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Routing and scheduling in Home Health Care: A Literature Survey and Bibliometric Analysis

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3 **Abstract**

4 Home Health Care (HHC) agencies aim at providing care and/or services to patients, at
5 their homes, ensuring a quality of service at least equivalent to that given in a hospital,
6 while controlling costs and improving living conditions.

7 The purpose of this paper is to propose a literature survey on "Home Health Care
8 problems" dealing with routing and scheduling, to provide an overview of the con-
9 straints and objectives addressed by Operations Research and Industrial Engineering
10 tools for both theoretical and practical HHC problems.

11 Based on an exhaustive methodology, the current state-of-the-art is reviewed, ana-
12 lyzed, and summarized. We focus not only on the methods used in the different papers
13 studied but also and mainly on constraints and objectives which are specific to the
14 HHC context, particularly highlighting the uncertain and dynamic aspects present in a
15 growing number of papers.

16 This literature survey enables us to identify several research directions, discussed
17 at the end of this paper. It makes it possible for researchers to identify unaddressed
18 problems, or to direct their research towards one or another method according to the
19 constraints and objectives under consideration, while for practitioners, it enables them
20 to see whether their problem has given rise to the development of planning methods.

21 The main contributions of this paper are a synthesis update of the literature dealing
22 with routing and scheduling in the HHC context, a set of comprehensive tables classi-
23 fying the papers, some discussions on current trends with a focus on the uncertain and
24 dynamic aspects, and future research directions.

25 *Keywords:* Home health care, Home service, Routing and scheduling, Optimization,
26 Hospital at home, Uncertainties

27 **1. Introduction**

28 HHC aims to provide medical or paramedical services to patients at their homes. It
 29 helps patients to maintain and improve their living conditions, while controlling health
 30 system costs, and then reducing the number of occupied beds in traditional hospitals.
 31 Although applicable to a wide variety of pathologies, HHC relates more generally to
 32 postpartum care, palliative care, and neurodegenerative diseases associated with aging.
 33 Thus, partly due to aging of the population, HHC has experienced strong growth in
 34 recent years. Taking France as an example, the number of patients using HHC ser-
 35 vices has increased constantly to reach 128,227 individuals in 2019 (FNEHAD, 2020),
 36 with an increase of +266% since 2005. Moreover, in 2018, 11.7% of Gross Domes-
 37 tic Product was spent on Health (INSEE, 2020), among which 1% was spent on HHC
 38 (FNEHAD, 2020).

39 While allowing potential reductions in hospitalization costs, HHC also gives rise
 40 to many additional organizational difficulties, compared to a conventional hospital ser-
 41 vice, as illustrated in Figure 1: patients stay at their homes and may be spread over
 42 a wide area, and the HHC agency has to manage several internal mobile resources
 43 (mainly human resources with specific skills and constraints) but also some external
 44 resources (such as liberal professionals, laboratories, etc.) to provide care to patients at
 45 their homes.

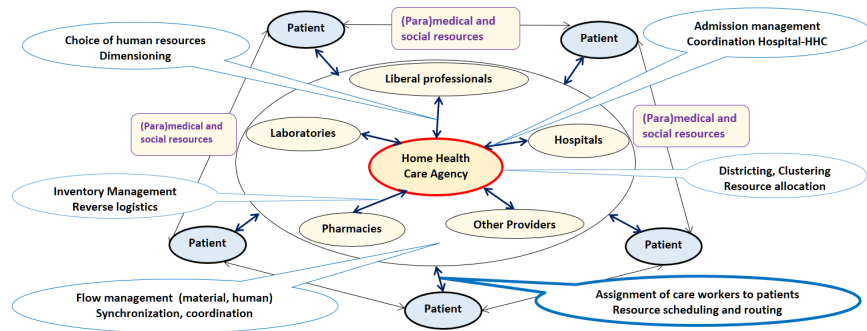


Figure 1: Home Health Care organizational issues

46 Development of HHC is at the heart of many issues, and raises many questions that

47 query many disciplinary fields, including the need to lay down norms and standards
48 (Detolle, 2001). This paper focuses exclusively on engineering science aspects. There
49 is a strong need for planning tools, and this is all the more true since in the HHC sector
50 a large number of agencies come from the associative sector (Petrella et al., 2020).

