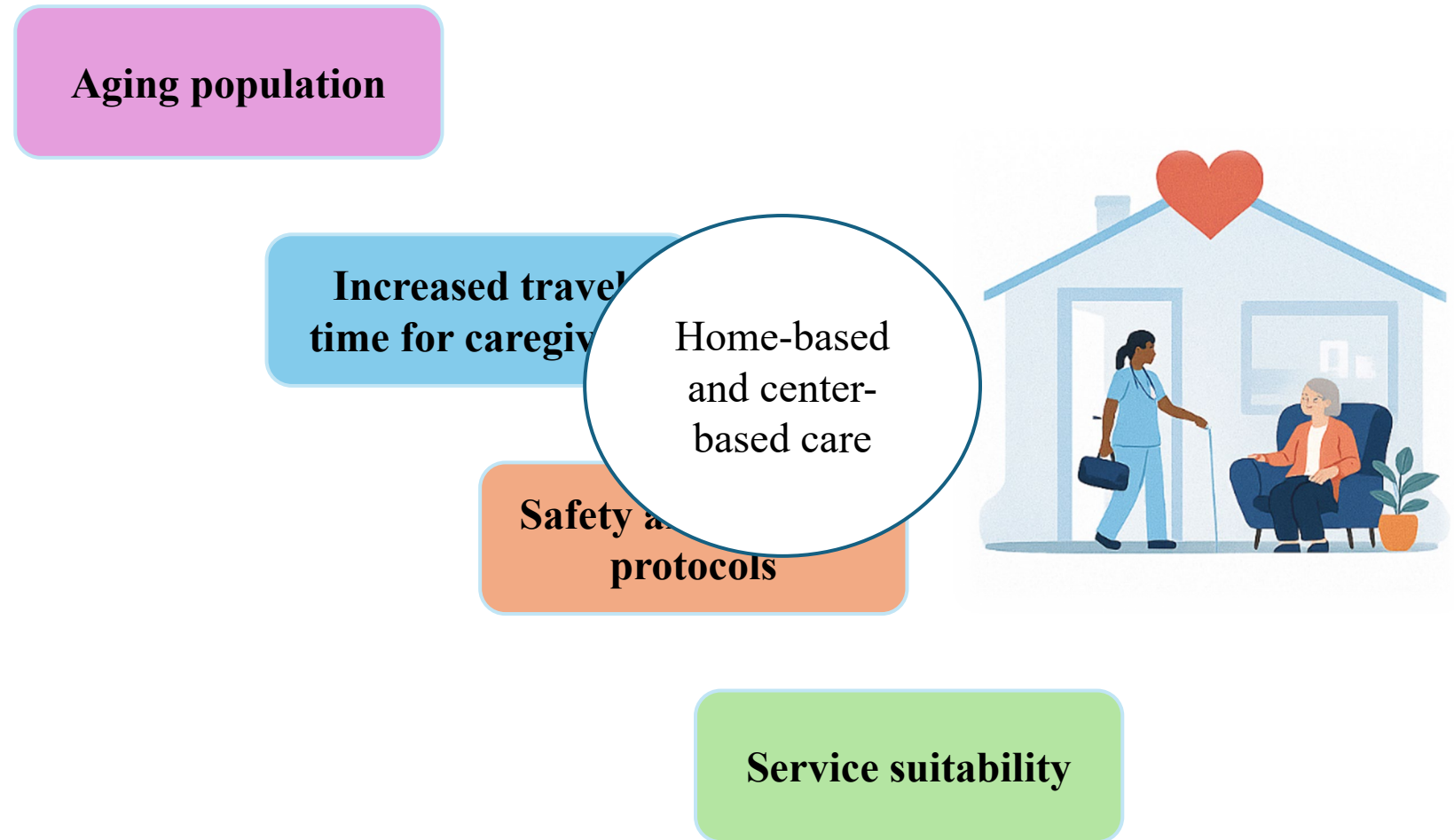




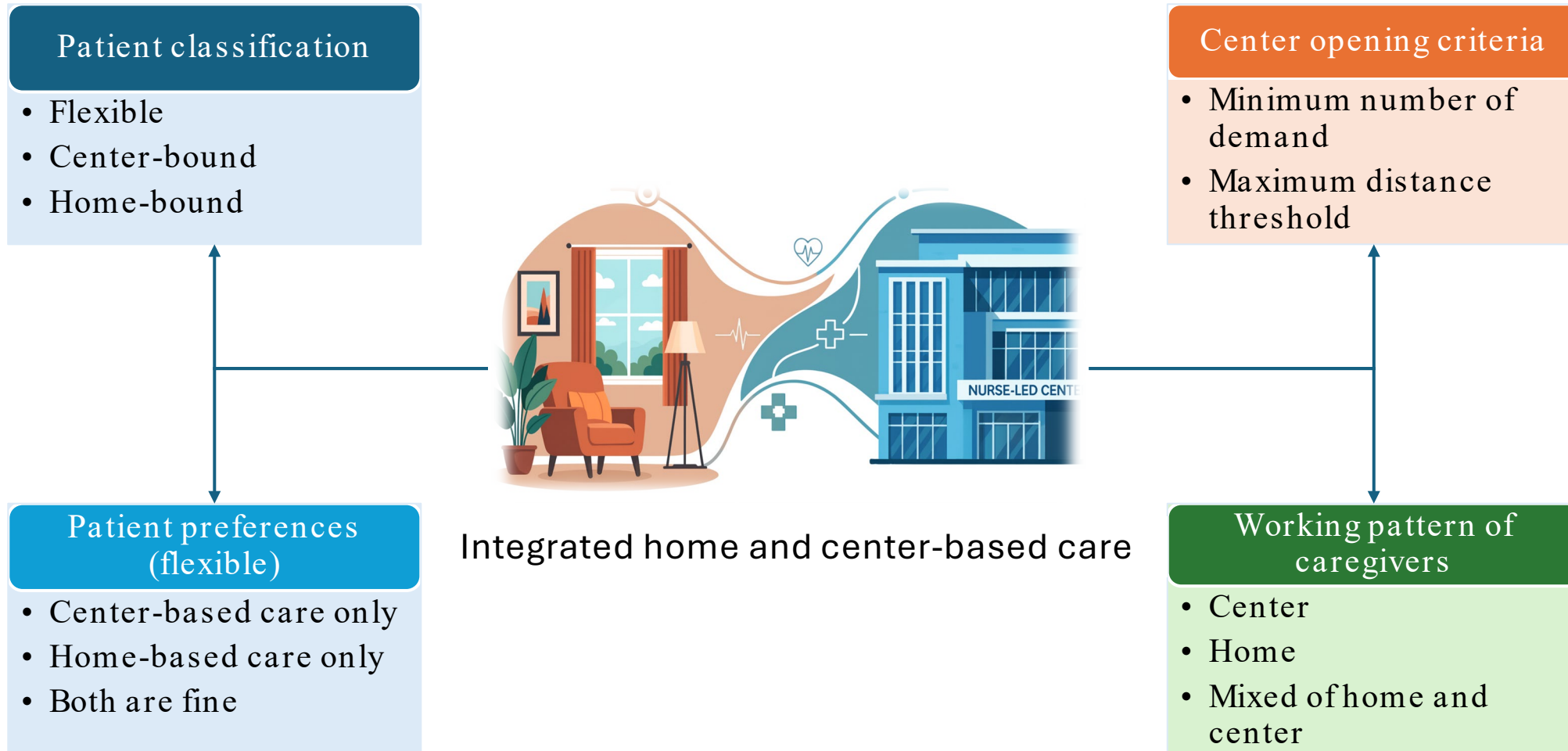
Home healthcare **close to home**: what does it achieve?

