.000000
                NUMBER_NURSE        60.00000            0.000000
               WORKING_SHIFT        3.000000            0.000000
                  HOURINSHIFT        8.000000            0.000000
            DAYWORK_ICUNURSE        7.000000            0.000000
                   WEIGHT_WL        1.000000            0.000000
                   WEIGHT_OT        1.000000            0.000000
                    OCOST_OR        400.0000            0.000000
                   OCOST_ICU        15.00000            0.000000
                   OCOST_MCU        5.000000            0.000000
                 OCOST_NURSE        4.000000            0.000000
           DAILY_BLOCKSUPPLY        7.000000            0.000000
        WEEKLY_ORBLOCKSUPPLY        35.00000            0.000000
                  ICUSUPPLY        3360.000            0.000000
                  MCUSUPPLY        5880.000            0.000000
               NURSETIMESUPPY        1120.000            0.000000
           DEMAND_WEEKLY_TPT        98.00000            0.000000
       TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                        OICU        0.000000            0.000000
                        OMCU        0.000000            0.000000
                         OOR        0.000000            0.000000
                      ONURSE        0.000000            150.7071
        AVERAGE_CLEARINGTIME        37.67678            0.000000
           TOTALBLOCK_ASSIGN        35.00000            0.000000
              TOTAL_ICU_TIME        3302.400            0.000000
          TOTAL_MCUDOWN_TIME        4824.000            0.000000
             TOTAL_MCUUP_TIME        1032.000            0.000000
        TOTAL_ICU_NURSE_TIME        1110.133            0.000000
              OR_UTILIZATION        100.0000            0.000000
             ICU_UTILIZATION        98.28571            0.000000
             MCU_UTILIZATION        99.59184            0.000000
           ONURSE_UTILIZATION        99.11905            0.000000
     TOTAL_PATIENTS_ASSIGNED        148.0000            0.000000
          TOTAL_WAITING_COST        4089871.            0.000000
              TOTAL_OOR_COST        0.000000            0.000000
             TOTAL_OICU_COST        0.000000            1.000000
             TOTAL_OMCU_COST        0.000000            1.000000
```

TOTAL_ONURSE_NURSE	0.000000	0.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBGYN)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBGYN)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBGYN)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBGYN)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBGYN)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBGYN)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBGYN)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBGYN)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBGYN)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBGYN)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBGYN)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBGYN)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBGYN)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	37095.57
ASSIGN(OBGYN)	2.000000	-111810.1
ASSIGN(URO)	2.000000	31096.03
ASSIGN(GEN)	10.00000	22010.62
ASSIGN(VAS)	2.000000	-412359.4
ASSIGN(ORT)	7.000000	-86196.78
ASSIGN(NEU)	2.000000	-207306.3
ASSIGN(CAR)	2.000000	0.000000
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBGYN)	46.80000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	28.60000	0.000000
TIMEELIMINATE(VAS)	52.00000	0.000000
TIMEELIMINATE(ORT)	42.71429	0.000000
TIMEELIMINATE(NEU)	43.33333	0.000000
TIMEELIMINATE(CAR)	25.99999	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	74360.07
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	4089871.	-1.000000
9	0.000000	-74360.07
10	0.000000	74360.07
11	7.000000	0.000000
12	1.000000	0.000000
13	1.000000	0.000000

14	9.000000	0.000000
15	1.000000	0.000000
16	6.000000	0.000000
17	1.000000	0.000000
18	1.000000	0.000000
19	20.00000	0.000000
20	26.00000	0.000000
21	26.00000	0.000000
22	18.00000	0.000000
23	26.00000	0.000000
24	21.00000	0.000000
25	26.00000	0.000000
26	26.00000	0.000000
27	0.000000	0.000000
28	57.60000	0.000000
29	0.000000	0.000000
30	0.000000	0.000000
31	24.00000	0.000000
32	0.000000	0.000000
33	9.866667	0.000000
34	0.000000	59289.36
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	70.00000	0.000000
39	68.28571	0.000000
40	69.59184	0.000000
41	69.11905	0.000000
42	0.000000	0.000000
43	50.00000	0.000000
44	19.00000	0.000000
45	1.000000	0.000000
46	4.000000	0.000000
47	18.00000	0.000000
48	0.000000	0.000000
49	5.000000	0.000000
50	1.000000	0.000000
51	2.000000	0.000000
52	0.000000	-273.0000
53	0.000000	-795.5996
54	0.000000	-208.0001
55	0.000000	-457.6000
56	0.000000	-2339.999
57	0.000000	-939.7142
58	0.000000	-2166.666
59	-0.3273435E-04	-1430.001
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	1.000000
67	0.000000	1.000000
68	0.000000	0.000000
69	0.000000	0.000000

Table 3 Equity

```
Local optimal solution found.
Objective value:                              4089871.
Objective bound:                              4089871.
Infeasibilities:                          0.3273435E-04
Extended solver steps:                              147
Total solver iterations:                          16674
Elapsed runtime seconds:                           0.80

Model Class:                                      MINLP

Total variables:                     36
Nonlinear variables:                 21
Integer variables:                    8

Total constraints:                   78
Nonlinear constraints:               13

Total nonzeros:                     178
Nonlinear nonzeros:                  29


                     Variable           Value        Reduced Cost
                   NUMBER_OR        7.000000            0.000000
                  DAYOPEN_OR        5.000000            0.000000
               OR_BLOCK_HOURS        8.000000            0.000000
                  NUMBER_ICU        20.00000            0.000000
                 DAYOPEN_ICU        7.000000            0.000000
           ICU_HOURS_OPERATE        24.00000            0.000000
                 NUMBER_MCU        35.00000            0.000000
                DAYOPEN_MCU        7.000000            0.000000
           MCU_HOURS_OPERATE        24.00000            0.000000
                NUMBER_NURSE        60.00000            0.000000
              WORKING_SHIFT         3.000000            0.000000
                 HOURINSHIFT        8.000000            0.000000
            DAYWORK_ICUNURSE        7.000000            0.000000
                   WEIGHT_WL        1.000000            0.000000
                   WEIGHT_OT        1.000000            0.000000
                    OCOST_OR        400.0000            0.000000
                   OCOST_ICU        15.00000            0.000000
                   OCOST_MCU        5.000000            0.000000
                  OCOST_NURSE        4.000000            0.000000
           DAILY_BLOCKSUPPLY         7.000000            0.000000
        WEEKLY_ORBLOCKSUPPLY         35.00000            0.000000
                  ICUSUPPLY          3360.000            0.000000
                  MCUSUPPLY          5880.000            0.000000
              NURSETIMESUPPY         1120.000            0.000000
           DEMAND_WEEKLY_TPT         98.00000            0.000000
       TOTAL_PATIENTS_ALLDEP         5096.000            0.000000
                        OICU         0.000000            0.000000
                        OMCU         0.000000            0.000000
                         OOR         0.000000            0.000000
                      ONURSE         0.000000            150.7071
        AVERAGE_CLEARINGTIME         37.67678            0.000000
           TOTALBLOCK_ASSIGN         35.00000            0.000000
              TOTAL_ICU_TIME         3302.400            0.000000
         TOTAL_MCUDOWN_TIME          4824.000            0.000000
           TOTAL_MCUUP_TIME          1032.000            0.000000
        TOTAL_ICU_NURSE_TIME         1110.133            0.000000
             OR_UTILIZATION          100.0000            0.000000
          ICU_UTILIZATION            98.28571            0.000000
          MCU_UTILIZATION            99.59184            0.000000
        ONURSE_UTILIZATION           99.11905            0.000000
      TOTAL_PATIENTS_ASSIGNED        148.0000            0.000000
           TOTAL_WAITING_COST        4089871.            0.000000
              TOTAL_OOR_COST         0.000000            0.000000
             TOTAL_OICU_COST         0.000000            1.000000
             TOTAL_OMCU_COST         0.000000            1.000000
```

TOTAL_ONURSE_NURSE	0.000000	0.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBG)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBG)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBG)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBG)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBG)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBG)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBG)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBG)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBG)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBG)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBG)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBG)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBG)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	37095.57
ASSIGN(OBG)	2.000000	-111810.1
ASSIGN(URO)	2.000000	31096.03
ASSIGN(GEN)	10.00000	22010.62
ASSIGN(VAS)	2.000000	-412359.4
ASSIGN(ORT)	7.000000	-86196.78
ASSIGN(NEU)	2.000000	-207306.3
ASSIGN(CAR)	2.000000	0.000000
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBG)	46.80000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	28.60000	0.000000
TIMEELIMINATE(VAS)	52.00000	0.000000
TIMEELIMINATE(ORT)	42.71429	0.000000
TIMEELIMINATE(NEU)	43.33333	0.000000
TIMEELIMINATE(CAR)	25.99999	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	74360.07
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	4089871.	-1.000000
9	0.000000	-74360.07
10	0.000000	74360.07
11	7.000000	0.000000
12	1.000000	0.000000
13	1.000000	0.000000

14	9.000000	0.000000
15	1.000000	0.000000
16	6.000000	0.000000
17	1.000000	0.000000
18	1.000000	0.000000
19	20.00000	0.000000
20	26.00000	0.000000
21	26.00000	0.000000
22	18.00000	0.000000
23	26.00000	0.000000
24	21.00000	0.000000
25	26.00000	0.000000
26	26.00000	0.000000
27	0.000000	0.000000
28	57.60000	0.000000
29	0.000000	0.000000
30	0.000000	0.000000
31	24.00000	0.000000
32	0.000000	0.000000
33	9.866667	0.000000
34	0.000000	59289.36
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	70.00000	0.000000
39	68.28571	0.000000
40	69.59184	0.000000
41	69.11905	0.000000
42	0.000000	0.000000
43	50.00000	0.000000
44	19.00000	0.000000
45	1.000000	0.000000
46	4.000000	0.000000
47	18.00000	0.000000
48	0.000000	0.000000
49	5.000000	0.000000
50	1.000000	0.000000
51	2.000000	0.000000
52	0.000000	-273.0000
53	0.000000	-795.5996
54	0.000000	-208.0001
55	0.000000	-457.6000
56	0.000000	-2339.999
57	0.000000	-939.7142
58	0.000000	-2166.666
59	-0.3273435E-04	-1430.001
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	1.000000
67	0.000000	1.000000
68	0.000000	0.000000
69	0.000000	0.000000
70	26.30000	0.000000
71	45.80000	0.000000
72	33.66667	0.000000
73	27.60000	0.000000
74	51.00000	0.000000
75	41.71429	0.000000
76	42.33333	0.000000
77	24.99999	0.000000
78	76.70000	0.000000
79	57.20000	0.000000
80	69.33333	0.000000
81	75.40000	0.000000

82	52.00000	0.000000
83	61.28571	0.000000
84	60.66667	0.000000
85	78.00001	0.000000

Table 4 Equality

```
Local optimal solution found.
Objective value:                              4976012.
Objective bound:                              4976012.
Infeasibilities:                              0.000000
Extended solver steps:                              17
Total solver iterations:                          5677
Elapsed runtime seconds:                          0.48

Model Class:                                     MINLP

Total variables:                    36
Nonlinear variables:                21
Integer variables:                   8

Total constraints:                  78
Nonlinear constraints:              13

Total nonzeros:                    178
Nonlinear nonzeros:                 29


                     Variable           Value        Reduced Cost
                   NUMBER_OR        7.000000            0.000000
                  DAYOPEN_OR        5.000000            0.000000
               OR_BLOCK_HOURS        8.000000            0.000000
                  NUMBER_ICU        20.00000            0.000000
                 DAYOPEN_ICU        7.000000            0.000000
           ICU_HOURS_OPERATE        24.00000            0.000000
                 NUMBER_MCU        35.00000            0.000000
                DAYOPEN_MCU        7.000000            0.000000
           MCU_HOURS_OPERATE        24.00000            0.000000
                NUMBER_NURSE        60.00000            0.000000
               WORKING_SHIFT        3.000000            0.000000
                  HOURINSHIFT        8.000000            0.000000
            DAYWORK_ICUNURSE        7.000000            0.000000
                   WEIGHT_WL        1.000000            0.000000
                   WEIGHT_OT        1.000000            0.000000
                    OCOST_OR        400.0000            0.000000
                   OCOST_ICU        15.00000            0.000000
                   OCOST_MCU        5.000000            0.000000
                  OCOST_NURSE        4.000000            0.000000
           DAILY_BLOCKSUPPLY        7.000000            0.000000
         WEEKLY_ORBLOCKSUPPLY        35.00000            0.000000
                  ICUSUPPLY        3360.000            0.000000
                  MCUSUPPLY        5880.000            0.000000
               NURSETIMESUPPY        1120.000            0.000000
           DEMAND_WEEKLY_TPT        98.00000            0.000000
        TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                         OICU        0.000000            0.000000
                         OMCU        0.000000            0.000000
                          OOR        0.000000            0.000000
                       ONURSE        0.000000            0.000000
       AVERAGE_CLEARINGTIME        38.97679            0.000000
          TOTALBLOCK_ASSIGN        35.00000            0.000000
             TOTAL_ICU_TIME        3278.400            0.000000
       TOTAL_MCUDOWN_TIME        4740.000            0.000000
          TOTAL_MCUUP_TIME        1044.000            0.000000
       TOTAL_ICU_NURSE_TIME        1119.467            0.000000
            OR_UTILIZATION        100.0000            0.000000
         ICU_UTILIZATION        97.57143            0.000000
         MCU_UTILIZATION        98.36735            0.000000
       ONURSE_UTILIZATION        99.95238            0.000000
      TOTAL_PATIENTS_ASSIGNED        151.0000            0.000000
           TOTAL_WAITING_COST        4976012.            0.000000
              TOTAL_OOR_COST        0.000000            0.000000
             TOTAL_OICU_COST        0.000000            1.000000
             TOTAL_OMCU_COST        0.000000            1.000000
```

TOTAL_ONURSE_NURSE	0.000000	1.000000
WAITCOST(ENT)	27.50000	0.000000
WAITCOST(OBGYN)	27.50000	0.000000
WAITCOST(URO)	27.50000	0.000000
WAITCOST(GEN)	27.50000	0.000000
WAITCOST(VAS)	27.50000	0.000000
WAITCOST(ORT)	27.50000	0.000000
WAITCOST(NEU)	27.50000	0.000000
WAITCOST(CAR)	27.50000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBGYN)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBGYN)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBGYN)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBGYN)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBGYN)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBGYN)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBGYN)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBGYN)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBGYN)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBGYN)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBGYN)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBGYN)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	52439.27
ASSIGN(OBGYN)	3.000000	21068.58
ASSIGN(URO)	2.000000	-43376.47
ASSIGN(GEN)	10.00000	64941.05
ASSIGN(VAS)	2.000000	-142523.0
ASSIGN(ORT)	7.000000	-45779.40
ASSIGN(NEU)	2.000000	0.000000
ASSIGN(CAR)	1.000000	0.000000
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBGYN)	31.20000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	28.60000	0.000000
TIMEELIMINATE(VAS)	52.00000	0.000000
TIMEELIMINATE(ORT)	42.71429	0.000000
TIMEELIMINATE(NEU)	43.33333	0.000000
TIMEELIMINATE(CAR)	52.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	154916.7
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	4976012.	-1.000000
9	0.000000	-154916.7
10	0.000000	154916.7
11	7.000000	0.000000
12	2.000000	0.000000
13	1.000000	0.000000

14	9.000000	0.000000
15	1.000000	0.000000
16	6.000000	0.000000
17	1.000000	0.000000
18	0.000000	-6196.667
19	20.00000	0.000000
20	25.00000	0.000000
21	26.00000	0.000000
22	18.00000	0.000000
23	26.00000	0.000000
24	21.00000	0.000000
25	26.00000	0.000000
26	27.00000	0.000000
27	0.000000	0.000000
28	81.60000	0.000000
29	0.000000	0.000000
30	0.000000	0.000000
31	96.00000	0.000000
32	0.000000	0.000000
33	0.5333333	0.000000
34	0.000000	139326.0
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	70.00000	0.000000
39	67.57143	0.000000
40	68.36735	0.000000
41	69.95238	0.000000
42	0.000000	0.000000
43	53.00000	0.000000
44	19.00000	0.000000
45	6.000000	0.000000
46	4.000000	0.000000
47	18.00000	0.000000
48	0.000000	0.000000
49	5.000000	0.000000
50	1.000000	0.000000
51	0.000000	0.000000
52	0.000000	-750.7501
53	0.000000	-858.0003
54	0.000000	-953.3329
55	0.000000	-786.5001
56	0.000000	-1429.999
57	0.000000	-1174.643
58	0.000000	-1191.667
59	0.000000	-1430.000
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	1.000000
67	0.000000	1.000000
68	0.000000	1.000000
69	0.000000	0.000000
70	26.30000	0.000000
71	30.20000	0.000000
72	33.66667	0.000000
73	27.60000	0.000000
74	51.00000	0.000000
75	41.71429	0.000000
76	42.33333	0.000000
77	51.00000	0.000000
78	76.70000	0.000000
79	72.80000	0.000000
80	69.33333	0.000000
81	75.40000	0.000000

82	52.00000	0.000000
83	61.28571	0.000000
84	60.66667	0.000000
85	52.00000	0.000000

Table 5 Waiting List Length Priority

```
Local optimal solution found.
Objective value:                              6207235.
Objective bound:                              6207235.
Infeasibilities:                          0.5241136E-04
Extended solver steps:                               11
Total solver iterations:                           1982
Elapsed runtime seconds:                           0.29

Model Class:                                      MINLP

Total variables:                     36
Nonlinear variables:                 21
Integer variables:                    8