51 This booming sector is thus opening up new research avenues in the field of in-
52 dustrial engineering and optimization, as illustrated again in Figure 1, highlighting the
53 diversity of these research issues. We can cite, in particular: partitioning of the terri-
54 tory and proper allocation of resources to each district, complying with various criteria
55 (Benzarti et al., 2013); optimization of the admission procedure for new patients com-
56 ing from hospitals to Home Health Care (De Angelis, 1998), (Koeleman et al., 2012);
57 choice and dimensioning of internal resources (Koeleman et al., 2012); flow and in-
58 ventory management (Vissers and Beech, 2005); assignment of the various workers
59 to patients (Lanzarone and Matta, 2012); optimization of workers' routes to patients'
60 homes; study of the impact of new patients' admissions on routes.

61 These problems are scientific issues, characterized by: an inherent uncertainty in
62 the sector (travel time, care duration, evolution of patients' needs, etc.); a wide variety
63 of workers with different skills and constraints (nurse, auxiliary nurse, physiotherapist,
64 etc.); the great importance of the human aspect, which has a direct impact on admission
65 (wishes of the family and patients, etc.), assignment of the care workers (limitation of
66 their number, human compatibility or incompatibility, etc.), the routes (medical and
67 human constraints for schedules); the importance of quality of service (respect for
68 medical constraints, patient preference), which is the primary goal in this sector, even
69 if costs are naturally of great importance.

70 We focus here on the HHC Routing and Scheduling Problem (HHCSP). Solving
71 such problems consists in assigning tasks to staff members of the HHC agency, plan-
72 ning visiting hours for a set of patients, and designing the care workers' routes while
73 respecting regulatory and operational constraints.

74 Some reviews study the existing literature related to the above scientific issues:
75 (Gutiérrez and Vidal, 2013) gives a general overview of logistic problems in the HHC
76 field. Various OR applications are detailed in (Milburn, 2012) and (Sahin and Matta,
77 2015). An overview of the characterization of the different factors inducing complex-

78 ity in the HHC context is given in (Sahin et al., 2013). (Becker et al., 2019), gives
79 an overview of approaches using multiagent systems in order to support planning and
80 scheduling in HHC. They analyze 11 papers, published up to 2017, among which only
81 a very few are considering also routing and are in common with our survey. More
82 recently, (Grieco et al., 2020) reviewed the OR approaches and resolution methods
83 used to address the various decision problems in HHC, through a systematic literature
84 review of peer-reviewed papers published up to the end of September 2018. They ex-
85 tracted information (aim of the study, decisions modeled, planning horizon, modeling
86 approach, solution approach, performance aspects, level of engagement with current
87 practice) from 77 non-review papers (70 journal papers and 7 conferences), with the
88 aim of identifying the decision hierarchies, and the OR approaches used in the litera-
89 ture on HHC, clustering papers according to the addressed decisions, and identifying
90 decisions that have been given insufficient attention in the literature.

91 Other reviews are more focused on the HHC Routing and Scheduling Problem
92 (HHCRSP): Fikar and Hirsch (2017) provided a comprehensive overview of existing
93 works up to 2015 in the field of HHC, focusing on the most common parameters in
94 routing and scheduling problems. In this paper, only journal papers are considered.
95 Later, Cissé et al. (2017) analyzed the literature on OR models applied to HHCRSP
96 (up to 2016) and extended the analysis of Fikar and Hirsch (2017) to other sources of
97 information and other works (like for example delivery of medicine or equipment).

