Taking patients' wishes into account for daily planning in the Home Health Care contex

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Abstract: We consider here the daily planning of human resources for home health care. We give a mathematical formulation of the problem, as a mixed integer linear program integrating real-world constraints, such as disjunction, synchronization and precedence between tasks. Our objective is to optimize several indicators of patients' satisfaction, regarding time of care and the caregivers' gender. We assess the performance of the MILP with some data generated in order to fit the specificities of the practical problem.

Keywords: Home Health Care, routing and scheduling, daily planning, temporal constraints, MILP

1. INTRODUCTION

Home Health Care offers an alternative or an extension to traditional hospitalization. It consists in delivering medical and paramedical services to patients at home. Although applicable to a wide variety of pathologies, the Home Health Care relates more largely to postpartum care, palliative care, and neuro-degenerative diseases associated with aging. Thus, in part because of the aging of population, the Home Health Care has experienced strong growth in recent years.

While allowing potential reductions in hospitalization costs, the Home Health Care also gives raise to a number of additional organizational difficulties, compared to a conventional hospital service, such as routing and scheduling of caregivers. The aim is to decide which caregiver visits which patient, at what time, respecting a set of constraints.

Besides the cost aspect, the Home Health Care being a service to persons, service quality is defined, among others, by the level of patient's satisfaction. Several criteria are possible to measure this satisfaction, such as respect for the wishes of patients regarding their provision of care. These wishes are usually difficult to meet, and often ignored in a schedule established " by hand " .

Our study addresses the routing and scheduling problem, by focusing on the human aspect, and specifically on patient's satisfaction.

This paper is organized as follows: Section 2 presents related studies and define our problem, relating it with the literature. We then propose in Section 3 a mathematical formulation of our problem using linear programming with mixed variables. Section 4 presents the data generation and Section 5 the experiences and results of this modeling.

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2. LITERATURE AND PROBLEM DESCRIPTION

The good effective functioning of a Home Health Care Center (HHCC) implies the resolution of several problems, such as resource dimensioning, partitioning patients and resources into districts, based on geography and / or on skills needed to treat patients, admission of patients and their assignment to one or more caregivers, and finally the scheduling and routing of human and material resources. We are interested here in the scheduling and routing problem of HHCC staff (i.e. deciding which human resource visits which patient at what time). In the literature, we find different variants of this problem. The main differences among the papers are the considered objectives, the constraints that are taken into account, and the methodology used for solving the problem. Readers can refer to Fikar and Hirsch (2017), or Cissé et al. (2017) for some recent reviews of existing OR models applied to Home Health Care Routing and Scheduling problem.

Within the planning problem, we can distinguish the problem of short-term planning (about a day or half a day), the problem of planning in the mid-term (about one or two weeks) or long term (about a month or more). We focus here our attention on the papers, published in journals and considering short term planning. Tables 1 and 2 summarize the objectives pursued in the planning, and the constraints that are taken into account in these papers.

2.1 Literature analysis for the daily planning problem

Table 1 shows that, almost all the articles aim at minimizing the transportation costs. However, the majority of the articles use a multiple objective, expressed as a weighted sum of several criteria, which do not necessarily have the same unit. To the best of our knowledge, only Ait Haddadene et al. (2016) and Braekers et al. (2016)

Table 1. Optimization criteria

References	Cost			Satisfaction					
	Routes costs	Staff member costs		Patient satisfaction				Staff member satisf	
	Min travel time cost/distance	Min Service Work /Duration	Min over times/ costs	Max Preferred time	Max Patient preferences	Min uncovered services	Min TW violation	Balance Workload	Max Clustering efficiency
Begur et al. (1997)	√	-	-	-	-	-	-	-	-
Blais et al. (2003)	√	√	-	-	-	-	-	√	-√
Bertels and Fahle (2006)	√	-	-	-	√	-	√	-	-
Eveborn et al. (2006)	√	-	-	√	√	-	-	-	-
Akjiratikarl et al. (2007)	√	-	-	-	-	-	-	-	-
Bredström and Rönnqvist (2008)	√	-	-	-	√	-	-	-	-
Hertz and Lahrichi (2009)	√	-	-	-	-	-	-	√	√
Rasmussen et al. (2012)	√	-	-	-	√	√	-	-	-
Benzarti et al. (2013)	√	-	-	-	-	-	-	-	-
Mutingi and Mbohwa (2013)	√	-	-	-	-	-	√	-	-
Mankowska et al. (2014)	√	-	-	-	-	-	√	-	-
Mutingi and Mbohwa (2014)	-	-	-	√	-	-	-	√	√
Issaoui et al. (2015)	√	-	-	-	√	-	-	-	-
Lieder et al. (2015)	-	-	-	-	-	-	√	-	-
Yuan et al. (2015)	√	√	-	-	-	-	-	-	-
Ait Haddadene et al. (2016)	√	-	-	-	√	-	-	-	-
Braekers et al. (2016)	√	-	√	√	√	-	-	-	-
Redjem and Marcon (2016)	√	-	-	-	√	-	-	-	-
Shi et al. (2016)	√	-	-	-	-	-	-	-	-
Yalçındag et al. (2016)	√	-	-	-	-	-	-	-	-
Our paper	-	-	-	√	√	-	-	-	-