Yasamin Babaei, Gréanne Leeftink, Derya Demirtas, Luc Wismans, Erwin W. Hans

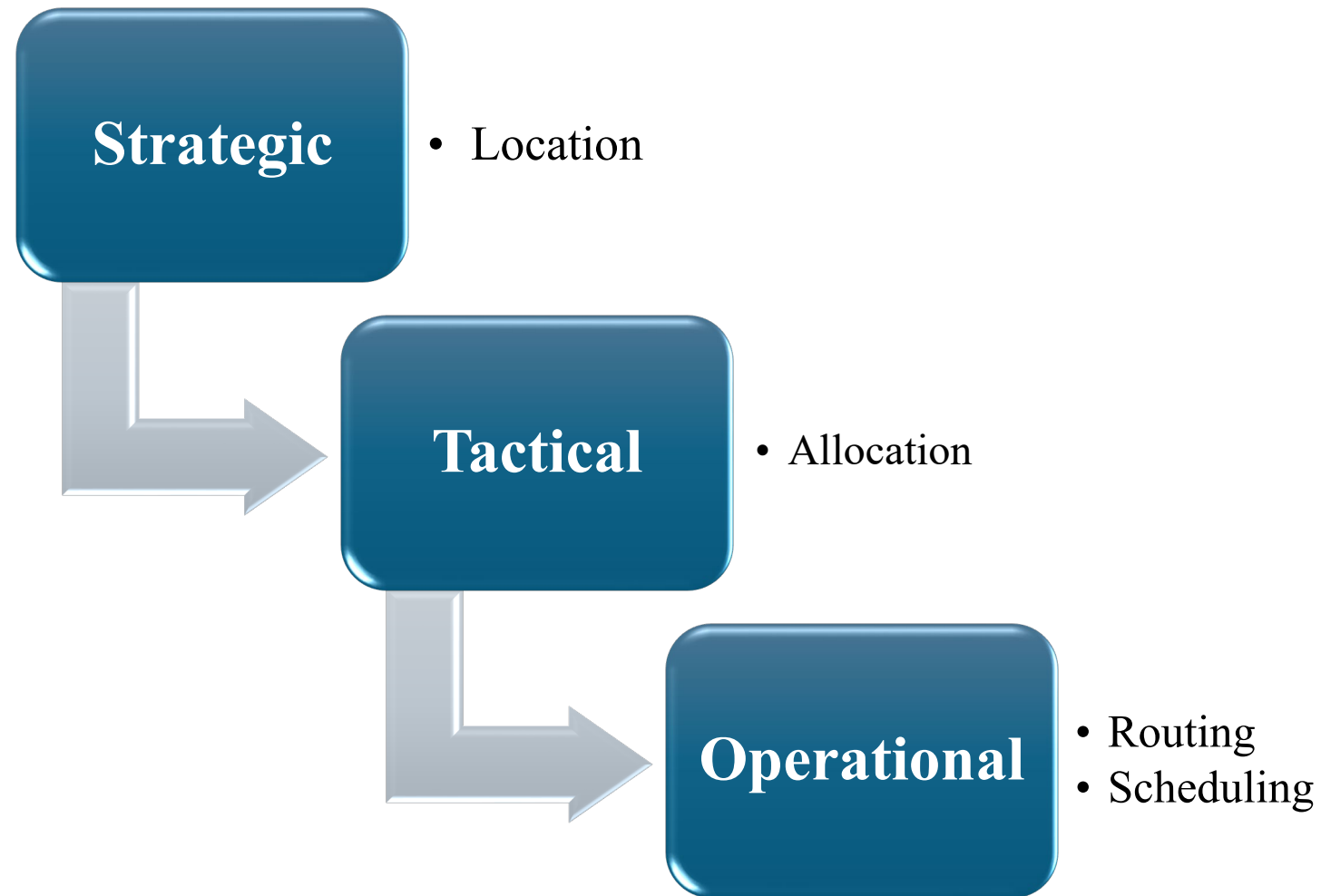
Home healthcare now....