98 Our purpose here is to identify the constraints and objectives specific to routing and
99 scheduling problems in the HHC context, which have given rise to the development of
100 methods or softwares based on Operations Research (OR) and/or Industrial Engineer-
101 ing (IE) tools. We thus carried out a survey and a bibliometric analysis of the literature,
102 available by mid-May 2019, and identified and structured the decision problems and
103 real-life characteristics. We were more particularly interested in comparing analyzed
104 papers regarding, not only the OR methods and tools used but also real-life charac-
105 teristics of the solved problems. Since the considered problem is an important issue,
106 which is increasingly emerging under different publication types, journal papers but
107 also conference publications are considered in this paper.

108 We provide a numerical analysis of the available literature, considering the jour-

109 nals, conferences, countries of the first author or the application, if present, and the
110 keywords used. We also provide comprehensive tables classifying the papers with de-
111 tailed information, especially considering real-life aspects. Finally, we observed that
112 there has been a recent increase in the number of papers taking uncertainties and dy-
113 namic aspects into account. We thus analyzed these papers more thoroughly to provide
114 their relevant features. To the best of our knowledge, to date no survey has focused on
115 this crucial point.

116 Note that, during the peer-review process, we conducted a new search, considering
117 papers available from mid-May 2019 to the beginning of November 2020, in order to
118 also include more recent works in our discussions. This new search led to 39 additional
119 papers of interest, among which 24 were published in 2020, and 26 were published in
120 journals. We cite some of them in our discussions, throughout the paper, in order to
121 illustrate some recent trends, but we did not add them to the Tables.

122 The contributions of this paper are thus as follows:

- 123 • A synthesis of the literature dealing with routing and scheduling in the HHC con-
124 text (numerical analysis and classification of the papers), up to mid-May 2019.

125 This synthesis updates the latest review focused on HHCRSP, (Cissé et al., 2017),
126 with 42 additional journal papers and 33 conference papers. Note that, compared
127 to the very recent review by (Grieco et al., 2020), we can say that we limit our
128 study to HHCRSP problems, which appear in their review to be the problem
129 most studied in the literature (59 papers among the 77 studied by these authors),
130 but we also update and extend their HHCRSP problem study. We achieved this
131 by considering several databases (they limited their search to Web Of Science),
132 and also by taking conferences into account (they only considered journal papers
133 and very limited conferences), which led to 153 non-review papers studied.

- 134 • A set of comprehensive tables classifying the 153 non-review papers and 12
135 reviews, published up to mid-May 2019, with detailed information on the pub-
136 lication, the problem studied, the modeling and resolution approach, the tested
137 instances, the objective functions, the constraints related to visits, patients, and
138 staff members.

139 In comparison to the last major reviews published in the field, (Cissé et al., 2017)
140 and (Grieco et al., 2020), these tables provide a more thorough analysis of the
141 constraints and objectives considered in the papers, focusing on the real-life char-
142 acteristics of the problems studied.

- 143 • Some discussions on current trends in HHC routing and scheduling, observed
144 from the tables and including the analysis of 39 additional papers published be-
145 tween mid-May 2019 and November 2020
- 146 • A focus on the uncertain and dynamic aspects, through a table containing de-
147 tailed information on the kind of uncertainties considered and their modeling,
148 for papers published up to mid-May 2019, but also a discussion including the
149 papers published since then. This subject, which is increasingly attracting the
150 attention of authors, has not yet been considered in a review paper.
- 151 • Future research directions, highlighting the aspects that have increasingly at-
152 tracted the attention of researchers in recent years, and the most promising av-
153 enues that are still open.

154 Such a study will allow new researchers in the field to acquire an overview of
155 the objectives, constraints, and methods used for solving an HHCRSP. They will thus
156 be able to easily position their problem and direct their research towards promising
157 research avenues. As for the decision-makers and planners of HHC agencies, they will
158 easily be able to identify case studies close to their problems, as well as the researchers
159 who studied them.