Table 2. Constraints

References	Service/Care						Patients			Staff Members						
										Staff characteristics		Availability	Rules		Other	
	Hard TW	Known service duration	Qualification needed	Disjunction	Synchronization	Precedence	Soft TW	Earliest time	Preferred starting time	workload	Skill level	Hard TW	Legislative rules	Limited of diff caregivers	District region	Vehicle capacity
Begur et al. (1997)	√	-	√	-	-	-	-	-	-	-	√	-	-	-	-	-
Blais et al. (2003)	-	-	-	-	-	-	-	-	-	√	-	-	-	-	√	-
Bertels and Fahle (2006)	√	√	-	-	-	-	√	-	-	-	-	√	-	-	-	-
Eveborn et al. (2006)	√	-	√	-	-	-	-	-	√	-	√	√	√	-	√	-
Akjiratikarl et al. (2007)	√	-	-	-	-	-	-	-	-	-	-	-	√	-	-	-
Bredström and Rönnqvist (2008)	√	√	-	-	√	-	-	-	-	-	-	√	-	-	-	-
Hertz and Lahrichi (2009)	-	-	-	-	-	-	-	-	-	√	-	-	-	-	√	-
Rasmussen et al. (2012)	√	√	-	-	-	√	-	-	-	-	-	√	√	-	-	-
Benzarti et al. (2013)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	√	-
Mutingi and Mbohwa (2013)	-	-	-	-	-	-	√	-	-	-	-	√	-	-	-	-
Mankowska et al. (2014)	√	√	√	-	√	√	-	-	-	-	√	√	-	-	-	-
Mutingi and Mbohwa (2014)	√	√	√	-	√	-	-	-	-	-	√	√	-	-	-	-
Issaoui et al. (2015)	√	-	√	-	-	-	-	-	-	-	√	-	√	-	-	-
Lieder et al. (2015)	-	√	√	-	-	-	-	√	√	-	√	-	-	-	-	-
Yuan et al. (2015)	-	√	√	-	-	-	-	-	-	-	√	-	-	√	-	-
Ait Haddadene et al. (2016)	√	√	√	-	√	√	-	-	-	-	√	√	-	-	-	-
Braekers et al. (2016)	√	√	√	-	-	-	-	-	√	-	√	-	√	-	-	-
Redjem and Marcon (2016)	√	√	-	-	-	√	-	-	-	-	-	√	-	-	-	-
Shi et al. (2016)	√	-	-	-	-	-	-	-	-	-	-	√	-	-	-	√
Yalçındag et al. (2016)	√	√	√	-	-	-	-	-	-	-	√	√	-	-	-	-
Our paper	√	√	√	√	√	√	√	-	-	-	√	√	√	-	-	-

considered the trade-off between costs and satisfation and proposed methods based on the ϵ-constraint approach and enumerating the Pareto frontier. In our paper, we aim at maximizing the patients' satisfaction, by minimizing a sum of penalties.

The characteristics of the schedules are summarized in table 2. Most of the articles take into account the diversity of the caregivers' skills, generally under the shape of strong constraints. In general, a set of skills is assigned to each caregiver, and a set of necessary qualifications to every visit. We notice however that in practice, instances contain a limited number of different skills (2 or 3). Almost all the articles dedicated to the planning impose a hard time window for the task execution. Only a very few of them consider temporal constraints or patient preferences. In our paper, we aim at overcoming some limitations observed in the literature, especially those concerning the temporal constraints and the patient preferences.