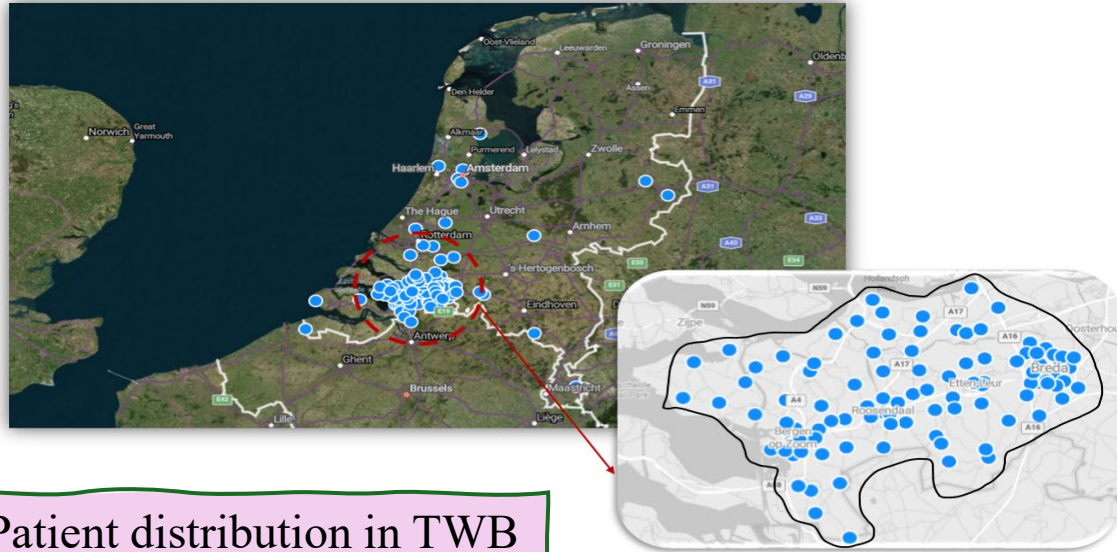
Rules & assumptions



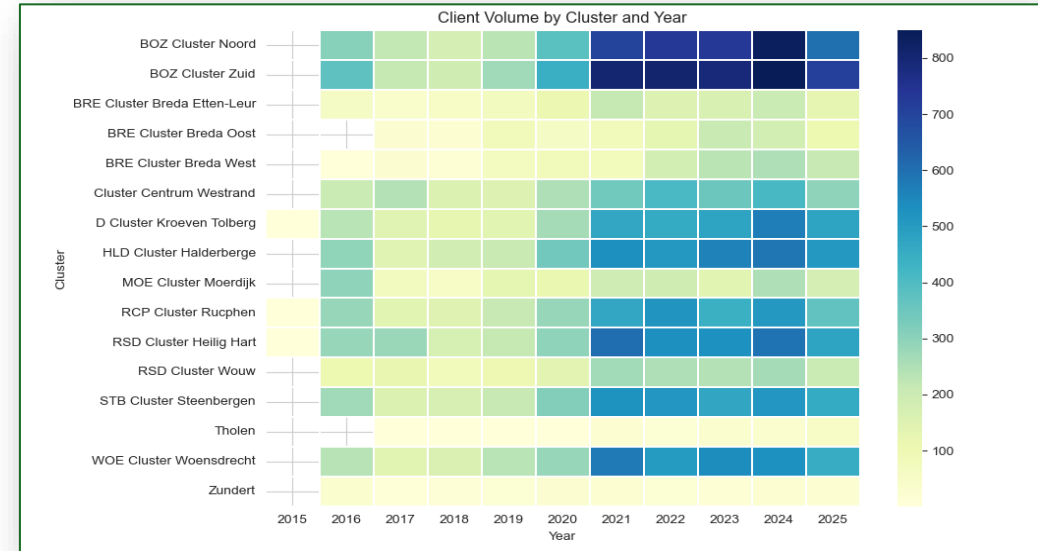
Operations Research in home healthcare



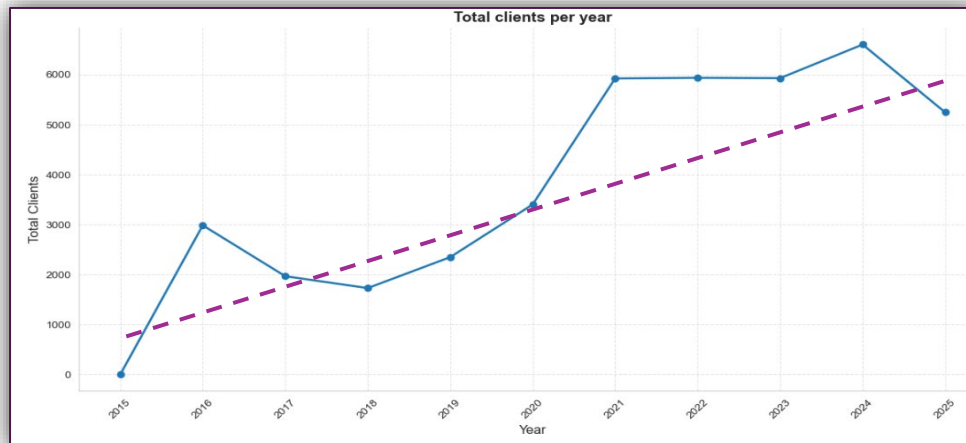
Patient demographic information



Patient distribution in TWB



Client volume by cluster and year



Total client volume per year

Long-term planning: Location decision based on real data



Modeling

$$\max Z_1 = \sum_{n \in \mathcal{N}} p_n \sum_{i \in \mathcal{I}} (d_{in} - w_{in}) \quad (1)$$

