

## Assumptions

1. LLHCCs and HLHCCs are selected among demand points.
2. Only one health center can be in each node.
3. The capacity level of HLHCCs is specified for each type of service.
4. Each LLHCC is assigned to only one HLHCC, and appropriate transportation facilities should also be provided for all HLHCCs.
5. The cost of transportation among points of demand has been calculated based on the value of the flow and the distance between the points, and it has been assumed that the cost of transportation is fixed and remains constant.
6. HLHCCs and LLHCCs have a specified covering radius.
7. There is no direct connection between two nodes that are not within the same radius of coverage.
8. The model specifies the location and number of facilities. If a facility has already been built, it can be added to the model.
9. The shortage is allowed.
10. The presented model is a multi-period model.
11. The demand is definite.

## Sets

$I$	The set of demand nodes ( $i \in I$ )
$J$	The set of LLHCCs ( $j, j' \in J, J \subseteq I$ )
$K$	The set of HLHCCs ( $K \subseteq I$ )
$T$	The set of periods ( $t \in T$ )
$N$	The set of services ( $n \in N$ )

## Parameters

$r_{2k}$	Covering radius of HLHCC $k \in I$
$r_{1j}$	Covering radius of LLHCC $j \in I$
$m$	Capacity level
$M$	A large positive number
$C_{jj'}$	Transportation costs among LLHCCs $j$ and $j'$
$\hat{c}_{nm}$	The $m^{\text{th}}$ capacity level for the $n^{\text{th}}$ service
$C''_{kjn}$	The variable cost of transferring the $n^{\text{th}}$ type of service from the $k^{\text{th}}$ HLHCC to the $j^{\text{th}}$ covered LLHCC
$q'_{ikn}$	The variable cost of providing the $n^{\text{th}}$ type of service from the $k^{\text{th}}$ HLHCC to the $i^{\text{th}}$ demand node
$q_{ijn}$	The variable cost of providing the $n^{\text{th}}$ type of service from the $j^{\text{th}}$ LLHCC to the $i^{\text{th}}$ demand node
$C'_{jj'n}$	The variable cost of transferring the $n^{\text{th}}$ type of service from the $j^{\text{th}}$ LLHCC to the $j^{\text{th}}$ LLHCC
$G_{knm}$	The variable cost of providing the $n^{\text{th}}$ type of service to the $k^{\text{th}}$ HLHCC at the $m^{\text{th}}$ capacity level
$b_{ikn}$	1 if the $i^{\text{th}}$ demand node for receiving the $n^{\text{th}}$ service is within the $k^{\text{th}}$ HLHCC covering radius, 0 otherwise
$a_{ijn}$	1 if the $i^{\text{th}}$ demand node for receiving the $n^{\text{th}}$ service regarding the covering radius ( $r_{1j}$ ) was under the coverage of $j^{\text{th}}$ LLHCC, 0 otherwise
$D_{int}$	The demand for node $i$ from $n^{\text{th}}$ type service in period $t$
$F_k$	The fixed cost of establishing an HLHCC at demand node $k$
$f_j$	The fixed cost of establishing an LLHCC at node $j$
$A_n$	1 if the $n$ type service is a HLHCC service, 0 otherwise
$P_{in}$	The cost of $n$ type service shortage for demand node $i$
$d_{ik}$	The distance among node $i$ and node $k$
$L_n$	The cost of the difference among the highest and the lowest value of the $n^{\text{th}}$ service shortage in all nodes
$\alpha_n^{\text{max}}$	The maximum difference among the maximum and the minimum value of the $n^{\text{th}}$ service shortage in all nodes

$V$	The minimum number of LLHCCs that must be covered by all nodes for each type of service
$H$	The minimum number of HLHCCs that must be covered by all nodes for each type of service

## Decision Variables

$y_j$	1 if an LLHCC is established at node $j$ , 0 otherwise
$X_{jk}$	1 if LLHCC $j$ is assigned to HLHCC $k$ , 0 otherwise
$X_{kk}$	1 if the $k$ HLHCC is set up in $k$ node, 0 otherwise
$Z_{knm}$	1 if the $k^{\text{th}}$ HLHCC provides the $n^{\text{th}}$ service at the $m^{\text{th}}$ capacity, 0 otherwise
$W_{k j n t}$	The amount of the $n^{\text{th}}$ type of service transferred from the $k^{\text{th}}$ HLHCC to the $j^{\text{th}}$ LLHCC in period $t$
$h_{j j' n t}$	The amount of the $n^{\text{th}}$ type of service transferred from $j^{\text{th}}$ LLHCC to $j'^{\text{th}}$ LLHCC in period $t$
$e_{j i n t}$	The amount of $n^{\text{th}}$ type of service provided from the $j^{\text{th}}$ LLHCC to the $i^{\text{th}}$ demand point in period $t$
$B_{i n t}$	The node $i$ shortage of the $n^{\text{th}}$ type of service in period $t$
$u_{k i n t}$	The amount of the $n^{\text{th}}$ type of service provided from the $k^{\text{th}}$ HLHCC to the $i^{\text{th}}$ demand point in period $t$
$x_{j j' t}$	1 if the LLHCC $j$ is connected to the LLHCC $j'$ in period $t$ , 0 otherwise
$\delta_{n t}$	The minimum amount of the $n^{\text{th}}$ service shortage in all nodes in period $t$
$\beta_{n t}$	The maximum amount of the $n^{\text{th}}$ service shortage in all nodes in period $t$
$\alpha_{n t}$	The difference among the maximum and the minimum value of the $n^{\text{th}}$ service shortage in all nodes in period $t$