160 This paper is organized as follows: Section 2 describes the routing and scheduling
161 problem in HHC and identifies some of the main characteristics of the optimization
162 models presented in the reviewed papers. Section 3 specifies the scope of our analysis
163 and describes the research methodology used in this paper. Section 4 provides some
164 general information from the selected papers, while Sections 5 and 6 classify them
165 according to different objective functions and constraints related to real-life problems.
166 Section 7 focuses on the uncertainties and dynamic aspects: a discussion and future
167 research directions are given in Section 8, while Section 9 concludes this paper.

168 **2. Routing and scheduling problem in HHC**

169 *2.1. Description of the problem*

170 In an HHCSR, we consider a set of patients, spread over a given territory, who
171 need care, for different durations, and requiring specific qualifications, at their homes.
172 Such care is provided by care workers, with different skills and availabilities, managed
173 by an HHC agency. An example of such a problem, with one HHC agency providing
174 care to 15 patients is given in the left part of Figure 2. A time window, corresponding to
175 the patient availability, and a number, corresponding to the visit duration, are assigned
176 to each patient. Weights can be assigned to each arc linking two patients. These weights
177 classically correspond to the distance between two patients or the travel cost. These
178 elements are illustrated only on one arc and on one pair of patients to avoid overloading
179 the figure.

180 Usually, care workers start traveling from the HHC agency, using diverse means
181 of transportation (mostly a car, but they can also use public transport, cycle or walk)
182 and return there at the end of their working period. However, in some situations, they
183 can start traveling from their homes, or from the first patient of the day to the last one.
184 The HHCSR consists in deciding which care worker visits which patient, at what
185 time, while respecting a set of various constraints and optimizing some criteria (such
186 as cost or quality of service), over a given horizon. The results are thus a set of routes,
187 indicating the planned visits, as illustrated in the right part of Figure 2, for a case with
188 4 care workers visiting 15 patients.

189 This problem is thus similar to the classical and widely studied Vehicle Routing
190 Problem (VRP) (Dantzig and Ramser, 1959). In this problem, the aim is to determine
191 a set of routes, minimizing the total distance or time traveled by a set of vehicles visit-
192 ing a set of customers spread over different locations. Each customer has to be visited
193 once by one of the vehicles, and the routes all begin and end at a single depot (the HHC
194 agency). Many of the problems considered in this survey can be seen as examples or
195 extensions of VRP, as VRPTW (VRP with Time Windows), in which each customer
196 has to be visited within a given time interval, or other extensions including the multi-
197 ple depot traveling salesman problem with time windows (MDTSPTW), for example.

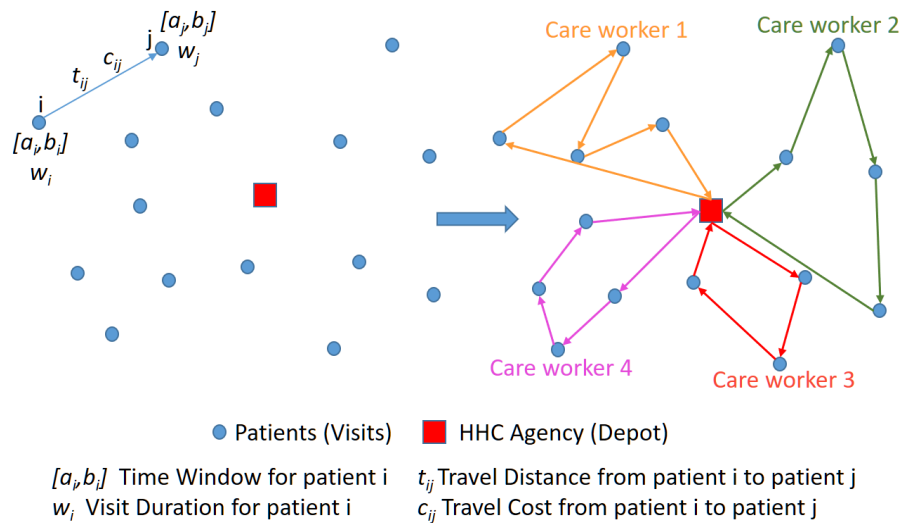


Figure 2: Example of an HHCSR solution with 4 care workers ($K=4$) and 15 patients

198 However, HHCSR involves some specific features that lead to new constraints and
 199 objectives to consider, as we will see in the next section.