$$\min Z_2 = \sum_{n \in \mathcal{N}} p_n \left[\sum_{h \in \mathcal{H}} (F_{h,t(n)} u_{hn} + CL_{h,t(n)} v_{hn} + \bar{O}_{h,t(n)} y_{hn}) + \sum_{i \in \mathcal{I}} \sum_{h \in \mathcal{H}} c_{ih,t(n)} x_{ihn} + \sum_{i \in \mathcal{I}} H_{i,t(n)} h_{in} + \kappa \sum_{i \in \mathcal{I}} w_{in} \right] \quad (2)$$

$$y_{h,n_0} = y_h^0 + u_{h,n_0} - v_{h,n_0} \quad \forall h \in \mathcal{H} \quad (3)$$

$$y_{h,n} = y_{h,a(n)} + u_{h,n} - v_{h,n} \quad \forall h \in \mathcal{H}, \forall n \in \mathcal{N} \setminus \{n_0\} \quad (4)$$

$$u_{h,n} + v_{h,n} \leq 1 \quad \forall h \in \mathcal{H}, \forall n \in \mathcal{N} \quad (5)$$

$$\sum_{h \in \mathcal{H}} F_{h,t(n)} u_{h,n} \leq B_{t(n)} \quad \forall n \in \mathcal{N} \quad (6)$$

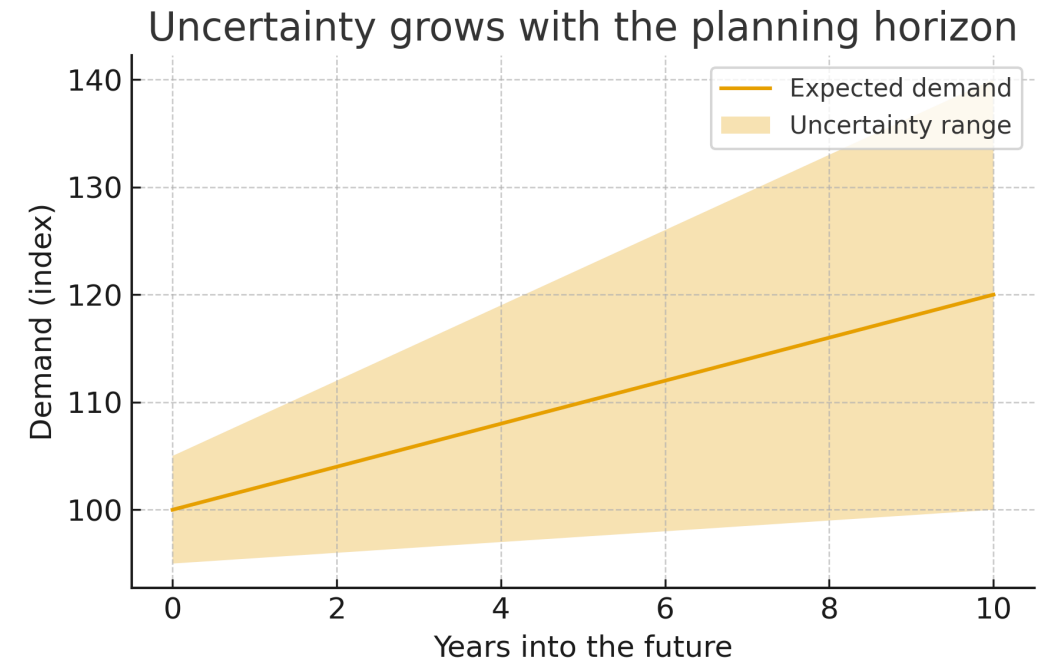
$$\sum_{h \in \mathcal{H}} x_{ihn} + h_{in} + w_{in} = d_{i,n} \quad \forall i \in \mathcal{I}, \forall n \in \mathcal{N} \quad (7)$$

$$x_{ihn} \leq d_{i,n} y_{h,n} \quad \forall i \in \mathcal{I}, \forall h \in \mathcal{H}, \forall n \in \mathcal{N} \quad (8)$$

