**Table 1. Common mathematical formulations for the DPHHC**

|  |  |  |
| --- | --- | --- |
| **Location-Allocation (*LA*)**  Hess et al. (1965) | **Facility-Location (*FL*)**  Hojati (1996) | **Set-Partitioning (*SP*)**  Bennet (2010) |
| **Notation:**  defined set of district centers  set of basic units  cost of assigning subunit to district center  binary variable indicating whether subunit is assigned to district center  demand of basic unit ,  average demand | **Notation:**  (additional to Hess et al., 1965)  set of potential district centers  set of basic units  variable indicating the fraction of subunit to be assigned to district center  binary variable indicating whether subunit is selected as a district center | **Notation:**  set of all feasible districts  binary parameter indicating 1 if district includes subunit and 0 otherwise  : cost of district  binary variable indicating whether district is selected |
| **Formulation:**   |  |  | | --- | --- | |  | (1) | | Subject to: |  | |  | (2) | |  | (3) | |  | (4) | | **Formulation:**   |  |  | | --- | --- | |  | (5) | | Subject to: |  | |  | (6) | |  | (7) | |  | (8) | |  | (9) | |  | (10) | |  | (11) | | **Formulation:**   |  |  | | --- | --- | |  | (12) | | Subject to: |  | |  | (13) | |  | (14) | |  | (15) | |
| **Objective**  (1) Minimizes the total cost of assigning subunits to district centers | **Objective**  (5) Minimizes the total cost of assigning subunits to district centers | **Objective**  (12) Minimizes the total cost of all selected districts |
| **Constraints**  (2) Ensure that demand assigned to each district is equal to the average demand  (3) Ensure each subunit is assigned exactly to one district | **Constraints**  (6) Same as (3)  (7) Same as (2) if a district is open  (8) Ensure districts are selected  (9) Ensure subunits can only be assigned to selected districts | **Constraints**  (13) Ensure that each subunit is included in exactly one district  (14) Ensure that districts are selected |

**Source: Presented by the authors based on each referred paper**

**Table 2. HHC Services offered in Cali, Colombia**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Type of Medical Activity** | **Type of Medical Staff** | **Group** | **Standard**  **Service Time , [min]** | **Annual**  **Demand**  **[annual visits]** |
| Medicines Supply (MSP) | Auxiliary Nurse (AN) | G1 | 30 | 45.950 |
| Auxiliary Nurse Care (ANC-6) | 360 | 5.240 |
| Auxiliary Nurse Care (ANC-12) | 720 | 15.040 |
| Auxiliary Nurse Care (ANC-24) | 1.440 | 38.360 |
| Nursing Care (NCR) | Nurse (NU) | 30 | 12.530 |
| General Practitioner Visit (GPV) | Gn. Practitioner (GP) | G2 | 30 | 6.590 |
| Specialist Home Visit (SHV) | Specialist (SP) | 30 | 2.180 |
| Therapies Home Visit (THV) | Therapist (TE) | 60 | 176.360 |

**Source: Presented by the authors**

**Table 3. Results minimizing *Travel Workload* ()**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***m*** | : **Travel Workload [hr/year]** | **Total Workload [hr/year]** | **Average Workload [hr/year]** | **:Workload Deviations [hr/year]** | **Ratio** |
| 1 | 1.132.067 | 2.230.377 | 2.230.377 | 0 | 103,07% |
| 2 | 435.002 | 1.533.310 | 766.655 | 210.800 | 39,61% |
| 3 | 242.188 | 1.340.498 | 446.833 | 277.036 | 22,05% |
| 4 | 179.018 | 1.277.328 | 319.332 | **79.658** | 16,30% |
| 5 | 129.777 | 1.228.087 | 245.617 | 346.956 | 11,82% |
| 6 | 94.087 | 1.192.397 | 198.733 | 340.506 | 8,57% |
| 7 | 72.868 | 1.171.178 | 167.311 | 231.159 | 6,63% |
| 8 | 55.736 | 1.154.045 | 144.256 | 172.255 | 5,07% |
| 9 | 43.844 | 1.142.154 | 126.906 | 263.710 | 3,99% |
| 10 | 34.324 | 1.132.633 | 113.263 | 199.284 | 3,13% |
| 11 | 27.805 | 1.126.115 | 102.374 | 226.629 | 2,53% |
| 12 | **22.307** | **1.120.617** | **93.385** | 244.243 | **2,03%** |