Total constraints:                   78
Nonlinear constraints:               13

Total nonzeros:                     178
Nonlinear nonzeros:                  29


                         Variable           Value        Reduced Cost
                        NUMBER_OR        7.000000            0.000000
                      DAYOPEN_OR         5.000000            0.000000
                   OR_BLOCK_HOURS        8.000000            0.000000
                       NUMBER_ICU        20.00000            0.000000
                      DAYOPEN_ICU        7.000000            0.000000
                ICU_HOURS_OPERATE        24.00000            0.000000
                       NUMBER_MCU        35.00000            0.000000
                      DAYOPEN_MCU        7.000000            0.000000
                MCU_HOURS_OPERATE        24.00000            0.000000
                     NUMBER_NURSE        60.00000            0.000000
                    WORKING_SHIFT        3.000000            0.000000
                      HOURINSHIFT        8.000000            0.000000
                 DAYWORK_ICUNURSE        7.000000            0.000000
                        WEIGHT_WL        1.000000            0.000000
                        WEIGHT_OT        1.000000            0.000000
                         OCOST_OR        400.0000            0.000000
                        OCOST_ICU        15.00000            0.000000
                        OCOST_MCU        5.000000            0.000000
                      OCOST_NURSE        4.000000            0.000000
                DAILY_BLOCKSUPPLY        7.000000            0.000000
            WEEKLY_ORBLOCKSUPPLY         35.00000            0.000000
                        ICUSUPPLY        3360.000            0.000000
                        MCUSUPPLY        5880.000            0.000000
                   NURSETIMESUPPY        1120.000            0.000000
               DEMAND_WEEKLY_TPT         98.00000            0.000000
            TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                             OICU        0.000000            0.000000
                             OMCU        0.000000            0.000000
                              OOR        0.000000            0.000000
                           ONURSE        0.000000            0.000000
             AVERAGE_CLEARINGTIME        40.13750            0.000000
                TOTALBLOCK_ASSIGN        35.00000            0.000000
                    TOTAL_ICU_TIME        2776.000            0.000000
              TOTAL_MCUDOWN_TIME          4344.000            0.000000
                TOTAL_MCUUP_TIME          1080.000            0.000000
            TOTAL_ICU_NURSE_TIME          856.0000            0.000000
                  OR_UTILIZATION          100.0000            0.000000
                ICU_UTILIZATION           82.61905            0.000000
                MCU_UTILIZATION           92.24490            0.000000
              ONURSE_UTILIZATION          76.42857            0.000000
          TOTAL_PATIENTS_ASSIGNED         150.0000            0.000000
               TOTAL_WAITING_COST         6207235.            0.000000
                   TOTAL_OOR_COST         0.000000            0.000000
                  TOTAL_OICU_COST         0.000000            1.000000
                  TOTAL_OMCU_COST         0.000000            1.000000
```

TOTAL_ONURSE_NURSE	0.000000	1.000000
WAITCOST(ENT)	45.00000	0.000000
WAITCOST(OBGYN)	22.00000	0.000000
WAITCOST(URO)	22.00000	0.000000
WAITCOST(GEN)	45.00000	0.000000
WAITCOST(VAS)	22.00000	0.000000
WAITCOST(ORT)	45.00000	0.000000
WAITCOST(NEU)	10.00000	0.000000
WAITCOST(CAR)	10.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBGYN)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBGYN)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBGYN)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBGYN)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBGYN)	10.00000	0.000000
REQICUDOWN(URO)	7.000000	0.000000
REQICUDOWN(GEN)	6.000000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	12.00000	0.000000
REQMCUDOWN(OBGYN)	12.00000	0.000000
REQMCUDOWN(URO)	12.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBGYN)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBGYN)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBGYN)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBGYN)	10.00000	0.000000
REQNURSETIME(URO)	7.000000	0.000000
REQNURSETIME(GEN)	6.000000	0.000000
REQNURSETIME(VAS)	48.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBGYN)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBGYN)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	14078.60
ASSIGN(OBGYN)	2.000000	-59157.27
ASSIGN(URO)	2.000000	23134.06
ASSIGN(GEN)	9.000000	0.000000
ASSIGN(VAS)	2.000000	-56182.87
ASSIGN(ORT)	9.000000	-16899.96
ASSIGN(NEU)	2.000000	125435.5
ASSIGN(CAR)	1.000000	0.000000
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBGYN)	46.80000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	31.77778	0.000000
TIMEELIMINATE(VAS)	52.00000	0.000000
TIMEELIMINATE(ORT)	33.22222	0.000000
TIMEELIMINATE(NEU)	43.33333	0.000000
TIMEELIMINATE(CAR)	52.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	181768.9
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	6207235.	-1.000000
9	0.000000	-181768.9
10	0.000000	181768.9
11	7.000000	0.000000
12	1.000000	0.000000
13	1.000000	0.000000

14	8.000000	0.000000
15	1.000000	0.000000
16	8.000000	0.000000
17	1.000000	0.000000
18	0.000000	-127688.9
19	20.00000	0.000000
20	26.00000	0.000000
21	26.00000	0.000000
22	19.00000	0.000000
23	26.00000	0.000000
24	19.00000	0.000000
25	26.00000	0.000000
26	27.00000	0.000000
27	0.000000	0.000000
28	584.0000	0.000000
29	0.000000	0.000000
30	0.000000	0.000000
31	456.0000	0.000000
32	0.000000	0.000000
33	264.0000	0.000000
34	0.000000	165713.9
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	70.00000	0.000000
39	52.61905	0.000000
40	62.24490	0.000000
41	46.42857	0.000000
42	0.000000	0.000000
43	52.00000	0.000000
44	19.00000	0.000000
45	1.000000	0.000000
46	4.000000	0.000000
47	14.00000	0.000000
48	0.000000	0.000000
49	13.00000	0.000000
50	1.000000	0.000000
51	0.000000	0.000000
52	0.000000	-1228.500
53	0.000000	-1029.599
54	0.000000	-762.6670
55	-0.5241136E-04	-1430.000
56	0.000000	-1143.999
57	0.000000	-1495.000
58	0.000000	-433.3336
59	0.000000	-520.0000
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	1.000000
67	0.000000	1.000000
68	0.000000	1.000000
69	0.000000	0.000000
70	26.30000	0.000000
71	45.80000	0.000000
72	33.66667	0.000000
73	30.77778	0.000000
74	51.00000	0.000000
75	32.22222	0.000000
76	42.33333	0.000000
77	51.00000	0.000000
78	76.70000	0.000000
79	57.20000	0.000000
80	69.33333	0.000000
81	72.22222	0.000000

82	52.00000	0.000000
83	70.77778	0.000000
84	60.66667	0.000000
85	52.00000	0.000000

Table 6 Resource intensity (high first)

```
Local optimal solution found.
Objective value:                              3893881.
Objective bound:                              3893881.
Infeasibilities:                          0.1217824E-03
Extended solver steps:                               61
Total solver iterations:                           8816
Elapsed runtime seconds:                           0.55

Model Class:                                      MINLP

Total variables:                     36
Nonlinear variables:                 21
Integer variables:                    8

Total constraints:                   78
Nonlinear constraints:               13

Total nonzeros:                     178
Nonlinear nonzeros:                  29


                         Variable           Value        Reduced Cost
                       NUMBER_OR        7.000000            0.000000
                      DAYOPEN_OR        5.000000            0.000000
                   OR_BLOCK_HOURS        8.000000            0.000000
                      NUMBER_ICU        20.00000            0.000000
                     DAYOPEN_ICU        7.000000            0.000000
                ICU_HOURS_OPERATE        24.00000            0.000000
                      NUMBER_MCU        35.00000            0.000000
                     DAYOPEN_MCU        7.000000            0.000000
                MCU_HOURS_OPERATE        24.00000            0.000000
                     NUMBER_NURSE        60.00000            0.000000
                    WORKING_SHIFT        3.000000            0.000000
                       HOURINSHIFT        8.000000            0.000000
                  DAYWORK_ICUNURSE        7.000000            0.000000
                         WEIGHT_WL        1.000000            0.000000
                         WEIGHT_OT        1.000000            0.000000
                          OCOST_OR        400.0000            0.000000
                         OCOST_ICU        15.00000            0.000000
                         OCOST_MCU        5.000000            0.000000
                        OCOST_NURSE        4.000000            0.000000
                DAILY_BLOCKSUPPLY        7.000000            0.000000
              WEEKLY_ORBLOCKSUPPLY        35.00000            0.000000
                        ICUSUPPLY        3360.000            0.000000
                        MCUSUPPLY        5880.000            0.000000
                   NURSETIMESUPPY        1120.000            0.000000
                DEMAND_WEEKLY_TPT        98.00000            0.000000
            TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                             OICU        0.000000            599.7892
                             OMCU        0.000000            0.000000
                              OOR        0.000000            15994.38
                           ONURSE        0.000000            0.000000
             AVERAGE_CLEARINGTIME        39.98596            0.000000
                TOTALBLOCK_ASSIGN        33.00000            0.000000
                   TOTAL_ICU_TIME        3338.400            0.000000
              TOTAL_MCUDOWN_TIME        4728.000            0.000000
                TOTAL_MCUUP_TIME        1104.000            0.000000
             TOTAL_ICU_NURSE_TIME        1113.467            0.000000
                   OR_UTILIZATION        94.28571            0.000000
                ICU_UTILIZATION        99.35714            0.000000
                MCU_UTILIZATION        99.18367            0.000000
               ONURSE_UTILIZATION        99.41667            0.000000
          TOTAL_PATIENTS_ASSIGNED        141.0000            0.000000
               TOTAL_WAITING_COST        3893881.            0.000000
                  TOTAL_OOR_COST        0.000000            0.000000
                 TOTAL_OICU_COST        0.000000            0.000000
                 TOTAL_OMCU_COST        0.000000            1.000000
```

TOTAL_ONURSE_NURSE	0.000000	1.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBGYN)	10.00000	0.000000
WAITCOST(URO)	10.00000	0.000000
WAITCOST(GEN)	10.00000	0.000000
WAITCOST(VAS)	30.00000	0.000000
WAITCOST(ORT)	30.00000	0.000000
WAITCOST(NEU)	60.00000	0.000000
WAITCOST(CAR)	60.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBGYN)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBGYN)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBGYN)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBGYN)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBGYN)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBGYN)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBGYN)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBGYN)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBGYN)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBGYN)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBGYN)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBGYN)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	-37264.49
ASSIGN(OBGYN)	2.000000	-109511.9
ASSIGN(URO)	2.000000	-72106.59
ASSIGN(GEN)	7.000000	-66772.23
ASSIGN(VAS)	2.000000	-324479.7
ASSIGN(ORT)	8.000000	-167626.8
ASSIGN(NEU)	3.000000	-150222.1
ASSIGN(CAR)	1.000000	-324479.4
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBGYN)	46.80000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	40.85714	0.000000
TIMEELIMINATE(VAS)	52.00000	0.000000
TIMEELIMINATE(ORT)	37.37500	0.000000
TIMEELIMINATE(NEU)	28.88889	0.000000
TIMEELIMINATE(CAR)	52.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	3893881.	-1.000000
9	0.000000	0.000000
10	2.000000	0.000000
11	7.000000	0.000000
12	1.000000	0.000000
13	1.000000	0.000000

14	6.000000	0.000000
15	1.000000	0.000000
16	7.000000	0.000000
17	2.000000	0.000000
18	0.000000	0.000000
19	20.00000	0.000000
20	26.00000	0.000000
21	26.00000	0.000000
22	21.00000	0.000000
23	26.00000	0.000000
24	20.00000	0.000000
25	25.00000	0.000000
26	27.00000	0.000000
27	0.000000	0.000000
28	21.60000	0.000000
29	0.000000	0.000000
30	0.000000	0.000000
31	48.00000	0.000000
32	0.000000	0.000000
33	6.533333	0.000000
34	0.000000	0.000000
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	64.28571	0.000000
39	69.35714	0.000000
40	69.18367	0.000000
41	69.41667	0.000000
42	0.000000	0.000000
43	43.00000	0.000000
44	19.00000	0.000000
45	1.000000	0.000000
46	4.000000	0.000000
47	6.000000	0.000000
48	0.000000	0.000000
49	9.000000	0.000000
50	4.000000	0.000000
51	0.000000	0.000000
52	-0.3037080E-06	-273.0000
53	0.000000	-467.9998
54	0.000000	-346.6665
55	-0.1217824E-03	-408.5714
56	0.000000	-1559.999
57	-0.5662741E-08	-1121.250
58	0.000000	-1733.333
59	0.000000	-3119.997
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	0.000000
67	0.000000	1.000000
68	0.000000	1.000000
69	0.000000	0.000000
70	26.30000	0.000000
71	45.80000	0.000000
72	33.66667	0.000000
73	39.85714	0.000000
74	51.00000	0.000000
75	36.37500	0.000000
76	27.88889	0.000000
77	51.00000	0.000000
78	76.70000	0.000000
79	57.20000	0.000000
80	69.33333	0.000000
81	63.14286	0.000000

82	52.00000	0.000000
83	66.62500	0.000000
84	75.11111	0.000000
85	52.00000	0.000000

Table 7 Resource intensity (low first)

```
Local optimal solution found.
Objective value:                              5309079.
Objective bound:                              5309079.
Infeasibilities:                          0.1121629E-03
Extended solver steps:                               19
Total solver iterations:                           3458
Elapsed runtime seconds:                           0.35

Model Class:                                      MINLP

Total variables:                     36
Nonlinear variables:                 21
Integer variables:                    8

Total constraints:                   78
Nonlinear constraints:               13

Total nonzeros:                     178
Nonlinear nonzeros:                  29


                     Variable           Value        Reduced Cost
                   NUMBER_OR        7.000000            0.000000
                  DAYOPEN_OR        5.000000            0.000000
               OR_BLOCK_HOURS        8.000000            0.000000
                  NUMBER_ICU        20.00000            0.000000
                 DAYOPEN_ICU        7.000000            0.000000
           ICU_HOURS_OPERATE        24.00000            0.000000
                  NUMBER_MCU        35.00000            0.000000
                 DAYOPEN_MCU        7.000000            0.000000
           MCU_HOURS_OPERATE        24.00000            0.000000
                NUMBER_NURSE        60.00000            0.000000
               WORKING_SHIFT        3.000000            0.000000
                  HOURINSHIFT        8.000000            0.000000
            DAYWORK_ICUNURSE        7.000000            0.000000
                   WEIGHT_WL        1.000000            0.000000
                   WEIGHT_OT        1.000000            0.000000
                    OCOST_OR        400.0000            0.000000
                   OCOST_ICU        15.00000            0.000000
                   OCOST_MCU        5.000000            0.000000
                  OCOST_NURSE        4.000000            0.000000
           DAILY_BLOCKSUPPLY        7.000000            0.000000
         WEEKLY_ORBLOCKSUPPLY        35.00000            0.000000
                  ICUSUPPLY        3360.000            0.000000
                  MCUSUPPLY        5880.000            0.000000
               NURSETIMESUPPY        1120.000            0.000000
           DEMAND_WEEKLY_TPT        98.00000            0.000000
         TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                       OICU        0.000000            0.000000
                       OMCU        0.000000            0.000000
                        OOR        0.000000            0.000000
                     ONURSE        0.000000            0.000000
        AVERAGE_CLEARINGTIME        37.92956            0.000000
           TOTALBLOCK_ASSIGN        35.00000            0.000000
              TOTAL_ICU_TIME        2550.000            0.000000
         TOTAL_MCUDOWN_TIME        4140.000            0.000000
           TOTAL_MCUUP_TIME        1116.000            0.000000
        TOTAL_ICU_NURSE_TIME        748.6667            0.000000
             OR_UTILIZATION        100.0000            0.000000
          ICU_UTILIZATION        75.89286            0.000000
          MCU_UTILIZATION        89.38776            0.000000
        ONURSE_UTILIZATION        66.84524            0.000000
      TOTAL_PATIENTS_ASSIGNED        153.0000            0.000000
           TOTAL_WAITING_COST        5309079.            0.000000
              TOTAL_OOR_COST        0.000000            0.000000
             TOTAL_OICU_COST        0.000000            1.000000
             TOTAL_OMCU_COST        0.000000            1.000000
```

TOTAL_ONURSE_NURSE	0.000000	1.000000
WAITCOST(ENT)	40.00000	0.000000
WAITCOST(OBGYN)	40.00000	0.000000
WAITCOST(URO)	40.00000	0.000000
WAITCOST(GEN)	40.00000	0.000000
WAITCOST(VAS)	21.00000	0.000000
WAITCOST(ORT)	21.00000	0.000000
WAITCOST(NEU)	10.00000	0.000000
WAITCOST(CAR)	10.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBGYN)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBGYN)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBGYN)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBGYN)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBGYN)	4.000000	0.000000
REQICUDOWN(URO)	7.000000	0.000000
REQICUDOWN(GEN)	5.000000	0.000000
REQICUDOWN(VAS)	60.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	12.00000	0.000000
REQMCUDOWN(OBGYN)	12.00000	0.000000
REQMCUDOWN(URO)	12.00000	0.000000
REQMCUDOWN(GEN)	12.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	60.00000	0.000000
REQMCUDOWN(NEU)	72.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBGYN)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBGYN)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBGYN)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBGYN)	4.000000	0.000000
REQNURSETIME(URO)	7.000000	0.000000
REQNURSETIME(GEN)	5.000000	0.000000
REQNURSETIME(VAS)	48.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBGYN)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBGYN)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	4200.820
ASSIGN(OBGYN)	3.000000	-41429.01
ASSIGN(URO)	3.000000	25069.14
ASSIGN(GEN)	9.000000	-8313.453
ASSIGN(VAS)	2.000000	-73876.92
ASSIGN(ORT)	7.000000	0.000000
ASSIGN(NEU)	2.000000	96925.47
ASSIGN(CAR)	1.000000	0.000000
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBGYN)	31.19999	0.000000
TIMEELIMINATE(URO)	23.11111	0.000000
TIMEELIMINATE(GEN)	31.77778	0.000000
TIMEELIMINATE(VAS)	52.00000	0.000000
TIMEELIMINATE(ORT)	42.71429	0.000000
TIMEELIMINATE(NEU)	43.33333	0.000000
TIMEELIMINATE(CAR)	52.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	153258.9
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	5309079.	-1.000000
9	0.000000	-153258.9
10	0.000000	153258.9
11	7.000000	0.000000
12	2.000000	0.000000
13	2.000000	0.000000

14	8.000000	0.000000
15	1.000000	0.000000
16	6.000000	0.000000
17	1.000000	0.000000
18	0.000000	-99178.86
19	20.00000	0.000000
20	25.00000	0.000000
21	25.00000	0.000000
22	19.00000	0.000000
23	26.00000	0.000000
24	21.00000	0.000000
25	26.00000	0.000000
26	27.00000	0.000000
27	0.000000	0.000000
28	810.0000	0.000000
29	0.000000	0.000000
30	0.000000	0.000000
31	624.0000	0.000000
32	0.000000	0.000000
33	371.3333	0.000000
34	0.000000	138087.0
35	0.000000	0.000000
36	0.000000	0.000000
37	0.000000	0.000000
38	70.00000	0.000000
39	45.89286	0.000000
40	59.38776	0.000000
41	36.84524	0.000000
42	0.000000	0.000000
43	55.00000	0.000000
44	19.00000	0.000000
45	6.000000	0.000000
46	10.00000	0.000000
47	14.00000	0.000000
48	0.000000	0.000000
49	5.000000	0.000000
50	1.000000	0.000000
51	0.000000	0.000000
52	0.000000	-1092.000
53	-0.1121629E-03	-1248.000
54	0.000000	-924.4448
55	0.000000	-1271.111
56	0.000000	-1091.999
57	0.000000	-897.0000
58	0.000000	-433.3336
59	0.000000	-520.0000
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	1.000000
67	0.000000	1.000000
68	0.000000	1.000000
69	0.000000	0.000000
70	26.30000	0.000000
71	30.19999	0.000000
72	22.11111	0.000000
73	30.77778	0.000000
74	51.00000	0.000000
75	41.71429	0.000000
76	42.33333	0.000000
77	51.00000	0.000000
78	76.70000	0.000000
79	72.80001	0.000000
80	80.88889	0.000000
81	72.22222	0.000000

82	52.00000	0.000000
83	61.28571	0.000000
84	60.66667	0.000000
85	52.00000	0.000000

Table 8 Overtime allowance 10%