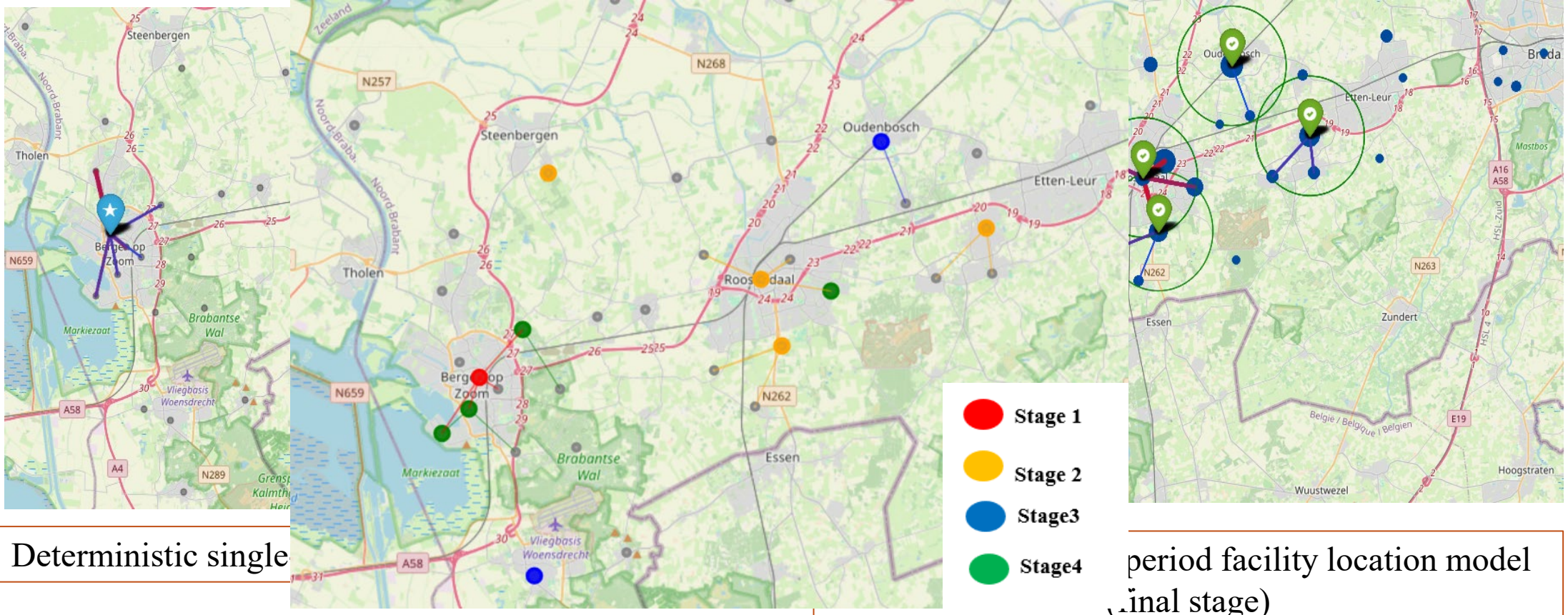
$$x_{ihn} = 0 \quad \forall (i, h) \notin \mathcal{A}, \forall n \in \mathcal{N} \quad (9)$$

$$\sum_{n \in \mathcal{N}: t(n)=t} p_n \sum_{i \in \mathcal{I}} w_{i,n} \leq (1 - \alpha_t) \sum_{n \in \mathcal{N}: t(n)=t} p_n \sum_{i \in \mathcal{I}} d_{i,n}, \quad \forall t \in \mathcal{T} \quad (10)$$

Maximize demand coverage
Minimize incurred cost



Result: Facility location model



Deterministic single

Multi-stage stochastic facility location model

period facility location model (final stage)

Short-term planning: Day-to-day assignment, scheduling, and routing



Modeling

$$Z_1 = \sum_{\xi \in \Xi} \phi^\xi \sum_{i \in C \setminus \xi} \sum_{t \in T} de_{it}^\xi$$

$$Z_2 = \underbrace{\sum_{h \in H} \gamma_h w_h}_{\text{First-stage resting cost}} + \sum_{\xi \in \Xi} \phi^\xi \left(\sum_{h \in H} \sum_{t \in T} f_{cht} x_{ht}^\xi + \sum_{(i,j) \in T \setminus \xi} \sum_{c \in C} \sum_{t \in T} \pi g_{ijct}^\xi t_{ij}^\xi \right) + \sum_{c \in C} \sum_{t \in T} u_h z_{ct}^{2,\xi} + \sum_{c \in C} \sum_{h \in H} \sum_{t \in T} u_c z_{cht}^{1,\xi}$$

$$Z_3 = \sum_{\xi \in \Xi} \phi^\xi \sum_{i \in C \setminus \xi} \sum_{h \in H} \sum_{t \in T} 2 d_{ih}^\xi y_{hit}^{1,\xi}$$

Minimize

- delay
- Patient distance
- cost

Working hours.