2.2 Problem description and positioning

The problem considered in this article is the daily planning of the caregivers tours. We take into account constraints that are commonly considered, as the working schedules of caregivers, the adequacy between the staff skills and the qualifications required by the care, and time windows imposed for some cares. Temporal constraints between tasks, which are important in practice and approached by relatively few works, are also considered. More precisely, in this article we take into account constraints of disjunction, synchronization, precedence and strict precedence.

Unlike the majority of the articles in the literature, the objective is not the tour minimization (total distance or duration), nor the balancing of the working time, but is the maximization of the patients' satisfaction. For that, two different criteria are taken into account:

- Respect for time windows desired by the patients: a patient can give a time window in which he/she prefers to receive the visits from the caregivers.
- Respect for the patients' wishes for the caregivers' gender: a patient can express a preference concerning the gender of the caregiver for some of the cares. In the literature some methods allow to model the wishes of gender thanks to the notion of qualification but none takes into account the gender as a particular constraint.

These criteria are modeled by soft constraints, with a penalty associated with their violation. The objective is to minimize the sum of these penalties in order to optimize the satisfaction of the patient. The performance of our solution is checked on generated testing data the closest possible to reality.

3. MODEL DESCRIPTION

3.1 Assumptions and definitions

Periods We consider a time horizon of 1 period of half a day.

Caregivers We consider several kinds of caregivers, corresponding to different levels of skills (which may correspond to nurses, auxiliary nurses, or other caregivers). A caregiver may perform all the tasks for which the required qualification is lower or equal to his/her skill level. All caregivers must begin and end their tour at the HHCC. Working hours may vary according to the caregivers, but are always continuous intervals. The gender of each caregiver is known.

Tasks A number T of tasks must be performed by caregivers. A task is a care for a given patient, performed by exactly one caregiver. Each task has a defined duration. A qualification is defined for each task corresponding to the minimal level of skill required by the caregiver to realize this task. Some tasks may have a time window. This time window could be a hard time window corresponding to a medical constraint, or a soft time window corresponding to a patient's wish. For the hard time window, the task must start and end within this time window. For the soft time window, if the task starts before this time window or finishes after this time window, a penalty is applied. A wish of gender can be associated with some tasks. If this wish of gender is not respected a penalty is applied.

Patients The travel time between patients and between patients and HHCC are known. It is assumed that these travel times satisfy the triangle inequality. These travel times are used to define travel times between tasks.

Patients may express wishes for tasks regarding, specifically:

- a preference on the gender of a caregiver may be associated with a task.
- a desired availability time window can be associated with a task. These time windows are continuous intervals. Let us define these time windows by soft time windows.

Each patient can need one or several task(s) by period. When two tasks are defined for the same patient on the same period, they can be of several type:

disjunction: both tasks cannot overlap, the order is irrelevant;
synchronization: both tasks start at the same time; In this case, these two care cannot be realized by the same caregiver, two caregivers are simultaneously required at the patient's home.
precedence: both tasks cannot overlap and must be performed in a certain order.
strict precedence: both tasks must be sequenced directly in a certain order. One starts immediately after the end of the other.

3.2 Data and parameters

- K : Set of caregivers.
- P : Set of patients.
- T : Set of tasks.
- $Demand_p$: set of tasks for the patient p.
- D : Set of depots. $D = \{0, \tau\}$
- S: Set of nodes. $S = T \cup D$.
- E set of arcs. $E = \{(i,j) \in D : i \neq j\} \setminus \{(\tau, j) : j \in T\} \setminus \{(j, 0) : j \in T\}$
- T_{dys} : set of couple of tasks for which a disjunction has been defined.
- T_{sync} : set of couple of tasks for which a synchronization has been defined.
- T_{precS} : set of couple of tasks for which a precedence has been defined.
- T_{precE} : set of couple of tasks for which a strict precedence has been defined.
- $K_t = \{k \in K : Qualif(k) >= Qualif(t)\}$: set of caregivers who can perform task t
- $Travel_{ij}$: Travel time between tasks i and j.
- $Duree_t$: Duration of task t
- C_Gen_k: Gender of caregiver k (0 for Female and 1 for Male)
- T_Gen_t: Wish of gender for task t (0 for Female, 1 for Male, -1 for not specified gender)
- $[a_k, b_k]$: Working time window of caregivers k
- $[\alpha_t, \beta_t]$: Hard Time window of task t (α_t =-1 and β_t= -1 if t does not require a hard TW).
- $[e_t, l_t]$: Soft Time window of task t (e_t =-1 and l_t -1 if t does not require a soft TW.
- CG: Gender costs.
- CT: Soft Time Window costs.
- M: a big constant settled to the end of the time horizon.