**Source: Presented by the authors**

**Table 4. Results minimizing *Workload Deviations* ()**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***m*** | **:Workload Deviations [hr/year]** | **Total Workload [hr/year]** | **Average Workload [hr/year]** | **Travel Workload [hr/year]** | **Ratio** |
| 1 | 0 | 2.230.383 | 2.230.383 | 1.132.073 | 103,07% |
| 2 | **11.492** | 1.579.638 | 789.819 | 481.328 | 43,82% |
| 3 | 18.046 | 1.448.363 | 559.545 | 350.053 | 31,87% |
| 4 | 24.600 | 1.317.087 | 329.272 | 218.777 | 19,92% |
| 5 | 30.408 | 1.226.503 | 174.402 | 128.193 | 11,67% |
| 6 | 36.217 | 1.225.637 | 204.273 | 127.327 | 11,59% |
| 7 | 37.083 | 1.226.503 | 175.413 | 128.193 | 11,67% |
| 8 | 37.949 | 1.172.423 | 146.553 | 74.113 | 6,75% |
| 9 | 47.158 | 1.163.543 | 131.010 | 65.233 | 5,94% |
| 10 | 56.367 | 1.154.663 | 115.466 | 56.353 | 5,13% |
| 11 | 80.945 | 1.149.851 | 105.443 | 51.541 | 4,69% |
| 12 | 105.523 | **1.145.040** | **95.420** | **46.730** | **4,25%** |

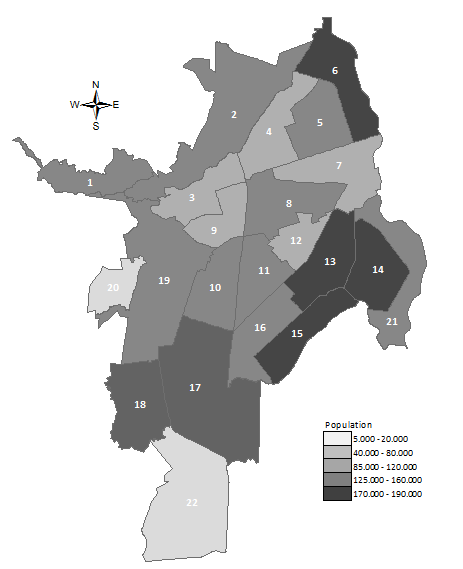
**Source: Presented by the authors**

**Table 5. Trade-offs Analysis: *Travel Workload* () and *Workload* *Deviations* ()**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **[%]** | **Travel Workload [hr/year]** | **:Workload Deviations [hr/year]** | **Total Workload [hr/year]** | **Average Workload [hr/year]** | **Deterioration of** | **Improvement of** |
| 1 | 55.735 | 172.255 | 1.154.045 | 144.256 | 0,00% | 0,00% |
| 5 | 56.478 | 155.369 | 1.154.788 | 144.348 | 1,33% | 10,87% |
| 10 | 57.400 | 146.450 | 1.155.710 | 144.464 | 2,99% | 17,62% |
| 15 | 57.969 | 99.811 | 1.156.279 | 144.535 | 4,01% | 72,58% |
| 20 | 58.779 | 92.211 | 1.157.089 | 144.636 | 5,46% | 86,80% |
| 25 | 62.303 | 93.706 | 1.160.613 | 145.077 | 11,78% | 83,83% |
| 30 | 63.094 | 74.474 | 1.161.404 | 145.176 | 13,20% | 131,30% |