$$\sum_{i \in C \setminus \xi} S_{ci}^\xi (a_{cit}^\xi y_{hit}^{1,\xi}) \leq W_o z_{cht}^{1,\xi} \quad \forall c \in C, \forall h \in H, \forall t \in T, \forall \xi \in \Xi$$

$$\sum_{i \in C \setminus \xi} S_{ci}^\xi (a_{cit}^\xi y_{it}^{2,\xi}) + \sum_{i,j \in C \setminus \xi, i \neq j} t_{ij}^\xi g_{ijct}^\xi \leq W_o z_{ct}^{2,\xi} \quad \forall c \in C, \forall t \in T, \forall \xi \in \Xi$$

Time windows.

$$e_i^{1,\xi} a_{cit}^\xi \leq ts_{cit}^\xi \leq l_i^{1,\xi} a_{cit}^\xi + de_{it}^\xi \quad \forall c \in C, \forall t \in T, \forall i \in P^\xi, \forall \xi \in \Xi$$

$$de_{it}^\xi \leq T_{\max} \quad \forall i \in P^\xi, \forall \xi \in \Xi$$

Center visit sequencing.

$$\sum_{i \in C \setminus \xi} a_{cit}^\xi y_{hit}^{1,\xi} \leq M u_{cht}^\xi \quad \forall c, h, t, \xi$$

$$\sum_{i \in C \setminus \xi} a_{cit}^\xi y_{hit}^{1,\xi} \geq u_{cht}^\xi \quad \forall c, h, t, \xi$$

$$b_{chijt}^\xi \leq z_{cht}^{1,\xi} \quad \forall c, h, t, i \neq j, \xi \in \Xi$$

$$b_{chijt}^\xi \leq a_{cit}^\xi y_{hit}^{1,\xi} \quad \forall c, h, t, i \neq j, \xi \in \Xi$$

$$b_{chijt}^\xi \leq a_{cjt}^\xi y_{hjt}^{1,\xi} \quad \forall c, h, t, i \neq j, \xi \in \Xi$$

$$b_{chijt}^\xi + b_{chjst}^\xi \leq 1 \quad \forall c, h, t, i \neq j, \xi \in \Xi$$

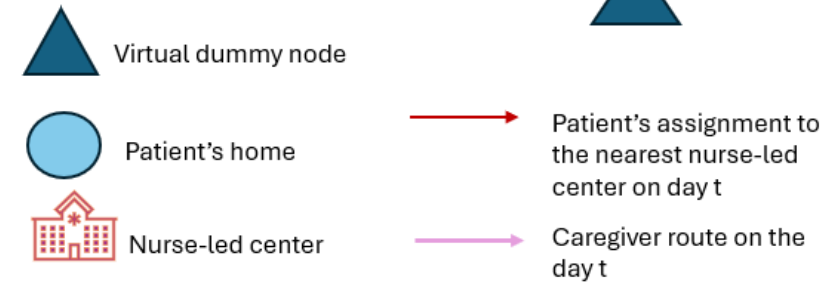
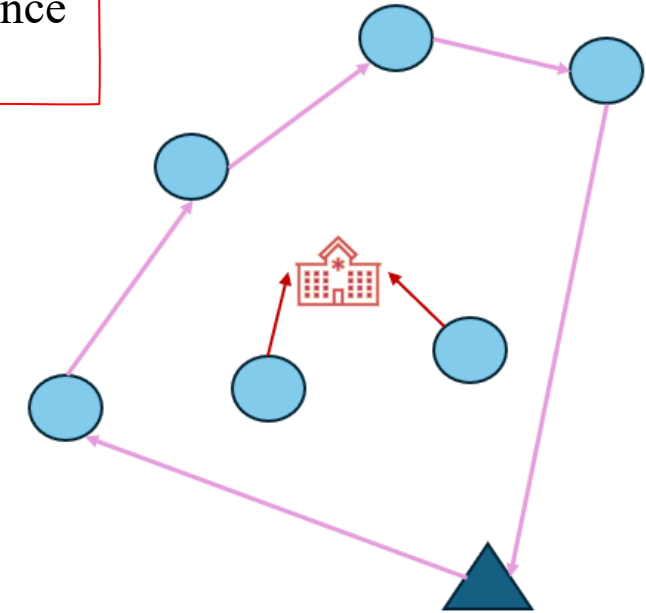
$$ts_{cjt}^\xi \geq ts_{cit}^\xi + S_{ci}^\xi - (1 - b_{chijt}^\xi)M \quad \forall c, h, t, i \neq j, \xi \in \Xi$$

$$\sum_{j \in C \setminus \xi} b_{chjst}^\xi + f_{chst}^\xi = a_{cit}^\xi y_{hit}^{1,\xi} \quad \forall c, h, t, i \in P_{\text{center}}^\xi, \xi \in \Xi$$

$$\sum_{j \in C \setminus \xi} b_{chijt}^\xi + f_{chst}^\xi = a_{cit}^\xi y_{hit}^{1,\xi} \quad \forall c, h, t, i \in P_{\text{center}}^\xi, \xi \in \Xi$$