```
Local optimal solution found.
Objective value:                              3928452.
Objective bound:                              3928452.
Infeasibilities:                              0.000000
Extended solver steps:                              35
Total solver iterations:                          6461
Elapsed runtime seconds:                          0.52

Model Class:                                     MINLP

Total variables:                    36
Nonlinear variables:                21
Integer variables:                   8

Total constraints:                  78
Nonlinear constraints:              13

Total nonzeros:                    178
Nonlinear nonzeros:                 29


                         Variable           Value        Reduced Cost
                        NUMBER_OR        7.000000            0.000000
                       DAYOPEN_OR        5.000000            0.000000
                   OR_BLOCK_HOURS        8.000000            0.000000
                       NUMBER_ICU        20.00000            0.000000
                      DAYOPEN_ICU        7.000000            0.000000
                ICU_HOURS_OPERATE        24.00000            0.000000
                       NUMBER_MCU        35.00000            0.000000
                      DAYOPEN_MCU        7.000000            0.000000
                MCU_HOURS_OPERATE        24.00000            0.000000
                     NUMBER_NURSE        60.00000            0.000000
                    WORKING_SHIFT        3.000000            0.000000
                      HOURINSHIFT        8.000000            0.000000
                 DAYWORK_ICUNURSE        7.000000            0.000000
                        WEIGHT_WL        1.000000            0.000000
                        WEIGHT_OT        1.000000            0.000000
                         OCOST_OR        350.0000            0.000000
                        OCOST_ICU        20.00000            0.000000
                        OCOST_MCU        5.000000            0.000000
                      OCOST_NURSE        4.000000            0.000000
                DAILY_BLOCKSUPPLY        7.000000            0.000000
            WEEKLY_ORBLOCKSUPPLY         35.00000            0.000000
                      ICUSUPPLY          3360.000            0.000000
                      MCUSUPPLY          5880.000            0.000000
                NURSETIMESUPPY           1120.000            0.000000
            DEMAND_WEEKLY_TPT            98.00000            0.000000
          TOTAL_PATIENTS_ALLDEP          5096.000            0.000000
                           OICU          134.4000            0.000000
                           OMCU          288.0000            0.000000
                            OOR          0.000000            12058.85
                         ONURSE          102.1333            0.000000
         AVERAGE_CLEARINGTIME            34.45387            0.000000
            TOTALBLOCK_ASSIGN            35.00000            0.000000
               TOTAL_ICU_TIME            3494.400            0.000000
          TOTAL_MCUDOWN_TIME             4980.000            0.000000
            TOTAL_MCUUP_TIME             1188.000            0.000000
         TOTAL_ICU_NURSE_TIME            1222.133            0.000000
                OR_UTILIZATION           100.0000            0.000000
              ICU_UTILIZATION            104.0000            0.000000
              MCU_UTILIZATION            104.8980            0.000000
            ONURSE_UTILIZATION           109.1190            0.000000
        TOTAL_PATIENTS_ASSIGNED          149.0000            0.000000
             TOTAL_WAITING_COST          3772151.            0.000000
                 TOTAL_OOR_COST          0.000000            0.000000
                TOTAL_OICU_COST          92612.00            0.000000
                TOTAL_OMCU_COST          49613.57            0.000000
```

TOTAL_ONURSE_NURSE	14075.55	0.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBG)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBG)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBG)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBG)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBG)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBG)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBG)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBG)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBG)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBG)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBG)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBG)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBG)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	8.000000	-7502.050
ASSIGN(OBG)	3.000000	20234.26
ASSIGN(URO)	2.000000	68790.78
ASSIGN(GEN)	8.000000	-23691.25
ASSIGN(VAS)	3.000000	-8983.019
ASSIGN(ORT)	7.000000	-16830.20
ASSIGN(NEU)	2.000000	-101562.4
ASSIGN(CAR)	2.000000	54797.23
TIMEELIMINATE(ENT)	27.30000	0.000000
TIMEELIMINATE(OBG)	31.20000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	35.75000	0.000000
TIMEELIMINATE(VAS)	34.66667	0.000000
TIMEELIMINATE(ORT)	42.71429	0.000000
TIMEELIMINATE(NEU)	43.33333	0.000000
TIMEELIMINATE(CAR)	26.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	0.000000
3	0.000000	689.0774
4	0.000000	172.2693
5	0.000000	137.8155
6	0.000000	0.000000
7	0.000000	0.000000
8	3928452.	-1.000000
9	0.000000	0.000000
10	0.000000	0.000000
11	7.000000	0.000000
12	2.000000	0.000000
13	1.000000	0.000000

14	7.000000	0.000000
15	2.000000	0.000000
16	6.000000	0.000000
17	1.000000	0.000000
18	1.000000	0.000000
19	20.00000	0.000000
20	25.00000	0.000000
21	26.00000	0.000000
22	20.00000	0.000000
23	25.00000	0.000000
24	21.00000	0.000000
25	26.00000	0.000000
26	26.00000	0.000000
27	0.000000	-689.0774
28	0.000000	689.0774
29	0.000000	-172.2693
30	0.000000	-172.2693
31	0.000000	172.2693
32	0.000000	-137.8155
33	0.000000	137.8155
34	3.500000	0.000000
35	201.6000	0.000000
36	300.0000	0.000000
37	9.866667	0.000000
38	70.00000	0.000000
39	74.00000	0.000000
40	74.89796	0.000000
41	79.11905	0.000000
42	0.000000	0.000000
43	51.00000	0.000000
44	19.00000	0.000000
45	6.000000	0.000000
46	4.000000	0.000000
47	10.00000	0.000000
48	4.000000	0.000000
49	5.000000	0.000000
50	1.000000	0.000000
51	2.000000	0.000000
52	0.000000	-287.1767
53	0.000000	-568.2047
54	0.000000	-255.2558
55	0.000000	-589.7208
56	0.000000	-1607.255
57	0.000000	-959.9666
58	0.000000	-2261.177
59	0.000000	-1571.768
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	0.000000
67	0.000000	0.000000
68	0.000000	0.000000
69	0.000000	-4536.541
70	26.30000	0.000000
71	30.20000	0.000000
72	33.66667	0.000000
73	34.75000	0.000000
74	33.66667	0.000000
75	41.71429	0.000000
76	42.33333	0.000000
77	25.00000	0.000000
78	76.70000	0.000000
79	72.80000	0.000000
80	69.33333	0.000000
81	68.25000	0.000000

82	69.33333	0.000000
83	61.28571	0.000000
84	60.66667	0.000000
85	78.00000	0.000000

Table 9 Overtime allowance 15%

```
Local optimal solution found.
Objective value:                              3923421.
Objective bound:                              3923421.
Infeasibilities:                          0.4303414E-02
Extended solver steps:                               41
Total solver iterations:                           8423
Elapsed runtime seconds:                           0.79

Model Class:                                      MINLP

Total variables:                     36
Nonlinear variables:                 21
Integer variables:                    8

Total constraints:                   78
Nonlinear constraints:               13

Total nonzeros:                     178
Nonlinear nonzeros:                  29


                     Variable           Value        Reduced Cost
                   NUMBER_OR        7.000000            0.000000
                  DAYOPEN_OR        5.000000            0.000000
               OR_BLOCK_HOURS        8.000000            0.000000
                  NUMBER_ICU        20.00000            0.000000
                 DAYOPEN_ICU        7.000000            0.000000
           ICU_HOURS_OPERATE        24.00000            0.000000
                  NUMBER_MCU        35.00000            0.000000
                 DAYOPEN_MCU        7.000000            0.000000
           MCU_HOURS_OPERATE        24.00000            0.000000
                NUMBER_NURSE        60.00000            0.000000
               WORKING_SHIFT        3.000000            0.000000
                  HOURINSHIFT        8.000000            0.000000
            DAYWORK_ICUNURSE        7.000000            0.000000
                   WEIGHT_WL        1.000000            0.000000
                   WEIGHT_OT        1.000000            0.000000
                    OCOST_OR        350.0000            0.000000
                   OCOST_ICU        20.00000            0.000000
                   OCOST_MCU        5.000000            0.000000
                 OCOST_NURSE        4.000000            0.000000
           DAILY_BLOCKSUPPLY        7.000000            0.000000
        WEEKLY_ORBLOCKSUPPLY        35.00000            0.000000
                  ICUSUPPLY        3360.000            0.000000
                  MCUSUPPLY        5880.000            0.000000
               NURSETIMESUPPY        1120.000            0.000000
           DEMAND_WEEKLY_TPT        98.00000            0.000000
        TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                         OICU        395.4000            0.000000
                         OMCU        480.0000            0.000000
                          OOR        1.000000            0.000000
                       ONURSE        163.1333            0.000000
     AVERAGE_CLEARINGTIME           32.63929            0.000000
        TOTALBLOCK_ASSIGN           36.00000            0.000000
           TOTAL_ICU_TIME           3755.400            0.000000
     TOTAL_MCUDOWN_TIME             5100.000            0.000000
        TOTAL_MCUUP_TIME            1260.000            0.000000
     TOTAL_ICU_NURSE_TIME           1283.133            0.000000
           OR_UTILIZATION           102.8571            0.000000
        ICU_UTILIZATION             111.7679            0.000000
        MCU_UTILIZATION             108.1633            0.000000
      ONURSE_UTILIZATION            114.5655            0.000000
    TOTAL_PATIENTS_ASSIGNED         151.0000            0.000000
         TOTAL_WAITING_COST         3554253.            0.000000
            TOTAL_OOR_COST          11423.75            0.000000
           TOTAL_OICU_COST          258111.5            0.000000
           TOTAL_OMCU_COST          78334.29            0.000000
```

TOTAL_ONURSE_NURSE	21298.22	0.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBG)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBG)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBG)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBG)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBG)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBG)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBG)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBG)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBG)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBG)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBG)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBG)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBG)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	7.000000	-13521.67
ASSIGN(OBG)	3.000000	17117.75
ASSIGN(URO)	2.000000	59118.28
ASSIGN(GEN)	9.000000	-752.0167
ASSIGN(VAS)	3.000000	-18608.82
ASSIGN(ORT)	7.000000	-18325.22
ASSIGN(NEU)	3.000000	54881.73
ASSIGN(CAR)	2.000000	48022.67
TIMEELIMINATE(ENT)	31.20000	0.000000
TIMEELIMINATE(OBG)	31.20000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	31.77778	0.000000
TIMEELIMINATE(VAS)	34.66667	0.000000
TIMEELIMINATE(ORT)	42.71428	0.000000
TIMEELIMINATE(NEU)	28.88889	0.000000
TIMEELIMINATE(CAR)	26.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	11423.75
3	0.000000	652.7858
4	0.000000	163.1964
5	0.000000	130.5572
6	0.000000	0.000000
7	0.000000	0.000000
8	3923421.	-1.000000
9	0.000000	-11423.75
10	0.000000	11423.75
11	6.000000	0.000000
12	2.000000	0.000000
13	1.000000	0.000000

14	8.000000	0.000000
15	2.000000	0.000000
16	6.000000	0.000000
17	2.000000	0.000000
18	1.000000	0.000000
19	21.00000	0.000000
20	25.00000	0.000000
21	26.00000	0.000000
22	19.00000	0.000000
23	25.00000	0.000000
24	21.00000	0.000000
25	25.00000	0.000000
26	26.00000	0.000000
27	0.000000	-652.7858
28	0.000000	652.7858
29	0.000000	-163.1964
30	0.000000	-163.1964
31	0.000000	163.1964
32	0.000000	-130.5572
33	0.000000	130.5572
34	4.250000	0.000000
35	108.6000	0.000000
36	402.0000	0.000000
37	4.866667	0.000000
38	72.85714	0.000000
39	81.76786	0.000000
40	78.16327	0.000000
41	84.56548	0.000000
42	0.000000	0.000000
43	53.00000	0.000000
44	14.00000	0.000000
45	6.000000	0.000000
46	4.000000	0.000000
47	14.00000	0.000000
48	4.000000	0.000000
49	5.000000	0.000000
50	4.000000	0.000000
51	2.000000	0.000000
52	0.000000	-352.3947
53	0.000000	-624.6546
54	0.000000	-325.8182
55	0.000000	-547.7171
56	0.000000	-1677.817
57	-0.4643414E-04	-990.2076
58	0.000000	-1601.536
59	0.000000	-1783.455
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	-0.6526840E-03	0.000000
66	-0.4303414E-02	0.000000
67	-0.1989578E-02	0.000000
68	-0.2868943E-03	0.000000
69	0.000000	-11310.53
70	30.20000	0.000000
71	30.20000	0.000000
72	33.66667	0.000000
73	30.77778	0.000000
74	33.66667	0.000000
75	41.71428	0.000000
76	27.88889	0.000000
77	25.00000	0.000000
78	72.80000	0.000000
79	72.80000	0.000000
80	69.33333	0.000000
81	72.22222	0.000000

82	69.33333	0.000000
83	61.28572	0.000000
84	75.11111	0.000000
85	78.00000	0.000000

Table 10 Overtime allowance 20%

```
Local optimal solution found.
Objective value:                              3912646.
Objective bound:                              3912646.
Infeasibilities:                              0.000000
Extended solver steps:                              29
Total solver iterations:                          5488
Elapsed runtime seconds:                          0.38

Model Class:                                      MINLP

Total variables:                    36
Nonlinear variables:                21
Integer variables:                   8

Total constraints:                  78
Nonlinear constraints:              13

Total nonzeros:                    178
Nonlinear nonzeros:                 29


                         Variable           Value        Reduced Cost
                       NUMBER_OR        7.000000            0.000000
                      DAYOPEN_OR        5.000000            0.000000
                   OR_BLOCK_HOURS        8.000000            0.000000
                      NUMBER_ICU        20.00000            0.000000
                     DAYOPEN_ICU        7.000000            0.000000
                ICU_HOURS_OPERATE        24.00000            0.000000
                      NUMBER_MCU        35.00000            0.000000
                     DAYOPEN_MCU        7.000000            0.000000
                MCU_HOURS_OPERATE        24.00000            0.000000
                     NUMBER_NURSE        60.00000            0.000000
                    WORKING_SHIFT        3.000000            0.000000
                       HOURINSHIFT        8.000000            0.000000
                  DAYWORK_ICUNURSE        7.000000            0.000000
                         WEIGHT_WL        1.000000            0.000000
                         WEIGHT_OT        1.000000            0.000000
                          OCOST_OR        350.0000            0.000000
                         OCOST_ICU        20.00000            0.000000
                         OCOST_MCU        5.000000            0.000000
                        OCOST_NURSE        4.000000            0.000000
                DAILY_BLOCKSUPPLY        7.000000            0.000000
              WEEKLY_ORBLOCKSUPPLY        35.00000            0.000000
                        ICUSUPPLY        3360.000            0.000000
                        MCUSUPPLY        5880.000            0.000000
                   NURSETIMESUPPY        1120.000            0.000000
                DEMAND_WEEKLY_TPT        98.00000            0.000000
            TOTAL_PATIENTS_ALLDEP        5096.000            0.000000
                             OICU        569.4000            0.000000
                             OMCU        960.0000            0.000000
                              OOR        4.000000            0.000000
                           ONURSE        221.1333            0.000000
          AVERAGE_CLEARINGTIME        31.10521            0.000000
             TOTALBLOCK_ASSIGN        39.00000            0.000000
                TOTAL_ICU_TIME        3929.400            0.000000
            TOTAL_MCUDOWN_TIME        5532.000            0.000000
              TOTAL_MCUUP_TIME        1308.000            0.000000
           TOTAL_ICU_NURSE_TIME        1341.133            0.000000
                 OR_UTILIZATION        111.4286            0.000000
              ICU_UTILIZATION        116.9464            0.000000
              MCU_UTILIZATION        116.3265            0.000000
            ONURSE_UTILIZATION        119.7440            0.000000
        TOTAL_PATIENTS_ASSIGNED        165.0000            0.000000
             TOTAL_WAITING_COST        3338054.            0.000000
                TOTAL_OOR_COST        43547.29            0.000000
               TOTAL_OICU_COST        354226.1            0.000000
               TOTAL_OMCU_COST        149305.0            0.000000
```

TOTAL_ONURSE_NURSE	27513.59	0.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBG)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBG)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBG)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBG)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBG)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBG)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBG)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBG)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBG)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBG)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBG)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBG)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBG)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	9.000000	3834.135
ASSIGN(OBG)	3.000000	2422.555
ASSIGN(URO)	2.000000	37636.76
ASSIGN(GEN)	9.000000	-7149.916
ASSIGN(VAS)	3.000000	-39014.37
ASSIGN(ORT)	8.000000	10054.23
ASSIGN(NEU)	3.000000	37157.62
ASSIGN(CAR)	2.000000	29768.47
TIMEELIMINATE(ENT)	24.26667	0.000000
TIMEELIMINATE(OBG)	31.20000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	31.77778	0.000000
TIMEELIMINATE(VAS)	34.66667	0.000000
TIMEELIMINATE(ORT)	37.37500	0.000000
TIMEELIMINATE(NEU)	28.88889	0.000000
TIMEELIMINATE(CAR)	26.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	10886.82
3	0.000000	622.1043
4	0.000000	155.5261
5	0.000000	124.4209
6	0.000000	0.000000
7	0.000000	0.000000
8	3912646.	-1.000000
9	0.000000	-10886.82
10	0.000000	10886.82
11	8.000000	0.000000
12	2.000000	0.000000
13	1.000000	0.000000

14	8.000000	0.000000
15	2.000000	0.000000
16	7.000000	0.000000
17	2.000000	0.000000
18	1.000000	0.000000
19	19.00000	0.000000
20	25.00000	0.000000
21	26.00000	0.000000
22	19.00000	0.000000
23	25.00000	0.000000
24	20.00000	0.000000
25	25.00000	0.000000
26	26.00000	0.000000
27	0.000000	-622.1043
28	0.000000	622.1043
29	0.000000	-155.5261
30	0.000000	-155.5261
31	0.000000	155.5261
32	0.000000	-124.4209
33	0.000000	124.4209
34	3.000000	0.000000
35	102.6000	0.000000
36	216.0000	0.000000
37	2.866667	0.000000
38	81.42857	0.000000
39	86.94643	0.000000
40	86.32653	0.000000
41	89.74405	0.000000
42	0.000000	0.000000
43	67.00000	0.000000
44	24.00000	0.000000
45	6.000000	0.000000
46	4.000000	0.000000
47	14.00000	0.000000
48	4.000000	0.000000
49	9.000000	0.000000
50	4.000000	0.000000
51	2.000000	0.000000
52	0.000000	-293.9793
53	0.000000	-684.3379
54	0.000000	-400.4223
55	0.000000	-572.5851
56	0.000000	-1752.421
57	0.000000	-894.4084
58	0.000000	-1701.008
59	0.000000	-2007.267
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	0.000000
67	0.000000	0.000000
68	0.000000	0.000000
69	0.000000	-18472.52
70	23.26667	0.000000
71	30.20000	0.000000
72	33.66667	0.000000
73	30.77778	0.000000
74	33.66667	0.000000
75	36.37500	0.000000
76	27.88889	0.000000
77	25.00000	0.000000
78	79.73333	0.000000
79	72.80000	0.000000
80	69.33333	0.000000
81	72.22222	0.000000

82	69.33333	0.000000
83	66.62500	0.000000
84	75.11111	0.000000
85	78.00000	0.000000

Table 11 Overtime allowance 25%