200 2.2. Main characteristics encountered in HHCSR

201 The specific features encountered in the HHCSR are the following:

202 *Visits.* A given number of visits must be performed by care workers to the patients’
 203 homes. A visit is a care for a given patient, performed by exactly one care worker
 204 who has the skill corresponding to the needed qualification. A care duration is usually
 205 fixed, but it can depend on the care worker’s skill in some cases. A patient may need
 206 one or more visits during the considered period. When there are multiple visits for the
 207 same patient, we may have some temporal dependencies among the visits, which can
 208 be more complex than the classical precedence constraints. Indeed, as already defined
 209 in (Kergosien et al., 2009) or (Di Mascolo et al., 2014), the dependency between visit
 210 times can be (1) a *disjunction*, meaning that two visits to the same patient should not
 211 overlap, (2) a *synchronization*, meaning that two visits to the same patient have to
 212 start simultaneously or (3) a *precedence*, when several visits have to succeed. This
 213 case is usually defined in three ways: (a) *Exact precedence constraints* i.e. one visit

214 should start immediately at a given time after the end of the other, (b) *Min precedence*
215 *constraints* i.e. one visit should start at least at a given time after the end of the other
216 and (c) *Max precedence constraints* i.e. one visit should start at most at a given time
217 after the end of the other. We may also have to consider a given frequency for the visits
218 (for example a visit every two days) or a pattern (for example a visit every Monday and
219 Wednesday).

220 *Care workers.* Several kinds of care workers are usually considered, with different ar-
221 eas of expertise, as nurses or auxiliary nurses. They are usually represented by different
222 skill levels, and a care worker may only perform tasks corresponding exactly to his/her
223 skill, or a lower skill, in some cases. As already told, all care workers usually begin
224 and end their tour at the Home Health Care Agency, but in some situations, it can be
225 from their homes, or from the first patient of the day to the last one. They can use dif-
226 ferent transportation means, as a car, public transport, bicycle, or walking. Besides the
227 classical Time Windows constraints representing the availability of the care workers,
228 we may have to respect a set of legislative rules (as a lunch break or maximum working
229 time). Finally, in some cases, we can have some incompatibilities between some care
230 workers and some patients (gender, language, allergy, etc.)

231 *Patients.* As in the classical VRP, travel time between patients and between patients
232 and HHC agency is known, sometimes with uncertainties. But in HCCRSP, patients
233 may express preferences for visits regarding, specifically:

- 234 ● a preference on the gender of a care worker may be associated with a visit; it can
235 also be any other preference or incompatibility with some care workers.
- 236 ● a desired availability time window (continuous interval) or a preferred day/time
237 can be associated with a visit.
- 238 ● a continuity of care may be ensured for the patients; this can be a human con-
239 tinuity of care, meaning that, during a period, a given patient always sees the
240 same care worker or a set of preferred care workers, but it can also be a temporal
241 continuity of care, meaning that the patient is always visited at the same time.

242 These characteristics will lead to models with new constraints compared to the
243 classical VRP. However, there are also differences linked with the considered objective
244 functions. Besides the minimizing of the route cost achieved for the VRP, in HHCRSP,
245 we find various other cost objective functions, considering costs related to care work-
246 ers (such as minimizing their waiting time or working time, for example), or prefer-
247 ence objective functions, aiming at maximizing the preferences of care workers (such
248 as workload balance, for example) or the preferences of patients (continuity of care
249 and other expressed preferences). In the next section, we present a basic model for a
250 VRPTW to illustrate the basis of the models used by most of the papers reviewed. We
251 also discuss some specificities encountered in the HHCRSP context.