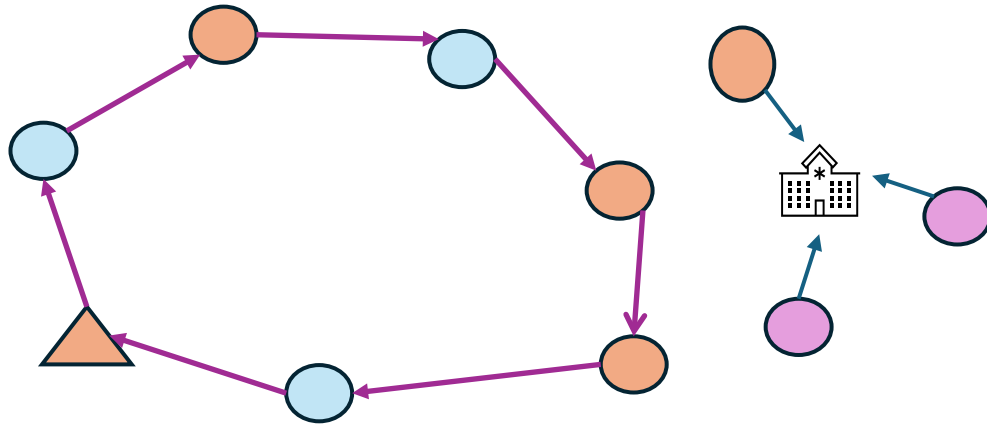
$$\sum_{i \in C \setminus \xi} f_{chst}^\xi = u_{cht}^\xi \quad \forall c, h, t, \xi \in \Xi$$

$$\sum_{i \in C \setminus \xi} l_{chst}^\xi = u_{cht}^\xi \quad \forall c, h, t, \xi \in \Xi$$

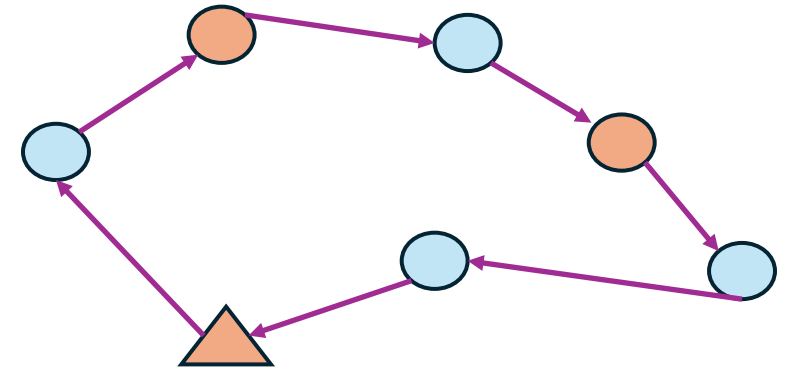


Result: daily caregiver visit schedule

Home-based and center-based care







Home-based care only



RAW delay = 42.80
 RAW cost = 11371.83
 RAW patient travel = 25.44

Cost Breakdown

Hub daily opening cost: 521.73
 Hub staffing cost: 2200.00
 Home staffing cost: 5400.00
 Travel cost: 3250.10
TOTAL COST (raw sum) : 11371.83

-  Center
-  home-bound patient
-  flexible patient
-  Center-bound patient

RAW delay = 134.20
 RAW cost = 13527.70
 RAW Patient travel = 0.0

Cost Breakdown

Hub daily opening cost: 0.00
 Hub staffing cost: 0.00
 Home staffing cost: 8400.00
 Travel cost: 5127.70
TOTAL COST (raw sum) : 13527.70

Thank you very much for your attention!

Key achievement



A hybrid setting that combines **nurse-led centers and home visits** can improve efficiency and access in home healthcare, especially under workforce pressure.



Where and when to open centers should be driven by data on the client population and **future demand patterns**.



With combined center and home-based care, we could satisfy **different patient demands**.

Getting more information

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