```
Local optimal solution found.
Objective value:                              3911936.
Objective bound:                              3911936.
Infeasibilities:                              0.000000
Extended solver steps:                              32
Total solver iterations:                          6534
Elapsed runtime seconds:                          0.62

Model Class:                                      MINLP

Total variables:                    36
Nonlinear variables:                21
Integer variables:                   8

Total constraints:                  78
Nonlinear constraints:              13

Total nonzeros:                    178
Nonlinear nonzeros:                 29


                         Variable           Value        Reduced Cost
                        NUMBER_OR        7.000000            0.000000
                       DAYOPEN_OR        5.000000            0.000000
                   OR_BLOCK_HOURS        8.000000            0.000000
                       NUMBER_ICU        20.00000            0.000000
                      DAYOPEN_ICU        7.000000            0.000000
                ICU_HOURS_OPERATE        24.00000            0.000000
                       NUMBER_MCU        35.00000            0.000000
                      DAYOPEN_MCU        7.000000            0.000000
                MCU_HOURS_OPERATE        24.00000            0.000000
                     NUMBER_NURSE        60.00000            0.000000
                    WORKING_SHIFT        3.000000            0.000000
                      HOURINSHIFT        8.000000            0.000000
                 DAYWORK_ICUNURSE        7.000000            0.000000
                        WEIGHT_WL        1.000000            0.000000
                        WEIGHT_OT        1.000000            0.000000
                         OCOST_OR        350.0000            0.000000
                        OCOST_ICU        20.00000            0.000000
                        OCOST_MCU        5.000000            0.000000
                      OCOST_NURSE        4.000000            0.000000
                DAILY_BLOCKSUPPLY        7.000000            0.000000
            WEEKLY_ORBLOCKSUPPLY         35.00000            0.000000
                      ICUSUPPLY          3360.000            0.000000
                      MCUSUPPLY          5880.000            0.000000
                  NURSETIMESUPPY         1120.000            0.000000
                DEMAND_WEEKLY_TPT        98.00000            0.000000
            TOTAL_PATIENTS_ALLDEP         5096.000            0.000000
                             OICU         629.4000            0.000000
                             OMCU         1056.000            0.000000
                              OOR         5.000000            0.000000
                           ONURSE         241.1333            0.000000
          AVERAGE_CLEARINGTIME            30.70799            0.000000
             TOTALBLOCK_ASSIGN            40.00000            0.000000
                TOTAL_ICU_TIME            3989.400            0.000000
           TOTAL_MCUDOWN_TIME             5628.000            0.000000
             TOTAL_MCUUP_TIME             1308.000            0.000000
          TOTAL_ICU_NURSE_TIME            1361.133            0.000000
                OR_UTILIZATION            114.2857            0.000000
             ICU_UTILIZATION              118.7321            0.000000
             MCU_UTILIZATION              117.9592            0.000000
           ONURSE_UTILIZATION             121.5298            0.000000
         TOTAL_PATIENTS_ASSIGNED          169.0000            0.000000
              TOTAL_WAITING_COST          3279888.            0.000000
                 TOTAL_OOR_COST           53738.98            0.000000
                TOTAL_OICU_COST           386552.1            0.000000
                TOTAL_OMCU_COST           162138.2            0.000000
```

TOTAL_ONURSE_NURSE	29618.88	0.000000
WAITCOST(ENT)	10.00000	0.000000
WAITCOST(OBG)	17.00000	0.000000
WAITCOST(URO)	6.000000	0.000000
WAITCOST(GEN)	16.00000	0.000000
WAITCOST(VAS)	45.00000	0.000000
WAITCOST(ORT)	22.00000	0.000000
WAITCOST(NEU)	50.00000	0.000000
WAITCOST(CAR)	55.00000	0.000000
WEEKLY_DEMAND(ENT)	21.00000	0.000000
WEEKLY_DEMAND(OBG)	9.000000	0.000000
WEEKLY_DEMAND(URO)	8.000000	0.000000
WEEKLY_DEMAND(GEN)	22.00000	0.000000
WEEKLY_DEMAND(VAS)	8.000000	0.000000
WEEKLY_DEMAND(ORT)	23.00000	0.000000
WEEKLY_DEMAND(NEU)	5.000000	0.000000
WEEKLY_DEMAND(CAR)	2.000000	0.000000
WAITING_LIST(ENT)	1092.000	0.000000
WAITING_LIST(OBG)	468.0000	0.000000
WAITING_LIST(URO)	416.0000	0.000000
WAITING_LIST(GEN)	1144.000	0.000000
WAITING_LIST(VAS)	416.0000	0.000000
WAITING_LIST(ORT)	1196.000	0.000000
WAITING_LIST(NEU)	260.0000	0.000000
WAITING_LIST(CAR)	104.0000	0.000000
EFFICIENCY(ENT)	5.000000	0.000000
EFFICIENCY(OBG)	5.000000	0.000000
EFFICIENCY(URO)	6.000000	0.000000
EFFICIENCY(GEN)	4.000000	0.000000
EFFICIENCY(VAS)	4.000000	0.000000
EFFICIENCY(ORT)	4.000000	0.000000
EFFICIENCY(NEU)	3.000000	0.000000
EFFICIENCY(CAR)	2.000000	0.000000
SURGERY_DUR(ENT)	1.233000	0.000000
SURGERY_DUR(OBG)	1.433000	0.000000
SURGERY_DUR(URO)	1.060000	0.000000
SURGERY_DUR(GEN)	1.550000	0.000000
SURGERY_DUR(VAS)	2.000000	0.000000
SURGERY_DUR(ORT)	1.780000	0.000000
SURGERY_DUR(NEU)	2.670000	0.000000
SURGERY_DUR(CAR)	4.000000	0.000000
REQICUDOWN(ENT)	3.000000	0.000000
REQICUDOWN(OBG)	24.00000	0.000000
REQICUDOWN(URO)	19.20000	0.000000
REQICUDOWN(GEN)	15.00000	0.000000
REQICUDOWN(VAS)	48.00000	0.000000
REQICUDOWN(ORT)	36.00000	0.000000
REQICUDOWN(NEU)	72.00000	0.000000
REQICUDOWN(CAR)	72.00000	0.000000
REQMCUDOWN(ENT)	24.00000	0.000000
REQMCUDOWN(OBG)	12.00000	0.000000
REQMCUDOWN(URO)	24.00000	0.000000
REQMCUDOWN(GEN)	24.00000	0.000000
REQMCUDOWN(VAS)	72.00000	0.000000
REQMCUDOWN(ORT)	48.00000	0.000000
REQMCUDOWN(NEU)	48.00000	0.000000
REQMCUDOWN(CAR)	72.00000	0.000000
REQMCUUP(ENT)	0.000000	0.000000
REQMCUUP(OBG)	12.00000	0.000000
REQMCUUP(URO)	12.00000	0.000000
REQMCUUP(GEN)	0.000000	0.000000
REQMCUUP(VAS)	24.00000	0.000000
REQMCUUP(ORT)	12.00000	0.000000
REQMCUUP(NEU)	24.00000	0.000000
REQMCUUP(CAR)	24.00000	0.000000
MIN_WEEKLYASSIGN(ENT)	1.000000	0.000000
MIN_WEEKLYASSIGN(OBG)	1.000000	0.000000
MIN_WEEKLYASSIGN(URO)	1.000000	0.000000

MIN_WEEKLYASSIGN(GEN)	1.000000	0.000000
MIN_WEEKLYASSIGN(VAS)	1.000000	0.000000
MIN_WEEKLYASSIGN(ORT)	1.000000	0.000000
MIN_WEEKLYASSIGN(NEU)	1.000000	0.000000
MIN_WEEKLYASSIGN(CAR)	1.000000	0.000000
MAX_WEEKLYASSIGN(ENT)	28.00000	0.000000
MAX_WEEKLYASSIGN(OBG)	28.00000	0.000000
MAX_WEEKLYASSIGN(URO)	28.00000	0.000000
MAX_WEEKLYASSIGN(GEN)	28.00000	0.000000
MAX_WEEKLYASSIGN(VAS)	28.00000	0.000000
MAX_WEEKLYASSIGN(ORT)	28.00000	0.000000
MAX_WEEKLYASSIGN(NEU)	28.00000	0.000000
MAX_WEEKLYASSIGN(CAR)	28.00000	0.000000
REQNURSETIME(ENT)	3.000000	0.000000
REQNURSETIME(OBG)	24.00000	0.000000
REQNURSETIME(URO)	19.20000	0.000000
REQNURSETIME(GEN)	15.00000	0.000000
REQNURSETIME(VAS)	84.00000	0.000000
REQNURSETIME(ORT)	36.00000	0.000000
REQNURSETIME(NEU)	46.00000	0.000000
REQNURSETIME(CAR)	46.00000	0.000000
LOWER_TIME(ENT)	1.000000	0.000000
LOWER_TIME(OBG)	1.000000	0.000000
LOWER_TIME(URO)	1.000000	0.000000
LOWER_TIME(GEN)	1.000000	0.000000
LOWER_TIME(VAS)	1.000000	0.000000
LOWER_TIME(ORT)	1.000000	0.000000
LOWER_TIME(NEU)	1.000000	0.000000
LOWER_TIME(CAR)	1.000000	0.000000
UPPER_TIME(ENT)	104.0000	0.000000
UPPER_TIME(OBG)	104.0000	0.000000
UPPER_TIME(URO)	104.0000	0.000000
UPPER_TIME(GEN)	104.0000	0.000000
UPPER_TIME(VAS)	104.0000	0.000000
UPPER_TIME(ORT)	104.0000	0.000000
UPPER_TIME(NEU)	104.0000	0.000000
UPPER_TIME(CAR)	104.0000	0.000000
ASSIGN(ENT)	9.000000	2618.511
ASSIGN(OBG)	3.000000	-1714.561
ASSIGN(URO)	2.000000	31520.83
ASSIGN(GEN)	10.00000	5086.155
ASSIGN(VAS)	3.000000	-44667.15
ASSIGN(ORT)	8.000000	6986.049
ASSIGN(NEU)	3.000000	32260.67
ASSIGN(CAR)	2.000000	24626.62
TIMEELIMINATE(ENT)	24.26667	0.000000
TIMEELIMINATE(OBG)	31.20000	0.000000
TIMEELIMINATE(URO)	34.66667	0.000000
TIMEELIMINATE(GEN)	28.60000	0.000000
TIMEELIMINATE(VAS)	34.66667	0.000000
TIMEELIMINATE(ORT)	37.37500	0.000000
TIMEELIMINATE(NEU)	28.88889	0.000000
TIMEELIMINATE(CAR)	26.00000	0.000000

Row	Slack or Surplus	Dual Price
1	0.000000	0.000000
2	0.000000	10747.80
3	0.000000	614.1598
4	0.000000	153.5399
5	0.000000	122.8320
6	0.000000	0.000000
7	0.000000	0.000000
8	3911936.	-1.000000
9	0.000000	-10747.80
10	0.000000	10747.80
11	8.000000	0.000000
12	2.000000	0.000000
13	1.000000	0.000000

14	9.000000	0.000000
15	2.000000	0.000000
16	7.000000	0.000000
17	2.000000	0.000000
18	1.000000	0.000000
19	19.00000	0.000000
20	25.00000	0.000000
21	26.00000	0.000000
22	18.00000	0.000000
23	25.00000	0.000000
24	20.00000	0.000000
25	25.00000	0.000000
26	26.00000	0.000000
27	0.000000	-614.1598
28	0.000000	614.1598
29	0.000000	-153.5399
30	0.000000	-153.5399
31	0.000000	153.5399
32	0.000000	-122.8320
33	0.000000	122.8320
34	3.750000	0.000000
35	210.6000	0.000000
36	414.0000	0.000000
37	38.86667	0.000000
38	84.28571	0.000000
39	88.73214	0.000000
40	87.95918	0.000000
41	91.52976	0.000000
42	0.000000	0.000000
43	71.00000	0.000000
44	24.00000	0.000000
45	6.000000	0.000000
46	4.000000	0.000000
47	18.00000	0.000000
48	4.000000	0.000000
49	9.000000	0.000000
50	4.000000	0.000000
51	2.000000	0.000000
52	0.000000	-299.8404
53	0.000000	-701.9208
54	0.000000	-422.4015
55	0.000000	-521.9204
56	0.000000	-1774.401
57	0.000000	-902.6506
58	0.000000	-1730.313
59	0.000000	-2073.205
60	0.000000	0.000000
61	0.000000	0.000000
62	0.000000	0.000000
63	0.000000	0.000000
64	0.000000	0.000000
65	0.000000	0.000000
66	0.000000	0.000000
67	0.000000	0.000000
68	0.000000	0.000000
69	0.000000	-20582.52
70	23.26667	0.000000
71	30.20000	0.000000
72	33.66667	0.000000
73	27.60000	0.000000
74	33.66667	0.000000
75	36.37500	0.000000
76	27.88889	0.000000
77	25.00000	0.000000
78	79.73333	0.000000
79	72.80000	0.000000
80	69.33333	0.000000
81	75.40000	0.000000

82	69.33333	0.000000
83	66.62500	0.000000
84	75.11111	0.000000
85	78.00000	0.000000

APPENDIX II

LIST OF PUBLICATIONS

1. Jittamai, P.; Toek, S.; Phengarree, K.; Kongkanjana, K.; Chanlawong, N. Multi-Criteria Decision-Making for Assessing and Evaluating Health and Wellness Tourism Destination Potential Using the 6AsTD Framework: A Case Study of Nakhon Ratchasima Province, Thailand. Sustainability 2025, 17, 4995. https://doi.org/10.3390/su17114995

sustainability

MDPI

Article

Multi-Criteria Decision-Making for Assessing and Evaluating Health and Wellness Tourism Destination Potential Using the 6AsTD Framework: A Case Study of Nakhon Ratchasima Province, Thailand

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Abstract: Health and wellness tourism is a rapidly expanding segment of the global tourism industry, driven by increasing consumer awareness of well-being and lifestyle enhancement. As the demand for wellness travel grows, destinations are expected to offer high standards of safety, hygiene, rehabilitation, and holistic experiences. This study aims to identify and evaluate the key attributes and determinants for developing health and wellness tourism destinations by applying the 6As Tourism Development framework: Attractions, Accessibility, Amenities, Activities, Available Packages, and Ancillary Services. A multi-criteria decision-making approach, specifically the TOPSIS, was employed to assess destination potential through a case study of Nakhon Ratchasima Province, Thailand. The results indicate that Attractions, Accessibility, and Amenities are the top three priorities for wellness tourists. Sub-criteria such as natural scenery, cultural significance, accessibility for all, safety, and accommodation quality are particularly influential. Three districts in Nakhon Ratchasima were found to exhibit distinct strengths—Pak Chong is best suited for rehabilitative tourism (e.g., aroma and water therapy), aligning with mind and nutrition wellness components; Wang Nam Khiao is ideal for ecotourism and cultural experiences, supporting environmental and nutritional dimensions; while Mueang Nakhon Ratchasima excels in sports tourism, supporting physical and nutritional well-being. The study offers practical insights for policymakers and tourism stakeholders to design sustainable, visitor-centered wellness destinations. The proposed framework supports strategic planning and resource allocation for health-focused tourism development.

Keywords: health and wellness tourism (HWT); multi-criteria decision-making (MCDM); 6As tourism destination (6AsTD); TOPSIS

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1. Introduction

The diversification of global tourism in recent decades has given rise to specialized forms of travel, among which health and wellness tourism (HWT) has gained increasing prominence. This form of tourism promotes physical, mental, and spiritual well-being through various types of travel experiences and the combination of traditional travel experiences with health-oriented activities [1]. According to the Global Wellness Economy Monitor [2], the wellness economy reached an unprecedented $6.3 trillion in 2023, with

projections estimating growth to nearly $9.0 trillion by 2028. HWT not only benefits the tourism industry but also stimulates various other industries, such as transportation, food, accommodation, entertainment, etc. [3]. It could be seen that wellness tourism is a large umbrella that potentially includes various business sectors, including culture and food exploration, nature expenditure, fitness activities, spas, yoga, and meditation. For example, the food industry could become healthy food services, and sightseeing activities in natural scenery could become sport trips [4].

HWT encompasses a wide range of activities, not only spa and yoga sessions but also unique cultural traditions, historical sites, traditional and healthy foods, and natural resources such as hot springs and mountains [5]. The form of health and wellness treatment promoted for tourists in each country tends to be different, depending on the destination, local resources, or social circumstances of the destination. For example, natural health practices, including homeopathy, are most prevalent in the United States, Europe, the Middle East, Australia, New Zealand, and various South Pacific nations. According to the Global Wellness Institute [6], in Southeast Asian countries, the focus is on healing that ties spirituality and alternative therapies by promoting activities that improve well-being through the surrounding environment. In addition, it is worth noting that Western travelers are increasingly drawn to Eastern philosophies and therapies available in various Asian countries, including shiatsu and onsen (hot springs) in Japan acupuncture, reflexology, tui na, and tai chi in China, Ayurvedic practices in India, and traditional Thai massage in Thailand [7]. In addition to the availability of diverse philosophies and therapies, the affordability of health and wellness treatments in Asian countries is a significant factor motivating Western tourists to visit the region. Consequently, Asia has emerged as a global leader in HWT, leading to intense competition among Asian countries.

Hekmat et al. [8] demonstrated that an increasing number of consumers perceive HWT tourism as a holistic experience. This perspective emphasizes not only the significance of products directly associated with health and wellness treatments but also the importance of leisure activities, safety and hygiene, accessibility, recreation, and cultural experiences. For these reasons, to stay competitive and attract tourists, understanding the core attributes and determinants of health and wellness destinations from the tourists' perspective is crucial for developing sustainable and successful HWT destinations [9,10]. The competitiveness of a wellness tourism destination means the readiness of an area to facilitate the development, improvement, or changes, and the appeal of that area to attract wellness tourists [11].

In this context, there is a need to identify the attributes and determinants that are most important for tourists when selecting destinations. Based on this premise, many researchers, policymakers, and practitioners consider the significance of destination competitiveness and its attributes' effects in planning and developing a tourism destination [12].

Hence, this study aims to develop a framework for assessing and evaluating health and wellness tourism destinations. This study leverages the 6As tourism destination development framework (6AsDT) from Buhalis [13] and Buhalis and Amaranggana [14]—comprising Attractions, Accessibility, Amenities, Activities, Available Packages, and Ancillary Services—to examine the key attributes and determinants that shape service quality and visitor satisfaction.

Based on an identified set of attributes and determinants of HWT destinations, the study proposed a framework for assessing and evaluating the HWT destinations based on identified attributes and determinants using a Multi-Criteria Decision-Making (MCDM) approach, specifically the TOPSIS. A case study of Nakhon Ratchasima, Thailand, is conducted to verify and validate the attributes and determinants, offering empirical insights into health and wellness destination development and assessment.

This paper is structured into five main sections. Section 1 presents the study's background and introduction. Section 2 reviews existing literature on health and wellness tourism, along with methodologies for assessing and identifying the potential of tourism destinations. Section 3 outlines the methodology employed in this study. First, a literature review and expert interviews helped identify attributes and determinants within the 6AsTD. Second, a mean-based thresholding technique was used to filter unnecessary attributes and determinants. Third, a weighting method prioritized these sub-criteria. Finally, the TOPSIS method was applied to rank tourism activities across districts. Section 4 explores the implications of the study's findings. Section 5 summarizes the study's conclusions, encapsulating the core insights and implications of the research.