252 2.3. Basic model for a Vehicle Routing Problem with Time Windows

253 The aim of the VRPTW is to find a set of paths in a network $G = (V, A)$ such that
254 each customer i (*visit in HHCRSP context*) is visited (*performed in HHCRSP context*)
255 exactly once by a vehicle (*care worker in HHCRSP context*) in the time window $[a_i, b_i]$.
256 VRPTW data is as follows (see Figure 2 for an illustration):

257

- 258 • $G = (V, A)$: network where each node $1 \dots n$ represents a customer (*a visit in*
259 *HHCRSP context*) and where two dummy nodes 0 and $n + 1$ have been added to
260 represent the depot (*HCC agency in HHCRSP context*).
- 261 • A time window $[a_i, b_i]$ and a duration of visit w_i is assigned to each node i .
- 262 • Each arc $(i, j) \in A$ represents a possible connection between two customers (*vis-*
263 *its in HHCRSP context*).
- 264 • A distance t_{ij} and a cost c_{ij} are assigned to each arc $(i, j) \in A$. In most papers,
265 this cost corresponds to a travel cost.
- 266 • A set K of vehicles (*care workers in HHCRSP context*).

267 A possible mathematical formulation for this problem is as follows (Cordeau et al.,
268 2000):

$$\min \sum_{k \in K} \sum_{i \in V} \sum_{j \in V} c_{ij} x_{ijk} \quad (1)$$

269 Subject to:

270

$$\sum_{k \in K} \sum_{j: (i,j) \in A} x_{ijk} = 1 \quad \forall i \in V \setminus \{0, n+1\} \quad (2)$$

$$\sum_{j: (0,j) \in A} x_{0jk} = 1 \quad \forall k \in K \quad (3)$$

$$\sum_{i: (i,n+1) \in A} x_{i,n+1,k} = 1 \quad \forall k \in K \quad (4)$$

$$\sum_{i: (i,l) \in A} x_{ilk} = \sum_{j: (l,j) \in A} x_{ljk} \quad \forall l \in V \setminus \{0, n+1\} \quad \forall k \in K \quad (5)$$

$$x_{ijk}(s_{ik} + w_i + t_{ij} - s_{jk}) \leq 0 \quad \forall (i,j) \in A \quad \forall k \in K \quad (6)$$

$$a_i \leq s_{ik} \leq b_i \quad \forall i \in V \quad \forall k \in K \quad (7)$$

$$x_{ijk} \in \{0, 1\} \quad \forall (i,j) \in A \quad \forall k \in K \quad (8)$$

$$s_{ik} \geq 0 \quad \forall i \in V \quad \forall k \in K \quad (9)$$

271 With

272 • $x_{ijk} = 1$ if the arc (i, j) is used by the vehicle k (*care worker k in HHCRSP*
273 *context*) and 0 otherwise

274 • s_{ik} is the start time of the visit for customer i (*patient i in HHCRSP context*) when
275 this customer is visited by vehicle k (*care worker k in HHCRSP context*)

276 Constraints (2) guarantee that all customers are visited exactly by one vehicle (*all visits*
277 *are performed exactly once by a care worker in HHCRSP context*)

278 Constraints (3) and (4) ensure that all paths start and finish at the depot (*HCC agency*
279 *in HHCRSP context*).

280 Constraints (5) are flow conservation constraints.

281 Constraints (6) and (7) ensure scheduling feasibility.

282 Constraints (8) impose binary conditions for the flow variables

283 and constraints (9) impose positive conditions for the scheduling variables.

284

285 Note that constraints (6) can be linearized as:

$$s_{ik} + w_i + t_{ij} - M(1 - x_{ijk}) \leq s_{jk} \quad \forall (i, j) \in A, \forall k \in K \quad (10)$$

286 with M being a big number.