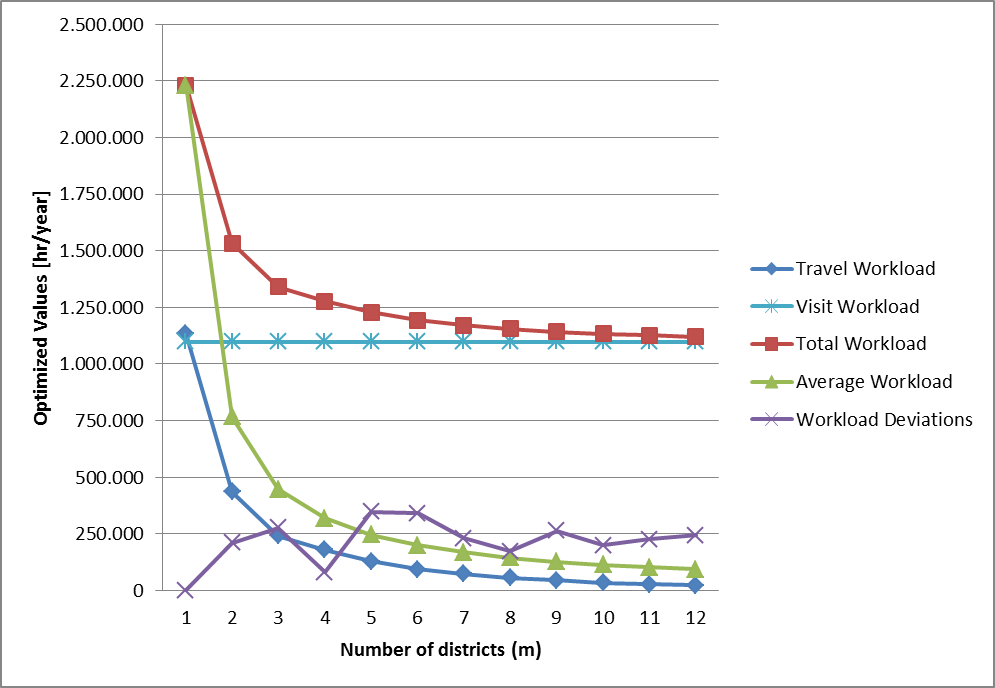
**Source: Presented by the authors**

**Figure 1. Cali, Colombia: Population Distribution**



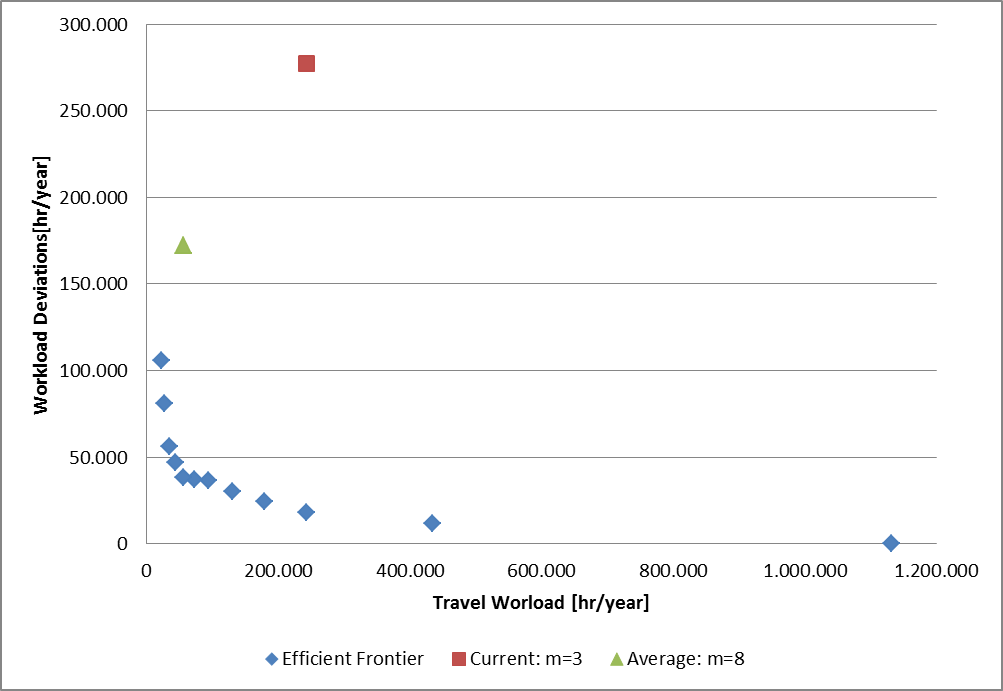
**Source: Presented by the authors based on (DAP, 2012)**