2. Literature Review

2.1. Health and Wellness Tourism (HWT)

Health and Wellness Tourism (HWT) encompasses travel experiences focused on improving or maintaining physical, mental, and spiritual well-being through a range of holistic activities. It frequently intersects with other forms of niche tourism, such as cultural, culinary, and eco-tourism, offering a comprehensive approach to well-being. This industry drives economic growth by creating jobs, supporting local products, and empowering women. It also connects to health practices, helping to revive traditional wellness methods and improve mental health. In addition, HWT helps protect natural and cultural heritage, supports the environment, and promotes sustainable tourism [3].

In general, HWT is classified into two main types: Health Promotion Tourism, which emphasizes preventive health practices in natural and cultural environments, and Health Healing Tourism, which is centered on medical treatments and rehabilitation efforts. According to Liao et al. [15], the health benefits of wellness tourism can be classified into four main areas: physical fitness, mental well-being, quality of life, and environmental health.

Existing research divides HWT into two main fields: medical and well-being tourism. The medical aspect focuses on illness, surgery, and therapeutic treatments within biological research, while the well-being aspect takes a broader approach, emphasizing the balance of mind, body, spirit, environment, and overall quality of life [16].

Majeed and Gon Kim [17] further categorize HWT based on the health conditions of the tourists into two groups: those with non-critical disease conditions and those with critical health conditions. Tourists with non-critical health conditions often seek conventional medical treatments or alternative therapies like yoga, meditation, massage, and wellness check-ups in health resorts, temples, or natural environments.

Conversely, wellness tourists with serious health conditions, such as those receiving cancer treatment, can benefit from a blend of conventional medical care and complementary health therapies. These travelers often engage in therapeutic activities, including spending time in natural settings or participating in gentle exercises like walking or breathing techniques. Hartwell et al. [16] highlighted three essential areas of wellness tourism research: destinations focused on health and well-being, the influence of tourism on the health of local communities, and its impact on the well-being of tourists. More recently, Kongtaveesawas et al. [18] highlighted that HWT experiences involve physical activities aimed at enhancing both physical and mental health. Their study also emphasized environmental concerns, which align with the widely accepted PMSE wellness tourism experience framework, covering physical, mental, spiritual, and environmental aspects.

Nonetheless, the perceived values and expectations from the destinations of customers are varied and different experience concepts in terms of cultural diversification. Hence, understanding the general attributes and determinants of health and wellness destinations is crucial for developing sustainable and successful destinations.

2.2. *Health and Wellness Tourism (HWT) in Thailand*

The tourism industry is a crucial driver of Thailand's economy, contributing significantly to both domestic and international markets. In recent years, Thailand has experienced steady growth in its tourism sector, marked by a consistent rise in international tourist arrivals and an increase in average spending per trip, with an annual growth rate of approximately 2%. Thailand remains a popular destination for tourists from developed countries due to its relatively low costs [19]. In 2018 alone, the country generated nearly USD 3.5 billion in tourism revenue. Wellness services contribute around 3% of Thailand's GDP, with 90% of this figure derived from the beauty, anti-aging, and preventive medicine sectors, while the remaining 10% comes from spa treatment businesses [20]. To stay competitive in the global tourism market, Thailand has increasingly focused on developing high-value products and services, particularly in the HWT sector. This niche market has gained momentum as global awareness of health and well-being continues to grow. The demand for holistic health practices, such as yoga, meditation, and traditional healing methods, has risen significantly, further highlighting the potential of HWT. According to the Global Wellness Economy Monitor [21], Thailand ranks fourth in the Asia-Pacific region for its wellness tourism market size. Csirmaz and Pető [22] noted that many countries in the region have rich resources and traditions that can be incorporated into health and wellness tourism. Examples include the Japanese and Korean bath cultures, Indonesian body treatments, Thai massage techniques, and the Southeast Asian cosmetic industry. Acknowledging this potential, HWT has become a key focus of Thailand's national development strategies, including the 20-year National Strategic Plan (2018–2037) and the Bio-Circular-Green (BCG) economic model. These strategies highlight the significance of HWT in increasing national revenue and enhancing service quality to align with international standards.

In Thailand, HWT is a thriving alternative tourism sector, integrating the country's natural resources, cultural heritage, and health traditions to promote overall well-being. Popular HWT programs include Traditional Thai Medicine Tours, which showcase traditional Thai massage techniques at landmarks like Wat Pho, and Herbal Cuisine Tours, where tourists explore herbal wisdom through culinary experiences and participate in yoga and meditation. Additionally, Rural Herbal Medicine Tours allow travelers to learn from local herbalists, while Natural Agriculture Tours offer insights into sustainable farming practices, such as growing chemical-free vegetables, based on the King Rama IX sufficiency economy philosophy. According to Kongtaveesawas et al. [18], the characteristics of HWT in Thailand consist of four main key characteristics, namely, Physical Attributes: Activities like spa treatments and detox programs that enhance physical health; Mental Attributes: Experiences that promote mental well-being, such as mindfulness and relaxation techniques; Spiritual Attributes: Opportunities for spiritual growth, including meditation and cultural practices; Environmental Attributes: The importance of the destination's atmosphere, including hygiene and local culture. Other wellness experiences in Thailand include Hot Spring and Mineral Bath Tours, which offer relaxation at natural hot spring resorts, and Meditation and Spiritual Retreats, which provide guided meditation sessions in serene monasteries. For those seeking to connect with nature, Nature and Biodiversity Tours invite travelers to national parks and forests, where activities like hiking and herbal foraging are combined with wellness services [23]. These diverse offerings emphasize Thailand's commitment to integrating natural, cultural, and health-focused elements, promoting holistic well-being for travelers. The growing appeal of HWT brings significant economic, social, and environmental benefits to destinations, attracting a broad range of travelers and contributing to sustainable tourism development.

2.3. Tourism Destination Development: The 6AsTD Framework and Multi-Criteria Decision-Making (MCDM)

2.3.1. The 6AsTD Framework in Tourism Destination Development

The 6AsTD framework is a widely used model for evaluating tourism destinations, focusing on six critical components: Attractions, Accessibility, Amenities, Available Packages, Activities, and Ancillary Services [13,14]. Each component consists of several sub-criteria that contribute to a destination's success, offering a holistic perspective from the tourist's viewpoint. Numerous studies have adopted the 6AsTD framework to guide strategic planning and resource allocation.

Based on the review literature on the 6AsTD framework, the criteria and sub-criteria of the six key components of the 6AsTD framework are defined as follows: Attractions (A1): This component focuses on features that draw visitors to the destination, such as natural landscapes (A11), artificial tourism sites (A12), cultural attractions (A13), and special events (A14). Accessibility (A2): This evaluates how easy it is for tourists to access the destination, considering transportation routes (A21), terminals (A22), and both internal (A23) and external (A24) public transportation options. Amenities (A3): Amenities include necessary facilities such as lodging (A31), restaurants (A32), public utilities (A33), and shopping centers (A34), ensuring tourist comfort. Available Packages (A4): The availability and variety of tour packages, such as guided tours (A41), organized packages (A42), and special interest tours (A43), contribute to the destination's appeal. Activities (A5): This component assesses the range of activities, from sightseeing to adventure sports and cultural experiences, that engage tourists during their visit. Ancillary Services (A6): Supporting services such as communication channels (A61), internet access (A62), financial services (A63), medical services (A64), and postal services (A65) are crucial for enhancing the tourist experience [24–30].

2.3.2. Multi-Criteria Decision-Making (MCDM) in Tourism Studies

Decision-making in tourism often involves evaluating multiple, sometimes conflicting, criteria. MCDM techniques provide systematic and robust tools for comparing alternatives based on various qualitative and quantitative factors. Several studies have applied the 6AsTD framework in conjunction with MCDM techniques. For example, Arif et al. [24] combined the 6AsTD framework with the TOPSIS method to prioritize tourism destinations based on the destination's attributes, providing a comprehensive analysis of tourism potential. In another study, Arif et al. [25] integrated the 6AsTD framework with blockchain technology to rate tourism destinations using data collected from tourists, enabling more accurate and decentralized destination evaluations. Arif et al. [26] applied the 6AsTD framework to develop a Multi-Criteria Recommender System (MCRS), which utilizes rating values between users to provide recommendations for selecting tourist destinations. Similarly, Agustan et al. [27] employed the 6AsTD framework with TOPSIS to assess local governments' priorities for destination development in Wakatobi, Indonesia. The analysis highlighted the significance of each 6AsTD component in determining tourism potential. Each variable within these components was evaluated, revealing important insights into the strengths and weaknesses of the destination. Other studies have applied the pure 6As framework to different tourism contexts. Govekar et al. [28] used the framework to develop a model for smart beach management, emphasizing sustainable and innovative strategies. Additionally, Agustina Riski and Wulandari [29] applied the 6As framework to assess the educational tourism potential of Desa Coklat Bali, demonstrating its versatility across different types of destinations. Lopes and Rodríguez-López [30] conducted a study to rank wellness tourism destinations in Northern Portugal using MCDM methods, specifically the PROMETHEE and GAIA approaches. These tools assist tourism experts and planners

in identifying optimal destinations. Unlike the 6AsTD framework, the study utilizes the Travel and Tourism Development Index (TTDI), which comprises five subindexes: enabling environment, tourism policy and conditions, infrastructure, tourism demand drivers, and sustainability.

Among the various MCDM methods, TOPSIS has emerged as one of the most popular approaches. TOPSIS ranks alternatives based on their distance to an ideal (best) and anti-ideal (worst) solution, making it highly suitable for tourism destination evaluation where both strengths and weaknesses must be considered simultaneously [24,27]. The selection of TOPSIS in this study is based on several reasons: It provides clear and interpretable rankings of alternatives as well as can handle multiple criteria effectively, and is computationally efficient. Moreover, TOPSIS supports quantitative integration of expert judgments, making it ideal for studies like this one that rely on stakeholders and expert inputs. Other MCDM methods, such as AHP, PROMETHEE, and GAIA, have their own merits, but they often involve more complex pairwise comparisons or assumptions not as well suited to the structure of this study. Hence, TOPSIS is selected for its simplicity, compatibility with 6AsTD, and demonstrated effectiveness in tourism-related decision-making contexts. It has been widely validated in tourism research, including applications involving the 6AsTD framework [24,27].

The 6AsTD framework has proven to be an effective tool for evaluating and developing tourism destinations, particularly when integrated with MCDM methods specifically. In the context of HWT, this study aims to identify the critical attributes and determinants within the 6AsTD essential for developing and accessing HWT destinations. Experts' insights into the tourism industry, related stakeholders, tourists, etc., gathered through a survey questionnaire, will be utilized to evaluate the sub-criteria within each primary variable of the 6AsTD framework.

3. Methodology

3.1. Study Design and Method

This study adopts an exploratory, mixed-methods design aimed at identifying, assessing, and prioritizing key attributes and determinants of HWT destinations. A case study in Nakhon Ratchasima Province is used to test the framework. The research does not involve hypothesis testing but is grounded in a systematic framework to support decision-making in HWT development.

The methodological approach integrates both qualitative and quantitative components to ensure a comprehensive evaluation. Qualitative data were obtained through expert interviews, focus group discussions, and a literature review to identify relevant criteria based on the 6AsTD framework. Quantitative data were collected through structured surveys using a Likert scale, enabling the prioritization of criteria and the evaluation of site suitability through a Multi-Criteria Decision-Making (MCDM) process. The methodology consists of four key stages as shown in Figure 1.

1. Literature Review and Expert Interviews/Assessment: A comprehensive literature review and expert interviews are conducted to identify and analyze the attributes and determinants of the Tourism Destination Framework (6AsTD), providing a basis for assessing and evaluating the potential of HWT in a given region.
2. Mean-based thresholding: A mean-based threshold is used to estimate the unnecessary attributes and determinants of 6AsTD based on the expert judgment of the Linkert scale of 1–5 (not necessary to most necessary).
3. Weighting method for attributes and determinants of 6AsTD: A weighting method is applied to prioritize the sub-criteria within the 6AsTD framework. This process involves expert judgment, statistical techniques, or a combination of both

to ensure an objective and reliable prioritization of factors influencing wellness tourism development.

4. Multi-Criteria Decision-Making (MCDM): TOPSIS is used as an MCDM approach to evaluate assessing and evaluating the suitability of HWT activities in each location. This method ranks tourism activities based on their proximity to an ideal solution, ensuring a data-driven decision-making process.

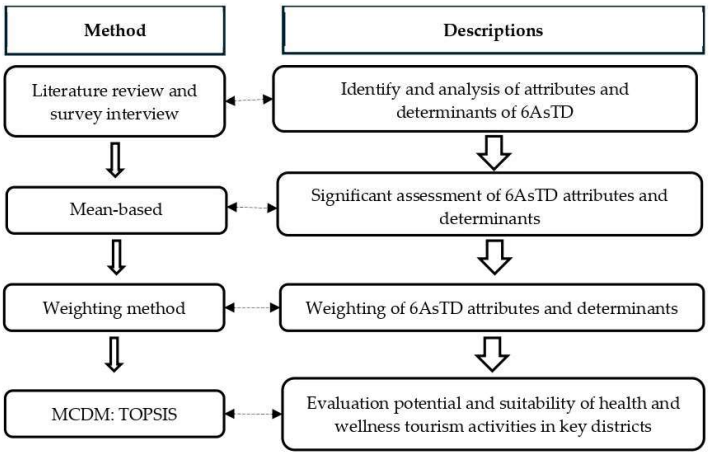
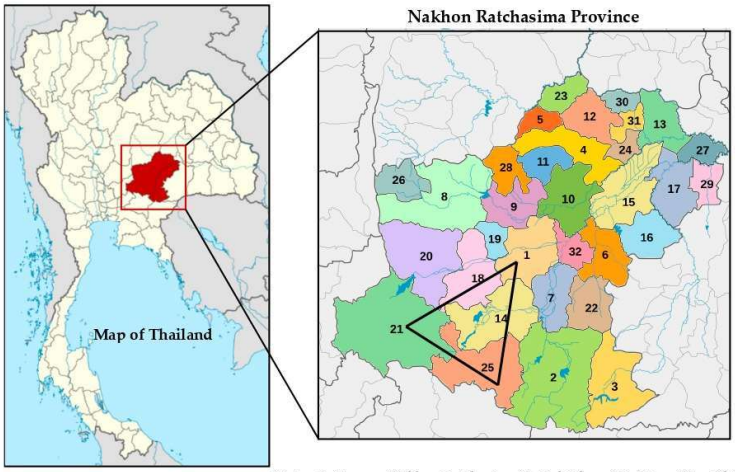


Figure 1. Research framework.

3.2. *Study Area*

Nakhon Ratchasima, Thailand's largest province by area and population, spans 20,493 square kilometers and houses over 2.6 million residents. Its geographical diversity, including mountainous landscapes, cultural sites, and urban centers, positions it as a strong contender for HWT development. The province already supports traditional Thai medicine, herbal food tourism, natural agriculture, hot springs, and eco-tourism, providing a strong foundation for an integrated HWT supply chain.

The study focuses on three key districts—Mueang Nakhon Ratchasima, Wang Nam Khiao, and Pak Chong—selected for their diverse HWT offerings (Figure 2). These districts represent a cross-section of the province's tourism landscape, ensuring a comprehensive assessment of the sector's potential. Each district has been chosen for its unique characteristics. These include a combination of modern urban amenities, cultural and traditional wellness practices, ecological attractions, sustainable agriculture, organic health products, and a variety of wellness-focused facilities such as resorts, hot springs, and spas. Across the districts in the province, eight HWT activities were selected and analyzed in this study, namely, Ecotourism, Cultural Tourism, Food Tourism, Culinary Tourism, Sport City, Cycling Tourism, Aroma Therapy, and Water Therapy. The selection is based on multiple factors, including tourist preferences from the survey, the region's unique characteristics, theoretical frameworks on health and wellness tourism, and the provincial policy for tourism development.



Notes: 1. Mueang Nakhon Ratchasima 21. Pak Chong 25. Wang Nam Khiao

Figure 2. Map of the study area.

3.3. Data Collected

3.3.1. Type of Data Collected