287

288 As mentioned before, in order to model the HHCRSP, several specific constraints
289 must be added. A specificity to be taken into account for the visit, is that there are
290 different types of precedence constraints. For example, in (Bredström and Rönnqvist,
291 2008), authors propose to introduce an offset variable o_{ij} to model two types of tempo-
292 ral constraints: precedence and disjunction, leading to the following constraints:

$$\sum_{k \in K} s_{ik} \leq o_{ij} + \sum_{k \in K} s_{jk} \quad \forall (i, j) \in V^{Prec} \quad (11)$$

293 with V^{Prec} being the set of couples (i, j) of visits linked with precedence constraints.

294

295 If $o_{ij} = -w_i$, constraint (11) ensures a disjunction between visits i and j .

296

297 In the HHCRSP context, it occurs that two care workers are needed for a visit, as
298 getting a heavy person out of bed, for example. This situation can be modeled by two
299 visits i and j linked by a precedence constraint. If the care worker can perform the visit
300 j at any time during the visit i , this situation can be modeled by two constraints (11),
301 one with $o_{ij} = 0$ and one with $o_{ij} = w_i$. For the continuity of care, several models are
302 proposed in the literature. In (Nickel et al., 2012) the notion of patient-nurse loyalty

303 is introduced. This loyalty represents the number of different care workers that are
304 allowed to perform visits for a patient, and the authors propose to take into account
305 this loyalty in the objective function. In (Yalçındag et al., 2016a), to take into account
306 continuity of care, assignment variables and constraints are introduced.

307

308 Note that, in the remainder of the paper, we consider not only Home Health Care
309 problems, as defined above, but we extend our analysis to Home Care or Home Ser-
310 vice problems, including also non-medical services aiming at helping elderly and more
311 generally fragile people carry out their daily activities, such as housekeeping, meal
312 preparation, bathing, etc. The reason for that is that Home Care and Home Service
313 agencies face routing and scheduling problems that are similar to those encountered
314 in HHC agencies, the main difference relating to the data. Therefore, in the remain-
315 der of the paper, we will use the term "staff member" instead of "care worker", and
316 "visit" instead of "care" or "service", but continue to use the term "patients", even for
317 "beneficiaries" of Home Services.

318 **3. Delimitation and methodology**

319 The process of collecting and selecting analyzed papers performed to define our
320 paper database is described step by step in Figure 3. First, we define a list of relevant
321 keywords used for the database search. Different possibilities of "Keywords Combi-
322 nations" are tested over the four databases classically used in the area of OR and IE,
323 namely Scopus, Web Of Science (WOS), Google Scholar, and ScienceDirect. The
324 keywords are relatively generic to avoid missing any relevant papers. The keywords
325 combinations considered in our search are the following:

326 (Home care AND Routing) OR

327 (Home care AND Scheduling) OR

328 (Home health AND Routing) OR

329 (Home health AND Scheduling) OR

330 (Home service AND Routing) OR

331 (Home service AND Scheduling) OR

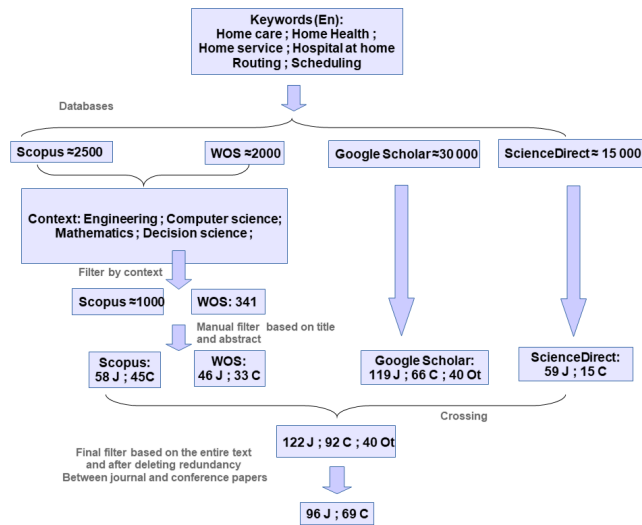


Figure 3: Bibliography research scheme

332 (Hospital at home AND Routing) OR

333 (Hospital at home AND Scheduling).