3.3 Variables

Assignment variables

- $y_{tk} = \begin{cases} 1 \text{ if } \textit{caregiver} \text{ k } \textit{performs task} \text{ t} \\ 0 \text{ otherwise.} \end{cases}$
- $z_{ijk} = \begin{cases} 1 \text{ if } \textit{caregiver} \text{ k } \textit{performs task} \text{ i } \textit{then} \text{ j} \\ 0 \text{ otherwise.} \end{cases}$
- $\lambda_t = \begin{cases} 1 \text{ if } \textit{the soft TW of task} \text{ t } \textit{is not respected} \\ 0 \text{ otherwise.} \end{cases}$
- $\gamma_t = \begin{cases} 1 \text{ if } \textit{the wish of gender for task} \text{ t } \textit{is not respected} \\ 0 \text{ otherwise.} \end{cases}$

Scheduling variables

- $time_t$= Starting time of task t.

3.4 Model

$$\min \quad CG.\sum_{t\in T}\gamma_t + CT.\sum_{t\in T:e_t\neq -1}\lambda_t \tag{1}$$

Subject to:

$$\forall t \in T, \quad \sum_{t\in K_t} y_{tk} = 1 \tag{2}$$

$$\forall t \in T, \forall k \in K_t, \quad \sum_{i\in D\setminus\{\tau\}} z_{itk} = \sum_{i\in E\setminus\{0\}} z_{tik} \tag{3}$$

$$\forall k \in K, \quad \sum_{t\in K_t} z_{0tk} = 1 \tag{4}$$

$$\forall k \in K, \quad \sum_{t\in K_t} z_{t\tau k} = 1 \tag{5}$$

$$\forall t \in T, \forall k \in K_t, \quad \sum_{i\neq t\in D\setminus\{0\}} z_{tik} = y_{tk} \tag{6}$$

$$\begin{gathered}\forall t_1, t_2 : t_1 \neq t_2 \in T, \\ time_{t_1} + Duree_{t_1} + Travel_{t_1t_2} \\ \leq time_{t_2} + M * (1 - \sum_{k\in K} z_{t_1t_2k})\end{gathered} \tag{7}$$

$$\begin{gathered}\forall t \in T, \forall k \in K_t, \\ a_k + Travel_{0t} - b_k.(1 - z_{0tk}) \leq time_t\end{gathered} \tag{8}$$

$$\begin{gathered}\forall t \in T, \forall k \in K_t, \\ time_t + Duree_t + Travel_{t\tau} \leq b_k + M.(1 - z_{t\tau k})\end{gathered} \tag{9}$$

$$\forall t \in T : \alpha_t \neq -1, \quad \alpha_t.\sum_{k\in K_t} y_{tk} \leq time_t \tag{10}$$

$$\forall t \in T : \alpha_t \neq -1, \quad time_t + Duree_t \leq \beta_t.\sum_{k\in K_t} y_{tk} \tag{11}$$

$$\forall t \in T : e_t \neq -1, \quad l_t.(1 - \lambda_t) \leq time_t \tag{12}$$

$$\forall t \in T : e_t \neq -1, \quad time_t + Duree_t \leq l_t + M.\lambda_t \tag{13}$$

$$\forall t \in T : T\_Gen_t = 0, \quad \sum_{k\in K_t} y_{tk}.C\_Gen_k = \gamma_t \tag{14}$$

$$\forall t \in T : T\_Gen_t = 1, \quad \sum_{k\in K_t} y_{tk}.(1 - C\_Gen_k) = \gamma_t \tag{15}$$

$$\forall (t_1, t_2) \in T_{sync}, \quad time_{t_1} = time_{t_2} \tag{16}$$

$$\begin{gathered}\forall (t_1, t_2) \in T_{sync}, \forall k_1 \in K_{t_1}, k_2 \in K_{t_2} : k_2 \neq k_1, \\ y_{t_1k_1} + y_{t_2k_2} \leq 1\end{gathered} \tag{17}$$

$$\forall (t_1, t_2) \in T_{precE}, time_{t_1} + Duree_{t_1} = time_{t_2} \tag{18}$$

$$\forall (t_1, t_2) \in T_{precS}, time_{t_1} + Duree_{t_1} \leq time_{t_2} \tag{19}$$