The data collection process in this study was structured to systematically assess and evaluate the potential and sustainability of HWT in Nakhon Ratchasima Province.

Primary data were collected through participatory surveys and semi-structured interviews, targeting key stakeholders such as tourism service providers, local authorities, and tourists. The interviews, conducted with HWT experts, local government representatives, and community leaders, offered qualitative insights into the internal and external factors affecting the region's tourism landscape, contributing to a deeper understanding of strategic priorities.

Secondary data were sourced through a literature review, which analyzed the sub-criteria of 6AsTD. This review, along with expert interviews and assessments, identified attributes and determinants relevant to the potential of health and wellness destinations. The literature also provided context for sustainability, wellness tourism trends, and supply chain management, ensuring a robust theoretical foundation.

3.3.2. Data Collection Procedures

The data collection process in this study was structured to systematically assess and evaluate the potential and sustainability of health and wellness tourism (HWT) in Nakhon Ratchasima Province through both qualitative and quantitative methods.

Phase 1: Criteria Identification, Elimination, and Weighting

Primary data in the initial phase was collected from two key groups using participatory surveys and structured group discussions: (1) 30 general health and wellness tourists and (2) 20 experts from tourism government agencies and academic institutions. These participants were selected using purposive sampling, based on their experience and familiarity with general tourism and HWT. Participants were first asked to identify sub-criteria under the 6As Tourism Destination (6AsTD) framework. They were guided by a list of

attributes and determinants identified through a prior literature review and their own opinion. Redundant or overlapping sub-criteria were then consolidated. To refine this list, the same respondents rated the importance of each sub-criterion using a 5-point Likert scale. A simple mean threshold was applied to eliminate sub-criteria with scores below the overall mean. The resulting final set of sub-criteria was subsequently rated again using a 10-point Likert scale to determine their relative importance (weights). These weights served as inputs for the MCDM process in later stages.

Phase 2: District-Level Evaluation of Tourism Activities

In the second phase, data were collected through field-level surveys involving 50 participants in Nakhon Ratchasima province. This group included tourists, community members, HWT service providers, and local government officials. Participants were selected using a mix of purposive and randomized sampling to ensure relevant experience while avoiding sampling bias. Participants evaluated local HWT activities based on the finalized and weighted sub-criteria. Their ratings were used as input for the TOPSIS analysis, facilitating a comparative assessment of HWT development potential across the districts. Table 1 shows a summary of participants' demographics and sampling methods.

Table 1. Summary of participant demographics' and sampling methods.

Participant Group	No. of Participants	Gender (M/F)	Age Range (Years)	Occupation/ Role	Sampling Method
Group 1: Criteria Identification and Weighting					
Health and Wellness Tourists	30	14/16	25–60	General tourists with an interest in health and wellness	Purposive
Experts (Government and Academia)	20	11/9	30–65	Tourism officials, researchers, consultants	Purposive
Group 2: District-Level Evaluation					
Tourists	10	5/5	20–55	Domestic visitors	Random
Local Community Members	15	6/9	25–65	Shopkeepers, wellness providers	Random
HWT service providers	15	8/7	30–60	Spa owners, resort managers, retreat operators	Random
Local Officials	10	6/4	35–60	District tourism officers	Purposive

3.4. Multi-Criteria Decision-Making (MCDM)

MCDM is a method dealing with making a decision based on multiple criteria. It is aimed at supporting structuring, analyzing, and recommending alternative solutions to assist decision-makers in several service sectors, including the tourism industry. This study employs an MCDM method, specifically TOPSIS, to evaluate the suitability of tourism destinations and their support for HWT activities. The details of the methodology are outlined below.

3.4.1. Criteria Identification

To effectively assess the potential and suitability of a destination for health and wellness tourism, it is crucial to break down the broad categories of the 6AsTD Framework into more specific sub-criteria tailored to this niche market. The 6AsTD framework, which

includes Attractions, Accessibility, Amenities, Available Packages, Activities, and Ancillary Services, serves as a comprehensive tool for evaluating tourism destinations by Buhalis [13]. However, for a focused analysis of health and wellness tourism, it is essential to identify sub-criteria that reflect the specific needs and preferences of wellness travelers.

In this study, sub-criteria are identified based on insights from existing literature, tourism expert interviews, and a focus group of wellness tourists. These sub-criteria will ensure that each dimension of the 6AsTD framework is contextualized for the health and wellness sector. By identifying these sub-criteria, this research aims to provide a more comprehensive and sector-specific application of the 6AsTD framework. The result is a set of tailored indicators that will be used to evaluate the region's potential and suitability for health and wellness activities for developing a competitive HWT offering.

3.4.2. Mean-Based Thresholding

Mean-based Thresholding, the average (mean) score or rating of each sub-criterion, C_i, is calculated based on an expert and focus group of wellness tourist evaluations S_{ij}. A predefined threshold, typically based on the average score $\overline{S_i}$ is used to determine the relevance of each sub-criterion. Sub-criteria C_i that have a mean score $\overline{S_i}$ below the threshold (T) are eliminated, as they are considered less significant. This approach helps in simplifying the decision-making process by focusing only on the most important factors. The result of this approach will be further used in the next section.

The process of Mean-based Thresholding can be outlined in a sequence of steps as follows:

(1) Mean Score Calculation:

$$\overline{S_i} = \frac{1}{m}\sum_{j=1}^{m} S_{ij}\ ;\ i = 1, 2, \ldots, n\ j = 1, 2, \ldots, m \tag{1}$$

(2) Threshold Definition:
Let T represent the **threshold value**, which is typically based on the overall average of all mean scores across sub-criteria. This can be calculated as follows:

$$T = \frac{1}{n}\sum_{i=1}^{n} \overline{S_i}\ ;\ i = 1, 2, \ldots, n \tag{2}$$

(3) Elimination of Less Important Sub-criteria:
Sub-criteria with a mean score $\overline{S_i}$ below the threshold T are considered less significant and are eliminated from further analysis. Formally, a sub-criterion C_i is eliminated if:

$$\overline{S_i} < T \tag{3}$$

Only sub-criteria C_i that satisfy $\overline{S_i} > T$ will be retained for further analysis.

(4) Final Decision-Making Model
The final set of weighted sub-criteria forms the input for the subsequent analysis. This ensures that only the most relevant sub-criteria (those with a mean score above the threshold) contribute to the decision-making process, simplifying the evaluation while focusing on key factors.

3.4.3. Criteria Scoring

Scoring function was applied to estimate each weight value of the sub-criteria. Experts were allowed to assess each value based on preference score e from 0 (extremely unimpor-

tant) to 10 (extremely important). Afterwards, the corresponding weight for each criterion i = {1, 2, . . . , n}, w_i is given by the following:

$$w_i = \frac{1}{W} \sum_{e=1}^{10} \mu_{i,e} \tag{4}$$

$$Where\ W = \sum_{i=1}^{n} \sum_{e=1}^{10} \mu_{i,e} \tag{5}$$

3.4.4. Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)

TOPSIS is a multi-criteria decision-making method designed to identify the optimal option from a set of alternatives. The fundamental concept is to choose the alternative that is closest to the ideal solution and furthest from the worst possible option. The TOPSIS methodology involves a series of steps, as detailed by Jahanshahloo et al. [31]:

(1) Calculate the normalized decision matrix. The normalized value n_{ij} is calculated as follows:

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} {x_{ij}}^2}};\ j = 1, 2, \ldots, m;\ i = 1, 2, \ldots, n \tag{6}$$

(2) Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as follows:

$$v_{ij} = w_i \times n_{ij};\ j = 1, 2, \ldots, m;\ i = 1, 2, \ldots, n \tag{7}$$

where w_i is the weight of the ith attribute or creation and criterion, and $\sum_{i=1}^{n} w_i = 1$

(3) Determine the positive ideal and negative ideal solution.

$$A^+ = \left\{ v_1^+,\ v_1^+, \ldots\ldots,\ v_n^+ \right\} = \left\{ \left(max_j\ v_{ij} | i \in I \right),\ \left(min_j\ v_{ij} | i \in J \right) \right\} \tag{8}$$

$$A^- = \left\{ v_1^-,\ v_1^-, \ldots\ldots,\ v_n^- \right\} = \left\{ \left(min_j\ v_{ij} | i \in I \right),\ \left(max_j\ v_{ij} | i \in J \right) \right\} \tag{9}$$

where I is associated with benefit criteria, and J is associated with cost criteria.

(4) Calculate the separation measures using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is calculated as follows:

$$d_j^+ = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v_{ij}^+ \right)^2};\ j = 1, 2, \ldots\ldots\ldots\ldots\ldots m. \tag{10}$$

Similarly, the separation from the negative ideal solution is given as follows:

$$d_j^- = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v_{ij}^- \right)^2};\ j = 1, 2, \ldots\ldots\ldots\ldots\ldots m. \tag{11}$$

(5) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative:

$$R_j = \frac{d_j^-}{d_j^+ + d_j^-};\ i = 1, 2, \ldots\ldots,\ m. \tag{12}$$

Since $d_j^- \geq 0$ *and* $d_j^+ \geq 0$, *then*, *clearly* $R \in [0, 1]$.

(6) Rank the preference order

4. Results and Discussion

4.1. Analysis of 6AsTD Framework

4.1.1. Identified Criteria

This study employed the 6AsTD, proposed by Buhalis [13], as the foundation for evaluating the potential of locations for HWT. Each of the components represents a key dimension in determining the suitability of a destination for health- and wellness-oriented experiences. To identify specific sub-criteria under each component, a multi-method approach was applied, combining an extensive literature review, expert interviews, tourist surveys, and internal brainstorming discussions within the research team. This approach ensured both theoretical depth and practical relevance.

The literature review drew on various academic sources, including the works of [18,24–30,32,33], which provided valuable insights into the essential elements influencing HWT destinations. These were further refined through in-depth discussions with tourism professionals and feedback from tourists, which helped validate the real-world applicability of the identified criteria. Brainstorming sessions among the research team also contributed to shaping and finalizing the list of sub-criteria.

As a result, a total of 39 attributes and determinants were identified and categorized under the six components of the 6AsTD framework. Within the Attractions component, five sub-criteria were determined, namely natural scenery or environment, cultural significance, health and wellness appeal, uniqueness of experience, and the presence of artificial tourism sites. Under Accessibility, six key sub-criteria were recognized, which include proximity to public transport hubs, quality of infrastructure, availability of transportation, accessibility for all users, ease of accessing information, and convenience in booking. The Amenities category also comprised six sub-criteria: availability of accommodation options such as resorts or hotels, dining and nutrition services, recreational facilities including sauna and steam rooms, safety and hygiene standards, opportunities for health-related shopping, and access to fitness facilities and public parks. In the case of Available Packages, seven sub-criteria were synthesized. These include a variety of wellness-focused packages, the possibility of customization, cost-effectiveness, appropriate duration, such as weekend or two-day packages, comprehensiveness of health packages, availability of coaching or expert-led programs, and the inclusion of group-based activities like aerobic dance. Similarly, seven sub-criteria were identified for the Activities component, including physical wellness activities such as sports or yoga, the level of engagement they offer, innovativeness such as plastic surgery options, special events with knowledge-sharing or storytelling elements, natural therapy activities like forest bathing or health-oriented hiking, mental therapy programs, and nutrition-focused activities. Lastly, the Ancillary Services component comprised eight sub-criteria, which cover health and wellness support services, the availability of local guides and experts, medical services, complementary services, financial services such as ATMs and banks, postal services, internet access including free Wi-Fi, and communication infrastructure such as mobile signal availability.

Altogether, these 39 sub-criteria offer a comprehensive assessment tool for determining the critical attributes and determinants for identifying the region's potential in supporting HWT initiatives. They form a solid foundation for subsequent stages of analysis and decision-making in destination planning and development. Table 2 presents a detailed summary of these attributes and determinants categorized under each of the six components of the 6AsTD framework.

Table 2. Summarizes the attributes and determinants for each of the 6AsTD.

Main Criteria	Sub-Criteria
Attractions:	Natural Scenery/Environment
	Cultural Significance
	Health and Wellness Appeal
	Uniqueness of Experience
	Artificial tourism sites
Accessibility:	Proximity to Public Transport Hubs
	Quality of Infrastructure
	Availability of Transportation
	Accessibility for All
	Accessibility for information
	Easily for booking
Amenities:	Accommodation Options (resort/hotel)
	Dining and Nutrition
	Recreational Facilities (sauna/stream)
	Safety and Hygiene
	Health-related Shopping
	Fitness and public park
Available Packages:	Variety of Packages (wellness activities)
	Customization Options
	Cost-Effectiveness
	Duration (e.g., 2 days package)
	Comprehensive Health Package
	Health Programs with Coaching/Experts
	Group packages (Aerobic dance)
Activities:	Physical Wellness activities (Sport/Yoga)
	Engagement Level
	Innovativeness (plastic surgery etc.)
	Special events (Knowledge/storytelling)
	Natural Therapy Activities (Forest Bathing, Health-Oriented Hiking, etc.)
	Mental therapy
	Nutritional Activities
Ancillary Services:	Health and Wellness Support
	Local Guides and Experts
	Medical Services
	Complementary Services
	Financial services (ATM/bank)
	Postal services
	Internet access (free WI-FI)
	Communication channels (signal call)

4.1.2. Thresholding Results

Following the identification of relevant attributes and determinants within the 6AsTD framework, a mean-based thresholding technique was employed to refine the list of sub-criteria. This process aimed to eliminate elements deemed less significant based on perceptions of two focused respondent groups: health and wellness tourists and experts.

Participants were asked to evaluate each of the 39 sub-criteria using a five-point Likert scale, where a score of 1 represented "not necessary", and a score of 5 indicated "most necessary". The mean score for each sub-criterion was calculated. A threshold value of T = 3.19 was established to differentiate between significant and insignificant sub-criteria. Any sub-criterion with a mean score below this threshold was excluded from further consideration.

For instance, the sub-criterion "Artificial Tourism Sites" received an average score of 1.50 and was subsequently eliminated. In total, 15 sub-criteria were excluded from the analysis, resulting in a more concise and focused list of sub-criteria that better reflects stakeholder priorities. These retained sub-criteria are aligned with the six components of the 6AsTD framework and are considered suitable for further weight methods. Table 3 presents the evaluation results, including mean scores, threshold comparison, and the final decision regarding each sub-criterion. The remaining sub-criteria to be used in the next analytical phase are illustrated in Figure 3.

Table 3. Mean-based threshold sub-criteria elimination.

Main Criteria	Sub-Criteria	Mean $\overline{S_i}$	Threshold T	Result
Attractions:	Natural Scenery/Environment	4.62	3.19	Retained
	Cultural Significance	3.52	3.19	Retained
	Health and Wellness Appeal	4.4	3.19	Retained
	Uniqueness of Experience	4.34	3.19	Retained
	Artificial tourism sites	1.5	3.19	Eliminated
Accessibility:	Proximity to Public Transport Hubs	1.82	3.19	Eliminated
	Quality of Infrastructure	3.58	3.19	Retained
	Availability of Transportation	4.46	3.19	Retained
	Accessibility for All	4.44	3.19	Retained
	Accessibility for information	3.54	3.19	Retained
	Easily for booking	2.18	3.19	Eliminated
Amenities:	Accommodation Options (resort/hotel)	4.44	3.19	Retained
	Dining and Nutrition	3.5	3.19	Retained
	Recreational Facilities (sauna/stream)	3.54	3.19	Retained
	Safety and Hygiene	4.54	3.19	Retained
	Health-related Shopping	2.12	3.19	Eliminated
	Fitness and public park	1.98	3.19	Eliminated
Available Packages:	Variety of Packages (wellness activities)	3.36	3.19	Retained
	Customization Options	4.6	3.19	Retained
	Cost-Effectiveness	4.44	3.19	Retained
	Duration (e.g., 2 days package)	3.54	3.19	Retained