**Figure 2. Optimized values when minimizing *Travel Workload* ()**



**Source: Presented by the authors**

**Figure 3. Efficient Frontier: *Travel Workload* () and *Workload* *Deviations* ()**

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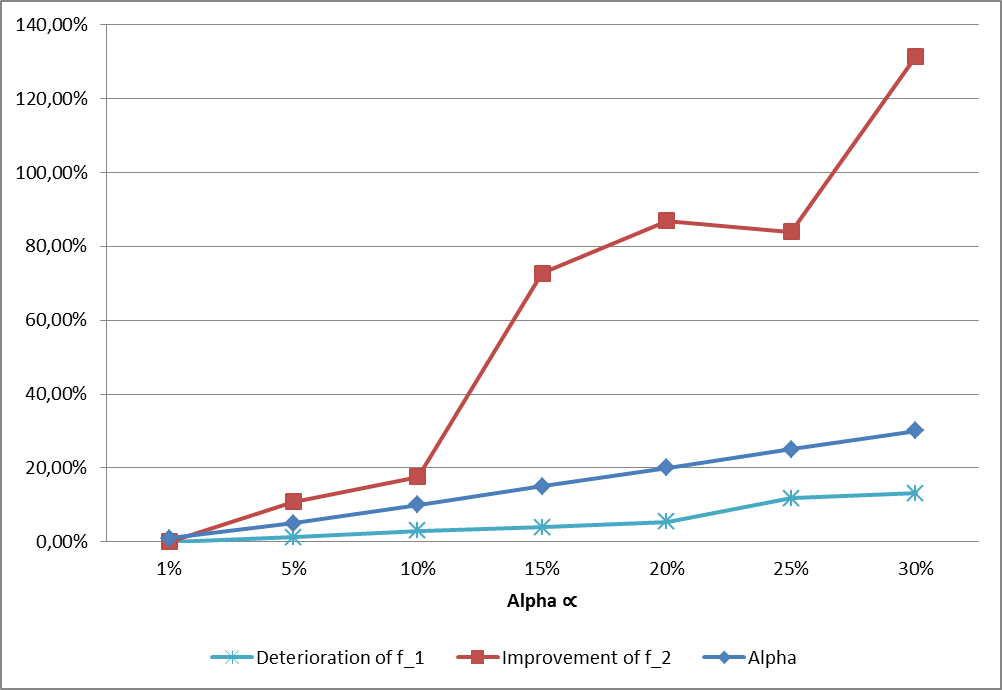
**Source: Presented by the authors**

**Figure 4. Districting Configurations Obtained**

|  |  |
| --- | --- |
| **a. Minimizing: *Total Travel Workload* individually** | **b. Thresholds: *Total Travel Workload* vs. *Workload Deviations* ()** |

**Source: Presented by the authors**

**Figure 5. Trade-offs Analysis: Improvements of *Workload* *Deviations* due to Deterioration of *Travel Workload***



**Source: Presented by the authors**