$$\begin{gathered}\forall (t_1, t_2) \in T_{dis}, \\ time_{t_1} + Duree_{t_1} \geq time_{t_2} \\ or \quad time_{t_1} + Duree_{t_1} \leq time_{t_2}\end{gathered} \tag{20}$$

$$\forall t \in T, \forall k \notin K_t, \quad \sum_{i\in D\setminus\{0\}} z_{tik} = 0 \tag{21}$$

$$\forall t \in T, \forall k \notin K_t, \quad \sum_{i\in D\setminus\{\tau\}} z_{itk} = 0 \tag{22}$$

$$\forall t \in T, \gamma_t \in \{0, 1\} \tag{23}$$

$$\forall t \in T, \lambda_t \in \{0, 1\} \tag{24}$$

$$\forall t \in T, \forall k \in K, y_{tk} \in \{0, 1\} \tag{25}$$

$$\forall i \in T, \forall j \in T, \forall k \in K, z_{ijk} \in \{0, 1\} \tag{26}$$

$$\forall t \in T, time_t \geq 0 \tag{27}$$

$$\forall t \in T, duree_t \geq 0 \tag{28}$$

The objective function (1) minimizes a weighted sum of the penalties associated with the non-satisfaction of the patient's wishes (gender and time windows). Constraint set (2) ensures that each task is completed by exactly one caregiver with the required skill level. Constraint set (3) is the classical constraint set of preservation of flow. Constraint sets (4) and (5) ensure that each caregiver starts and ends his/her working day at the HHCC. Constraint sets (6) set y_{tk} to 1 if one the variables z_{itk} has been assigned to 1, that is to say if the caregiver k performs, during his/her tour, the task t. Constraint set (7) ensures that if a pair of tasks (t_1, t_2) is performed by the same caregiver k then task t_1 must end before task t_2, starts, and without overlapping. The assumption regarding the respect of the triangle inequality for travel time is used here. Contraint sets (8) and (9) ensure that caregivers' working time windows are respected. Contraint sets (10) and (11) ensure that the planning respects the tasks' time windows, when defined. Constraint sets (12) and (13) ensure that if the desired soft time window of a patient for a task t is not respected, the decision variable corresponding to the non satisfaction of this wish λ_t is equal to one. Constraint sets (14), (15) ensure that if the gender preference of the patient for a task t is not respected, the decision variable corresponding to the non satisfaction of this wish γ_t is equal to one. Constraint sets (16), (18), (19), (20) ensure that scheduling variables are assigned according to synchronization, strict precedence and precedence and disjunction constraints. Constraint sets (17) ensure that if two tasks must be synchronized, these two tasks will be performed by two different caregivers. Constraint sets (21) and (22) ensure that a task of a tour cannot be assigned to a caregiver with an insufficient skill level.

4. DATA GENERATION

We generate randomly the instances, by respecting a number of rules stemming from constraints of the problem observed in practice. We assume that regular care are performed in the morning (in practice, afternoon is frequently dedicated to episodic cares). We shall thus consider that a period represents a morning constituted of 300 minutes, numbered from 0 to 300. In all our instances, we consider

Table 3. Working hours (in minutes) for the caregivers

Probability	Beginning	End
0.4	0	300
0.15	0	240
0.15	60	300
0.1	0	180
0.1	120	300
0.05	180	300
0.05	0	120

Table 4. Desired (soft) time windows for the tasks (in minutes)

Probability	Beginning	Probability	Duration
0.2	0	0.2	60
0.2	30	0.2	90
0.2	60	0.2	120
0.2	90	0.2	150
0.2	120	0.2	180

that, for each qualification, there are 20% of men and 80% of women amonf the caregivers, which corresponds to the existing distribution within the profession in France. Caregivers' working time windows are randomly generated, as shown in table 3. The number of caregivers is taken equal to 45% to 50% of the number of tasks.

A task corresponds to a visit from a caregiver to a patient. As, usually, the majority of the cares are of average duration, but a small part of the cares are shorter, or longer, possibly lasting more than one hour, we chose to distribute the tasks into three groups, 20% are in the first group (shorter), 70% in the second (average) and 10% in the third (longer). Durations of the tasks of the first group (short tasks) are between 20 and 35 minutes, those of the second (average tasks) between 35 and 55 minutes, and those of the third (long tasks) between 55 and 180 minutes. For each of these intervals, the duration of the tasks is randomly generated according to a uniform distribution.