	Comprehensive Health Package	2	3.19	Eliminated

Table 3. *Cont.*

Main Criteria	Sub-Criteria	Mean $\overline{S_i}$	Threshold T	Result
Available Packages:	Health Programs with Coaching/Experts	2.06	3.19	Eliminated
	Group packages (Aerobic dance)	2.06	3.19	Eliminated
Activities:	Physical Wellness activities (Sport/Yoga)	3.44	3.19	Retained
	Engagement Level	4.52	3.19	Retained
	Innovativeness (plastic surgery etc.)	1.46	3.19	Eliminated
	Special events (Knowledge/storytelling)	1.56	3.19	Eliminated
	Natural Therapy Activities (Forest Bathing, Nature Therapy, Health-Oriented Hiking)	4.4	3.19	Retained
	Mental therapy	1.88	3.19	Eliminated
	Nutritional Activities	3.64	3.19	Retained
Ancillary Services:	Health and Wellness Support	4.6	3.19	Retained
	Local Guides and Experts	1.96	3.19	Eliminated
	Medical Services	4.52	3.19	Retained
	Complementary Services	1.56	3.19	Eliminated
	Financial services (ATM/bank)	1.52	3.19	Eliminated
	Postal services	1.48	3.19	Eliminated
	Internet access (free WI-FI)	3.54	3.19	Retained
	Communication channels (signal call)	3.46	3.19	Retained

4.1.3. Weighting Criteria

To systematically prioritize the various factors influencing the assessment and development of HWT destinations, a weighting methodology was applied to the attributes and determinants retained from the 6AsTD framework. This process incorporated both quantitative statistical techniques and qualitative judgments derived from two focus groups—one comprising health and wellness tourists and the other consisting of domain experts. This integration ensured a balanced and robust evaluation of the relative importance of each criterion.

Initially, participants rated each of the retained sub-criteria. These preliminary scores were subsequently refined through a statistical weighting approach, designed to reflect the relative significance of each factor. The final weights thus represent a composite measure derived from empirical participant ratings, enhancing both objectivity and reliability in the evaluation process. This method allowed for a comprehensive understanding of how each attribute and determinant contributes to the overall development of an HWT destination.

The results of the weighting analysis are presented in Table 4, which displays the relative weights assigned to each criterion. Among the six main components of the 6AsTD framework, Attractions emerged as the most influential factor, receiving the highest overall weight of 0.19808, followed by Accessibility (0.17992) and Amenities (0.16672). Conversely, Available Packages (0.13552) and Ancillary Services (0.11193) received the lowest weights, indicating their relatively lower influence in the assessment framework. At the sub-criteria level, Natural Scenery/Environment and Cultural Significance, under the Attractions category, were identified as the most critical attributes, with weights of 0.05457 and 0.05137, respectively. Within the Accessibility component, the sub-criterion Accessibility for All held considerable significance with a weight of 0.05377. In the Amenities dimension, Safety and Hygiene (0.05477) and Accommodation Options (0.05157) emerged as key priorities.

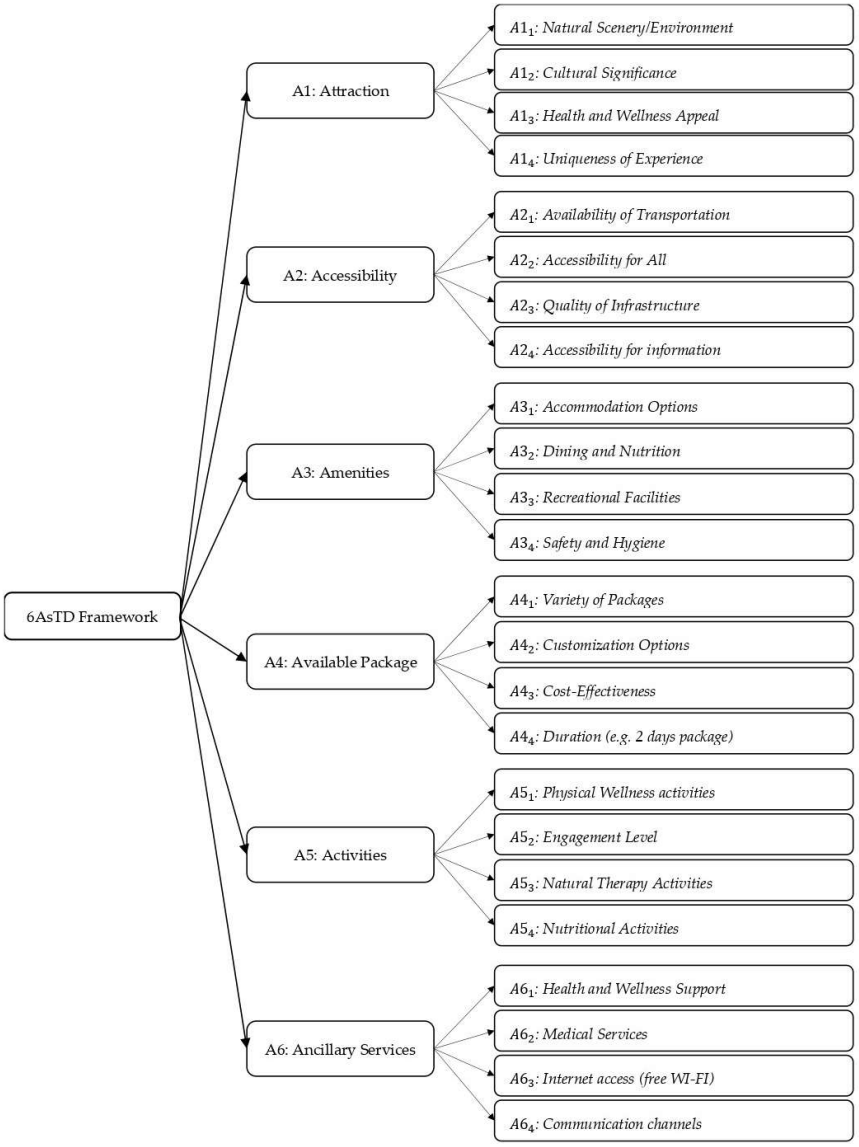


Figure 3. Final 6AsTD sub-criteria.

Table 4. Criteria scoring.

Main Criteria	Sub-Criteria	Wi	Total Sum
A1: Attraction	A11: Natural Scenery/Environment	0.05457	0.19808
	A12: Cultural Significance	0.05137	
	A13: Health and Wellness Appeal	0.04817	
	A14: Uniqueness of Experience	0.04397	
A2: Accessibility	A21: Quality of Infrastructure	0.04177	0.18589
	A22: Availability of Transportation	0.04357	
	A23: Accessibility for All	0.05377	
	A24: Accessibility for information	0.04677	
A3: Amenities	A31: Accommodation Options	0.05157	0.18989
	A32: Dining and Nutrition	0.04617	
	A33: Recreational Facilities	0.03738	
	A34: Safety and Hygiene	0.05477	
A4: Available Package	A41: Variety of Packages	0.03338	0.13552
	A42: Customization Options	0.02978	
	A43: Cost-Effectiveness	0.04657	
	A44: Duration	0.02578	
A5: Activities	A51: Physical Wellness activities	0.05137	0.17869
	A52: Engagement Level	0.04138	
	A53: Natural Therapy Activities	0.04357	
	A54: Nutritional Activities	0.04237	
A6: Ancillary Services	A61: Health and Wellness Support	0.04078	0.11193
	A62: Medical Services	0.03518	
	$A6_3$: Internet access	0.01839	
	$A6_4$: Communication channels	0.01759	

These findings are consistent with previous research [18,32,33]. For instance, Mikulić et al. [32] found that natural beauty, personal safety, quality of accommodation, and cultural tourism offerings exerted the strongest influence on wellness tourist satisfaction. The present study further corroborates these results by demonstrating the centrality of environmental quality, security, and cultural value in determining HWT destination appeal.

4.2. MCDM-TOPSIS

To further evaluate and prioritize the suitability of HWT activities across different districts in Nakhon Ratchasima Province, this study applied the TOPSIS. Using the set of weighted criteria derived from Section 4.1.3, experts were invited to assess the relative suitability of eight HWT activities across three distinct locations. These activities were evaluated based on a comprehensive set of criteria, including tourist preferences, accessibility, environmental sustainability, and development potential.

The TOPSIS method was employed to compute the Relative Closeness Coefficient (R_j) which indicates how close each activity-location alternative is to the ideal solution while maximizing its distance from the negative-ideal solution. This structured and objective approach enables decision-makers to rank the alternatives effectively, thereby supporting the identification of the most appropriate strategies for sustainable tourism development.

Pak Chong District demonstrates the highest Relative Closeness (R_j) values for activities primarily associated with therapeutic and rehabilitative health tourism. As presented in Table 5, Water Therapy (R_j = 0.01372), Aroma Therapy (R_j = 0.01439), Culinary Tourism (R_j = 0.00565), and Food Tourism (R_j = 0.00693) rank as the most suitable HWT activities in this district. The high scores of Water Therapy and Aroma Therapy, in particular, underscore Pak Chong's significant potential to serve as a wellness tourism hub, especially for activities that promote physical rehabilitation and mental rejuvenation.

Table 5. TOPSIS evaluation of health and wellness tourism activities in Pak Chong.

	Activities	D_j-	D_j+	R_j
Pak Chong	1. Ecotourism	0.001145288	0.004126516	−0.00184
	2. Cultural Tourism	0.000225765	0.007336432	−0.00688
	3. Food Tourism	0.004063259	0.001200834	0.00693
	4. Culinary Tourism	0.003547864	0.001448603	0.00565
	5. Sport City	0.000242247	0.007297193	−0.00681
	6. Cycling Tourism	0.000426958	0.006216822	−0.00536
	7. Aroma Therapy	0.007298298	0.000210557	0.01439
	8. Water Therapy	0.00698267	0.000246973	0.01372

This finding is well-aligned with the district's natural and environmental assets, such as geothermal springs, herbal plantations, and traditional spa facilities, which contribute directly to the appeal and viability of health-oriented tourism. The alignment between the district's natural characteristics and the top-ranked activities emphasizes the strategic opportunity for targeted development of health and wellness experiences in Pak Chong.

Wang Nam Khiao District displays the highest Relative Closeness (R_j) values for Ecotourism (R_j = 0.97048) and Cultural Tourism (R_j = 0.97735), followed by Culinary Tourism (R_j = 0.69367) and Food Tourism (R_j = 0.72227) as shown in Table 6. The exceptionally high scores for Ecotourism and Cultural Tourism indicate that Wang Nam Khiao is particularly well-suited for tourism development rooted in sustainability and cultural heritage. These results align with the district's rich ecological assets and well-preserved local traditions. The presence of lush natural landscapes, biodiversity, and community-led tourism initiatives provides a robust foundation for promoting ecotourism. Concurrently, the strong cultural identity of local communities supports the development of cultural tourism as a vehicle for preserving indigenous knowledge and fostering meaningful tourist engagement. Together, these factors position Wang Nam Khiao as a model destination for integrated HWT with an emphasis on environmental and cultural sustainability.

Table 6. TOPSIS evaluation of health and wellness tourism activities in Wang Nam Khiao.

	Activities	D_j-	D_j+	R_j
Wang Nam Khiao	1. Ecotourism	0.007317158	0.000222569	0.97048
	2. Cultural Tourism	0.007534903	0.000174574	0.97735
	3. Food Tourism	0.003674549	0.001412912	0.72227
	4. Culinary Tourism	0.0034606	0.001528184	0.69367
	5. Sport City	0.000287344	0.006931184	0.03980
	6. Cycling Tourism	0.00034611	0.006552783	0.05016
	7. Aroma Therapy	0.000558324	0.005125303	0.09823
	8. Water Therapy	0.000558324	0.005125303	0.09823

Mueang Nakhon Ratchasima District emerges as the most suitable location for sports and rehabilitative health tourism, particularly in activities such as Sport City (R_j = 0.95335), Cycling Tourism (R_j = 0.97112), Culinary Tourism (R_j = 0.63238), and Food Tourism (R_j = 0.71809), as detailed in Table 7. The district's established sports infrastructure, including professional-grade venues, training facilities, and extensive cycling routes, supports its capacity to host regional and international sporting events. These assets collectively position Mueang Nakhon Ratchasima as a strategic hub for sports-based wellness tourism, combining physical activity with holistic health experiences.

Table 7. TOPSIS evaluation of health and wellness tourism activities in Mueang.

	Activities	D_j-	D_j+	R_j
Mueang Nakhon Ratchasima	1. Ecotourism	0.000297666	0.006843805	0.04168
	2. Cultural Tourism	0.000257886	0.007113465	0.03498
	3. Food Tourism	0.003610517	0.0014174	0.71809
	4. Culinary Tourism	0.003081732	0.001791508	0.63238
	5. Sport City	0.006611754	0.000323538	0.95335
	6. Cycling Tourism	0.007162599	0.000213022	0.97112
	7. Aroma Therapy	0.001272773	0.003820796	0.24988
	8. Water Therapy	0.001170336	0.004106051	0.22181

The comparative ranking of high-potential wellness tourism activities across the three districts—Pak Chong, Wang Nam Khiao, and Mueang Nakhon Ratchasima—reveals distinct strengths and specialized tourism assets unique to each area. Pak Chong demonstrates comparative advantages in therapeutic and rehabilitative activities, Wang Nam Khiao excels in ecotourism and cultural tourism, while Mueang Nakhon Ratchasima leads in sports-based and active wellness, as shown in Table 8 and Figure 4.

Table 8. Attributes of health and wellness triangle of Nakhon Ratchasima Province.

EMBN Model	Mueang (B-N)	Wang Nam Khiao (E-N)	Pak Chong (M-N)
E = Environment Clean air, pollution-free		✓	
M = Mind Good mental health, relaxation from stress			✓
B = Physical Body Physical health	✓		
N = Nutrition Healthy food	✓	✓	✓

A particularly salient observation is the consistent appearance of Food Tourism and Culinary Tourism among the top four activities in all three districts. This recurring pattern suggests that food- and nutrition-based tourism may serve as a strategic linkage, enabling the formation of an integrated wellness tourism network across the province. The shared emphasis on health-conscious culinary experiences and the utilization of locally sourced ingredients presents an opportunity to unify district-level strengths into a coherent provincial tourism identity. By capitalizing on this commonality, Nakhon Ratchasima can advance a holistic and sustainable wellness tourism model that not only leverages local resources and cultural assets but also promotes regional collaboration, inclusive development, and

long-term destination competitiveness. Like the four dimensions of the PMSE experience framework, namely, physical, mental, spiritual, and environmental, that holistically served as a mechanism toward wellness tourism in Thailand context [18]. The results of this study show that Nakhon Ratchasima is the capital of the HWT hub, with a key strength of the Nakhon Ratchasima area emphasizing four aspects of health and wellness tourism: environment (E), mind (M), physical body health (B), and nutrition (N).

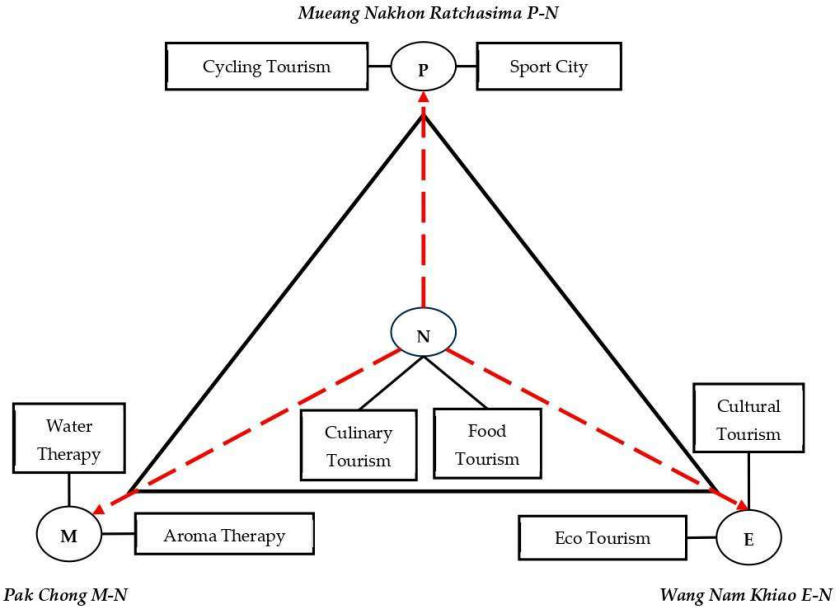


Figure 4. EMBN health and wellness attribute of Nakhon Ratchasima.

5. Conclusions

This study presents a comprehensive approach to assessing and evaluating health and wellness tourism (HWT) destination potential by integrating the 6AsTD framework with a multi-criteria decision-making (MCDM) approach, specifically the TOPSIS method. The findings are twofold. First, the study identifies and structures the key attributes and determinants influencing tourist satisfaction in HWT destinations. By adapting the general 6As tourism framework—Attractions, Accessibility, Amenities, Activities, Available Packages, and Ancillary Services—to the context of HWT, this research offers a contextualized and holistic understanding of the elements contributing to successful HWT destinations. Among the six criteria, Attractions, Accessibility, and Amenities emerged as the top priorities for HWT tourists. Within these, critical attributes and determinants such as natural scenery/environment, health and wellness appeal, universal accessibility, transportation availability, and safety and hygiene significantly influence tourist satisfaction, aligned with [32,33]. Second, the study integrates these findings into the TOPSIS evaluation model to assess and rank HWT activities and locations. This integration allows for a detailed assessment of each location's suitability for specific health and wellness activities and

broader strategic positioning, while also identifying areas for improvement based on the 6AsTD framework.

Empirical results show that different districts within Nakhon Ratchasima Province exhibit distinct HWT potential, aligned with the EMBN model—Environment, Mind, Physical Body, and Nutrition. For instance, Wang Nam Khiao District excels in eco-tourism, cultural experiences, and health-focused culinary tourism, aligning with the Environment and Nutrition dimensions. Pak Chong District is recognized for its health and wellness services, such as aromatherapy, traditional Thai massage, herbal steam, and hot spring therapies, reflecting the Mind and Nutrition dimensions. Meanwhile, Mueang District focuses on physical wellness through its sports city initiative, promoting cycling, physical activity, and health-focused cuisine, thus fitting under the Physical Body and Nutrition dimensions. Additionally, the province demonstrates strong capabilities in various forms of health and wellness, supported by medical professionals, hospitals, and high-standard accommodation, positioning Nakhon Ratchasima as a competitive destination for HWT. Its affordability compared to Bangkok further enhances its appeal. By integrating eco-tourism with wellness and medical services, the province can evolve into a comprehensive HWT destination.

The study's contributions span theoretical, practical, and managerial domains: *Theoretical Contribution:* This study demonstrates that the 6AsTD framework can be effectively adapted to the HWT context, providing a solid theoretical foundation for evaluating and developing health and wellness destinations. The combination of 6AsTD and MCDM-TOPSIS offers a promising analytical framework for structured decision-making in wellness tourism development. In comparison to Kongtaveesawas et al. [18], who emphasized spiritual and environmental elements in wellness tourism development in northern Thailand, our findings highlight a stronger emphasis on physical and nutritional wellness dimensions in the Nakhon Ratchasima case, reflecting the province's distinctive policy focus and resource endowments. This contrast underscores the framework's flexibility across different regional contexts. *Practical Contribution:* The findings are valuable for stakeholders such as the Thailand Tourism Authority and regional offices (e.g., Nakhon Ratchasima Tourism Authority), as well as businesses involved in health and wellness services. They offer guidance for shaping policies and designing compelling tourism experiences. Consistent with Praprom & Laipaporn [34], the study reinforces the importance of innovating new wellness tourism services to increase attractiveness and value. It also supports the development of wellness programs reflecting holistic attributes—physical, mental, spiritual, and environmental—as emphasized by Kongtaveesawas et al. [18]. *Managerial Contribution:* The research provides practical insights for experience design and strategic destination management within the Thai context. It recommends that findings be used to guide strategic planning, particularly in positioning Nakhon Ratchasima as a multidimensional health capital through various forms of health and wellness activities. By operating the 6AsTD framework within an MCDM-TOPSIS model, the study delivers a decision-support tool that enables policy-makers, tourism planners, and local businesses to prioritize development efforts, allocate resources effectively, and tailor marketing strategies toward high-impact wellness dimensions. Effective policy development should capitalize on these strengths. Moreover, this study suggests general policy actions for HWT destination managers and firms to improve overall tourist satisfaction. Special attention should be paid to the determinants with the strongest association with perceived destination attractiveness, especially complementary services that enhance wellness experiences.

Limitations and Future Research Directions