Finally, for some tasks, called constrained tasks, execution time windows are generated. According to cares of this type handled in real HHCC, we consider two kinds of constrained tasks. 5% of the tasks have a time window defined in the following way: a multiplier chosen randomly between 1.2 and 1.5 is applied to the duration of the task to obtain the size of the time window. The beginning of the window is randomly chosen within the limits of period. This corresponds, among others, to the tasks that must be made before a medical examination. 5% of the tasks have a time window defined in the following way: a multiplier chosen randomly between 1.5 and 2 is applied to the duration of the task to obtain the size of the temporal window. The window begins at instant 0 with a probability 1/2, or ends at instant 300 with a probability 1/2. This corresponds to the care that must be executed at the beginning or at the middle of the day.

For some tasks, desired (soft) time windows are randomly generated as indicated in table 4.

The travel time between tasks, is set to a random value between 0 and 10 minutes.

Table 5. Performance of the MILP - resolution

Problem	ISolved	avRTime	minRTime	maxRTime
(20;2;11;25)	91	24.9	0.9	464.0
(20;2;12;25)	92	32.2	1.5	593.3
(20;3;11;25)	35	38.5	1.6	549.4
(20;2;12;25)	87	56.9	1.4	800.6
(30;2;16;36)	47	308.7	0.1	899.6
(30;2;18;36)	76	437.1	8.0	1801.0
(30;3;16;36)	44	317.6	13.0	317.6
(30;3;18;36)	48	160.8	9.9	643.0

ISolved: % of instances solved within 30 minutes
avRTime: average resolution time in seconds
minRTime: min resolution time in seconds
maxRTime: max resolution time in seconds

For all the instances, the percentage of gender wishes is about 10% of wish for a female caregiver, and 2.5% of wishes for a male caregiver.

5. EXPERIMENTS

To assess the performances of the MILP, we used the solver IBM ILOG CPLEX and the modeling language IBM ILOG OPL.

The program was tested on instances generated in a random way so as to remain close to reality. The MILP was tested on instances of various size and characteristics, following the generation rules described above. To be applicable in practice, the MILP must be solved within a reasonable time period. Here, we stop the execution after 30 minutes of running time.

In the remainder of the article, instances are referred to in the following way (P; Q; K; T), with:

- P number of patients,
- Q number of qualifications,
- K number of caregivers,
- T number of tasks

In tables 5 and 6, results obtained on various sizes of instances are presented. For each size shown in the tables, we generated 80 instances, by varying the proportion of temporal constraints (10 or 20 %), the proportion of hard time windows (10 or 20%), and the proportion of soft time windows (30 or 40%)

We observe that instances with 20 patients are solved within one minute and instances with 30 patients within 5 minutes. Remember that the tested instances have at least 10% of temporal constraints, 10% of hard time windows, and 30 % of soft time windows.

If we consider now the obtained results, we can observe that, in most cases, the gender preferences are satisfied, and that the soft time windows are satisfied in more than 80% of the cases. If we compare the obtained results to those obtained with a MILP aiming at optimizing the travel time, we can observe that the travel time is around 20% greater than the optimal one. Moreover, when optimizing the travel time, we could never satisfy the soft time windows, and satisfy the gender preferences only in around 70% of the cases.

Table 6. Performance of the MILP - results

Problem	AvTravel	GenderPref	softTWPref	OptTravel
(20;2;11;25)	252	1.0	13.9	203
(20;2;12;25)	258	4.4	13.4	213
(20;3;11;25)	257	3.3	12.9	208
(20;2;12;25)	256	3.4	13.9	210
(30;2;16;36)	360	1.8	18.6	295
(30;2;18;36)	372	0.0	16.5	309
(30;3;16;36)	359	2.1	18.6	294
(30;3;18;36)	375	0.0	18.2	312

AvTravel: Average travel time (minutes)
GenderPref: % of non satisfied Gender preferences
softTWPref: % of non satisfied soft time window preferences
OptTravel: Optimal Travel Time

6. CONCLUDING REMARKS AND FUTURE ISSUES

We proposed a new mathematical model for the daily planning problem in a HHCC focusing on the patients' satisfaction to overcome some limitations identified in the previous articles in the literature. The experiments show that the proposed MILP gives rather good results for the problem of daily planning, considering the patients' satisfaction, and without degrading too much the travel time.

A challenging future issue would be to have a bi-criteria approach to emphasis simultaneously the two contradictory criteria: patients and caregivers'satisfaction and costs.

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