This research is not without limitations. First, the study's sample of tourists and experts was limited to Thailand, which may restrict the generalizability of the findings. Different regions and age groups may hold differing perspectives toward HWT destinations [33]. Second, the multi-step process involving various groups in attribute identification, weighting, and evaluation may introduce biases or inconsistencies. Lastly, the evaluation of HWT activities was conducted solely by experts, omitting input from tourists and local residents, which may overlook important user-centered insights.

Future studies should consider incorporating dynamic criteria, tourist segmentation, and seasonal variations to refine destination assessment and strategic planning. As highlighted by But & Ap [35], the impact of tourism depends heavily on both traveler and destination characteristics. However, the influence of tourists' personal attributes remains underexplored, particularly since many health and wellness tourists may be coping with illness or chronic conditions. Exploring these effects can deepen our understanding of tourist behavior and destination impact. Additional research could investigate other factors not covered in this study that may influence destination choice, tourist satisfaction, and competitiveness. Exploring aspects such as personalization, wellness program pricing, and cross-border wellness mobility may yield valuable insights for both domestic and international markets.

Author Contributions: P.J. formed the research idea, supervised the research, commented on, and edited the manuscript. S.T. methodology development analyzed the data, drafted the manuscript, and edited the manuscript. K.P. and K.K. collected and analyzed the data and commented on the manuscript. N.C. commented, submitted, and communicated with the journal editor. All authors have read and agreed to the published version of the manuscript.

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2. 3rd World Conference on Engineering and Technology (WORLDCET) 10-12 June 22 | Vienna, Austria : Multi-Criteria Decision-Making Model for Elective Surgical Patient Prioritization in Non-Urgent Healthcare Service Setting

3rd World Conference on Engineering and Technology (WORLDCET)
10-12 June 22 | Vienna, Austria

Multi-Criteria Decision-Making Model for Elective Surgical Patient Prioritization in Non-Urgent Healthcare Service Setting

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Abstract.

Elective surgery is an important procedure in which the patient can be scheduled in advance. A main challenge in scheduling elective surgical patients is to properly manage patient prioritization in order to improve overall health of each patient before surgery, by applying several biopsychosocial aspects in the decision process. Thus, this research aims to demonstrate a decision-making framework to support elective surgical patient prioritization, using Multi-Criteria Decision-Making (MCDM) method and scoring method for weighting associated criteria conducted from the literature. Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) was applied to formulate the elective surgical patient prioritization model and develop a decision framework in the patient scheduling procedure. A case study was presented to illustrate numerical example of the framework based on the data in a non-urgent healthcare service setting. Results were presented to exemplify a consequence of the elective surgical patient prioritization framework in this study. The discussion is also provided based on the prospect of balancing patient satisfaction and medical resources utilization in advance in the healthcare service setting.

Keywords: Patient Prioritization; Elective Surgery, Multi-Criteria Decision-Making (MCDM), Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)

1. Introduction

Elective surgery is an important procedure in which the patient can be scheduled in advance. A main challenge in scheduling elective surgical patients is to properly manage patient prioritization to improve overall health of each patient before the surgery. A poor decision-making in such procedure may lead to obstacles in patient satisfaction and medical resources utilization in a healthcare service setting. Thus, patient prioritization has been a prior issue in the elective surgery context in which each patient is facilitated to gain entry to and to receive care and service from healthcare system. Correspondingly, it is essential to enhance an ability to make a proper

decision in the elective surgical patient prioritization to improve such process in terms of patient satisfaction and medical resources utilization in the healthcare service setting.

The crucial manner in prioritizing elective surgical patients is to associate not only clinical aspect of the patient but also other criteria such as biopsychosocial factors. Most of the decision-making in elective surgical patient prioritization relied on clinical criteria such as main disease, severity, mobility, and similar characteristics (Solans et al., 2013); (Rahimi et al., 2016); (Srikunmar et al.,2018) and (Silva et al.,2021). However, biopsychosocial factors such as health benefit, social, and individual aspects, play an important role in the elective surgical patient prioritization. Clinical criteria can be applied to measure the current health condition while probability of the improvement and comorbidity can be evaluated through benefit aspect to determine the chance of health outcome of each elective patient. While individual criteria are also important to be defined such as age, gender, and personal medical conditions because these could directly affect patient prioritization on urgency treatment. Social aspect is used to evaluate activities of daily living after the surgery as well. Therefore, applying multiple biopsychosocial criteria is necessary to support patient prioritization in order to enhance decision-making process more decisively.

Thus, this research aims to utilize a Multi-Criteria Decision-Making (MCDM) method to demonstrate a decision-making framework based on multiple biopsychosocial criteria to enhance elective surgical patient prioritization. Associated criteria used in the framework are addressed and scoring technique is conducted based on the adjustment of the professionals in the context. A practical MCDM technique is addressed to formulate the patient prioritization model for the elective surgery using the data at a non-urgent healthcare service setting as a case study in order to illustrate numerical example of the results. Furthermore, discussion is also provided from the proposed framework to briefly describe the prospect of balancing patient satisfaction and medical resources utilization in the healthcare service setting.

2. Methodology

MCDM is a method dealing with making a decision based on multiple criteria. It is aimed to support the structuring, analyze, and recommend alternative solution to assist decision makers in several service sectors, including healthcare. This research utilizes an MCDM method, using Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) to formulate the elective surgical patient prioritization model to develop the decision framework in the patient scheduling procedure. The methodology details are described as follows.

2.1 Criteria

Four main criteria incorporated in this study were synthesized from the literature and practices in the area, including qualitative and quantitative sets, namely, C1: clinical and function variables; C2: expected benefits; C3: social variables; and C4: personal characteristic (Rahimi et al., 2016). Furthermore, we adopted the sub-criteria under each main criterion from (Rahimi et al.,

2016); (Li et al., 2019); (Srikunmar et al., 2018) and (Silva et al., 2021). Analytical hierarchy process (AHP) for elective surgical patient prioritization can be illustrated in Figure 1.

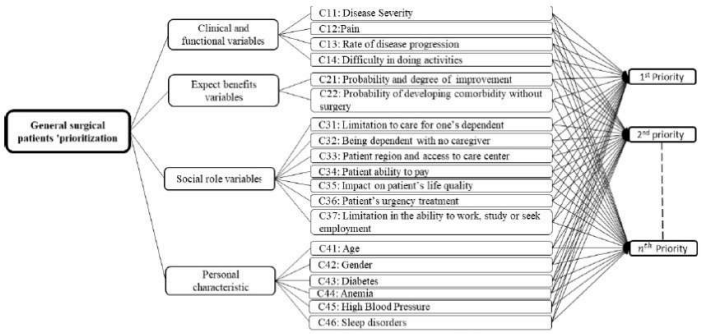

Figure 1: Analytic Hierarchy Process for General surgical patient prioritization

2.2 Criteria scoring

Scoring function was applied to estimate each weight value. Experts were allowed to assess each value based on preference score from 0 (extremely unimportant) to 10 (extremely important). Afterwards, the corresponding weight for each criterion i ={1, 19}, w_i is given by:

$$w_i = \frac{1}{W}\sum_{e=1}^{10}\mu_{i,e} \quad (1)$$

$$\text{Where } W = \sum_{i=1}^{19}\sum_{e=1}^{10}\mu_{i,e} \quad (2)$$

2.3 TOPSIS

TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives. The basic principle is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The procedure of TOPSIS can be expressed in a series of steps as follows (Jahanshaloo et al.,2006):

(1) Calculate the normalized decision matrix. The normalized value n_{ij} is calculated as

$$n_{ij} = x_{ij}/\sqrt{\sum_{j=1}^{m} x_{ij}^2} \text{ ,j=1, 2, …, m; i=1, 2, …, n.} \quad (3)$$

(2) Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as:

$$v_{ij} = w_i * n_{ij} \text{ , j=1, 2, …, m; i=1, 2, …, n.} \quad (4)$$

Where w_i is the weight of the i^{th} attribute or criterion, and $\sum_{i=1}^{n} w_i = 1$

(3) Determine the positive ideal and negative ideal solution.

$$A^+ = \{v_1^+, v_2^+, \ldots., v_n^+\} = \{(max_j v_{ij}|i \in I), (min_j v_{ij}|i \in J) \quad (5)$$

$$A^- = \{v_1^-, v_2^-, \ldots., v_n^-\} = \{(min_j v_{ij}|i \in I), (max_j v_{ij}|i \in J) \quad (6)$$

where I is associated with benefit criteria, and J is associated with cost criteria.

(4) Calculate the separation measures, using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as:

$$d_j^+ = \{\sum_{i=1}^{n}(v_{ij} - v_i^+)^2\}^{\frac{1}{2}}, \text{j=1, 2, ..., m.} \quad (7)$$

Similarly, the separation from the negative ideal solution is given as

$$d_j^+ = \{\sum_{i=1}^{n}(v_{ij} - v_i^-)^2\}^{\frac{1}{2}}, \text{j=1, 2, ..., m.} \quad (8)$$

(5) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative $A_j$with respect to A+ is defined as:

$$R_j = \frac{d_j^-}{d_j^+ + d_j^-}, \text{i} = 1, 2, \ldots, \text{m.} \quad (9)$$

Since $d_j^- \geq 0$ *and* $d_j^+ \geq 0, then, clearly\ R_j \in [0,1]$.

(6) Rank the preference order.

3. Results

3.1 Weighting method

The average relevant scores were evaluated with clinical and function approximate one-third while expected benefit accounted for 19%, social role for 27%, and personal characteristic around 20%. The average relevant scores are shown in Table 1.

Table 1: Relevant scores assigned by 10 experts in related area to 19 criteria

Main criteria	Criteria/ Expert	Expert judgement										Wi	Total Sum for main criteria
		1	2	3	4	5	6	7	8	9	10		
C1: Clinical and function	*C11*	10	9	8	10	8	10	10	9	9	9	***0.1021***	0.3285
	C12	9	8	8	8	8	8	9	8	8	7	***0.0899***	
	C13	8	5	5	7	8	6	8	5	7	5	***0.0710***	
	C14	6	7	5	5	7	7	5	6	6	5	***0.0655***	
C2: Expected benefit	*C21*	10	9	8	10	10	7	9	10	9	9	***0.1010***	0.1898
	C22	7	7	7	10	7	9	9	7	10	7	***0.0888***	
C3: Social Role	*C31*	3	6	3	2	5	3	2	3	1	1	***0.0322***	0.2752
	C32	3	3	5	4	2	4	6	1	5	1	***0.0377***	
	C33	6	6	1	6	6	2	3	6	2	5	***0.0477***	
	C34	3	4	4	3	4	2	4	5	5	6	***0.0444***	
	C35	2	4	1	3	3	4	2	4	5	6	***0.0377***	
	C36	1	5	1	5	5	3	6	5	4	4	***0.0433***	
	C37	2	6	2	4	2	2	3	1	5	2	***0.0322***	
C4: Personal characteristic	*C41*	3	5	2	3	3	1	5	2	2	5	***0.0344***	0.2064
	C42	5	3	3	5	4	4	2	1	2	1	***0.0333***	
	C43	2	4	2	3	4	2	3	4	5	2	***0.0344***	
	C44	5	5	5	2	5	5	4	5	4	5	***0.0499***	
	C45	4	1	1	1	1	5	1	3	4	3	***0.0266***	
	C46	5	2	4	1	1	1	1	2	5	3	***0.0277***	

3.2 TOPSIS

A case study is presented to illustrate numerical example of the framework based on the data in a non-urgent healthcare service setting. The data in the queue were used to prioritize the schedule for elective surgery, and compare with the first-come, first-serve procedure from real case.

Numerical example for illustration

Basic patient information and clinical evaluation was presented in Table 3, with respected to the 19 criteria. For criteria C11 to C14, five scale scoring method (0 less; 5 most) was used. While C21 and C22 used percentage as an expression of probability and C41 was ages of the patient. The other criteria were binary with YES (1) and NO (0).

Table 2: Basic patient information and clinical evaluation

Patient rank	Basic patient data/clinical info																		
	C11	*C12*	*C13*	*C14*	*C21*	*C22*	*C31*	*C32*	*C33*	*C34*	*C35*	*C36*	*C37*	*C41*	*C42*	*C43*	*C44*	*C45*	*C46*
1	4	2	5	5	7	68	1	0	1	0	1	0	0	30	0	1	0	1	1
2	4	3	1	2	86	86	1	1	1	1	1	1	1	21	1	1	1	1	0
3	1	4	3	5	87	46	1	1	1	0	0	1	0	41	0	1	1	0	1
4	3	3	1	5	35	99	0	0	1	0	0	0	0	75	0	1	0	1	0
5	2	0	5	1	14	26	0	1	0	0	0	1	1	69	1	1	1	0	1
6	5	1	1	4	13	21	0	1	1	0	0	1	0	47	1	1	1	1	0
7	2	4	1	3	47	40	1	1	1	1	0	1	1	44	0	1	1	1	1
8	2	1	2	1	58	54	1	1	1	0	0	1	1	19	1	0	1	0	0
9	4	1	1	1	32	72	1	0	1	1	1	0	0	76	0	0	1	0	1
10	3	2	2	2	55	54	1	0	0	1	1	0	1	70	1	0	1	0	1

Ten patients were in the waiting list for elective surgery. Personal and clinical data were collected by the physician with respect to all variable. Eq. (3) was used to normalize the matrix to be input in Eq. (4) for the calculation of its weight to each criteria variable with respect to table 2 and results were shown in table 3.

Table 3: Weighted normalize matrix

Rank	C11	C12	C13	C14	C21	C22	C31	C32	C33	C34	C35	C36	C37	C41	C42	C43	C44	C45	C46
1	0.039	0.022	0.043	0.033	0.005	0.034	0.013	0.000	0.010	0.000	0.014	0.000	0.000	0.007	0.000	0.013	0.000	0.015	0.015
2	0.039	0.033	0.009	0.013	0.055	0.043	0.013	0.018	0.010	0.014	0.014	0.017	0.016	0.005	0.018	0.013	0.012	0.015	0.000
3	0.010	0.044	0.026	0.033	0.056	0.023	0.013	0.018	0.010	0.000	0.000	0.017	0.000	0.009	0.000	0.013	0.012	0.000	0.015
4	0.029	0.033	0.009	0.033	0.023	0.049	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.017	0.000	0.013	0.000	0.015	0.000
5	0.020	0.000	0.043	0.007	0.009	0.013	0.000	0.018	0.000	0.000	0.000	0.017	0.016	0.016	0.018	0.013	0.012	0.000	0.015
6	0.049	0.011	0.009	0.026	0.008	0.010	0.000	0.018	0.010	0.000	0.000	0.017	0.000	0.011	0.018	0.013	0.012	0.015	0.000
7	0.020	0.044	0.009	0.020	0.030	0.020	0.013	0.018	0.010	0.014	0.000	0.017	0.016	0.010	0.000	0.013	0.012	0.015	0.015
8	0.020	0.011	0.017	0.007	0.037	0.027	0.013	0.018	0.010	0.000	0.000	0.017	0.016	0.004	0.018	0.000	0.012	0.000	0.000
9	0.039	0.011	0.009	0.007	0.021	0.036	0.013	0.000	0.010	0.014	0.014	0.000	0.000	0.017	0.000	0.000	0.012	0.000	0.015
10	0.029	0.022	0.017	0.013	0.035	0.027	0.013	0.000	0.000	0.014	0.014	0.000	0.016	0.016	0.018	0.000	0.012	0.000	0.015

Eqs. (5) & (6) were used to generate the best ideal solution for each variable as shown in table 4.

Table 4: Ideal best solutions

	C11	C12	C13	C14	C21	C22	C31	C32	C33	C34	C35	C36	C37	C41	C42	C43	C44	C45	C46
A+	0.049	0.044	0.043	0.033	0.056	0.049	0.013	0.018	0.010	0.014	0.014	0.017	0.016	0.017	0.018	0.013	0.012	0.015	0.015
A-	0.010	0.000	0.009	0.007	0.005	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000

Lastly, Eqs. (7) & (8) were used to obtain Euclidean distance from the best ideal solution and then Eq. (9) was used to calculate the relative closeness and rank the patient priority on their performance score as presented in table 5.

Table 5: Euclidean distance and the relative closeness & rank

Patient	d+	d-	Rj	Rank
1	0.072	0.070	0.493	**6**
2	0.047	0.094	0.665	**1**
3	0.061	0.087	0.586	**2**
4	0.070	0.075	0.515	**4**
5	0.089	0.058	0.394	**10**
6	0.085	0.061	0.420	**9**
7	0.066	0.074	0.528	**3**
8	0.073	0.061	0.454	**7**
9	0.078	0.061	0.439	**8**
10	0.063	0.066	0.511	**5**

4. Discussions

The ranking of the patient from the TOPSIS model was calculated based on the biopsychosocial aspects used in this study. While its rank was found to be different compared to the current first-come first-serve procedure from real case. For instance, TOPSIS ranked patient no.5 as the 10th order while the current procedure was given at the 5th order. The different of results between two frameworks (MCDM and staff) implies that using different decision-making method may lead to inconstancy in the decision process. Staff are able to make decision more rapidly than using the MCDM model because they use their experience while MCDM has to calculate based on the recorded data.

MCDM tends to provide the result more concisely because it can interpret the results based on multiple criteria in which staff cannot achieve this ability. The satisfaction of the patient may be increased due to the ability in making a proper prioritization which can improve overall health of each patient before surgery. The MCDM framework required to be operated in a computing device which may lead to investment consideration in the future. However, the non-urgent healthcare service setting can be beneficial from incorporating MCDM framework for elective surgical patient prioritization in advance because the care service can gather the scheduled patient data to improve the planning of the resources utilization in the healthcare service setting more appropriately.

5. Conclusion

A main challenge in scheduling elective surgical patient is to manage a patient prioritization based on multiple biopsychosocial criteria. This research demonstrates a decision-making framework, using both MCDM method and TOPSIS technique, to support elective surgical patient prioritization based on multiple biopsychosocial criteria. A case study was presented to illustrate numerical example of the framework based on the data in a non-urgent healthcare service setting. Results were presented to exemplify a consequence of the elective surgical patient prioritization framework in this study. The satisfaction of the patient is increased due to the ability in making a decisive prioritization which can improve overall health of each patient before surgery. The non-urgent healthcare service setting can gather the scheduled patient data to from the MCDM framework to improve the planning of the resources utilization in the healthcare service setting more appropriately.

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