334 The initial search did not use any limitation and resulted in a large number of pa-
 335 pers in English for each database, that is why a first limitation by context (engineering,
 336 computer science, mathematics and decision science) is introduced for the first two
 337 databases. Note that context limitation is not available for Google Scholar and Sci-
 338 enceDirect databases, thus all resulted papers were browsed one by one and selected
 339 by reviewing the title, keywords, and abstract. This is also the case for the second filter
 340 applied to the other databases after the context filter.

341 Then, the resulted papers were crossed and 3 categories were distinguished, namely:
 342 journal papers (J), conference papers (C), and others (Ot) including book chapters,
 343 technical reports, and Ph.D. thesis. We decided to keep only journal and conference
 344 papers, and all of the promising papers were then analyzed using a full-text review.
 345 To consider a paper as relevant, several criteria must be met.

346 The first criterion is a focus on HHC i.e. the purpose and objectives must explic-
 347 itly address HHC concerns. Indeed, we restrict our survey to problems in which staff
 348 members deliver cares or services to patients, and thus spend some time at each home;

349 this leads to the exclusion of some papers considering routing for pickup and delivery
350 problems in HC agencies, such as (Liu et al., 2013), or (Shi et al., 2018), for example,
351 which are taken into account in (Cissé et al., 2017) and (Grieco et al., 2020).

352 The second criterion focuses on papers that address routing and scheduling prob-
353 lems within an HHC context. This leads to the exclusion of some papers talking about
354 HHC as a potential application, among others, of a generic routing and scheduling
355 problem they are solving, such as (Parragh and Doerner, 2018) for example, but also
356 the exclusion of some papers dealing with problems in the context of HHC, but consid-
357 ering mainly resource dimensioning, such as (Regis-Hernández et al., 2019), or only
358 assignment, such as (Nasir et al., 2018).

359 The last criterion is redundancy, i.e. conference papers that have been published in
360 a journal paper later are ignored. To be more accurate, we found 21 such redundant
361 conference papers, which are only considered when studying the general characteris-
362 tics, in section 4, and are omitted in the tables.

363 We eventually end up with 96 journal papers (J) and 69 conference papers (C) to
364 analyze, i.e. 165 papers, from 1997 to mid-May 2019. More specifically, the 96 journal
365 papers include 6 review papers (representing 6%), the 69 conference papers include 6
366 review papers (representing 9%) which leads to 90 journal papers and 63 conference
367 papers (i.e. 153 papers which are not review papers).

368 All conferences not being present in the used databases, we cannot guarantee to
369 have an exhaustive view of the conference papers, however by listing the conference
370 papers, our objective was to highlight the latest trends. Note that the list of papers
371 obtained using this methodology includes all the papers studied in (Cissé et al., 2017)
372 and (Grieco et al., 2020), and which are within our scope.

373 We analyzed all these papers in order to extract information of interest. The fol-
374 lowing sections show this content analysis by using tables, which present quantitative
375 outcomes resulting from the reviewed papers related to HHC routing and scheduling
376 literature.

377 All the tables can be found at the end of this paper. We chose to separate tables
378 dealing with journal papers from tables dealing with conference papers, however, the
379 tables dedicated to conference papers also include global sums and proportions, ob-

380 tained considering all the 153 papers (or 165 when considering the type of paper in
381 Table 4), thus ignoring if they come from journals or conferences.

382 In all the tables, when a paper tackles one of the mentioned characteristics, a sym-
383 bol (\checkmark) is displayed in the corresponding cell, and the total number of papers consid-
384 ering each characteristic and each subgroup (sum), and their proportion (%), are given.
385 Note that the proportion is calculated considering 91 journal papers and 63 conference
386 papers, except for the type of paper, for which we took into account also the reviews,
387 considering thus 96 journal papers and 69 conference papers. In these tables, we added
388 some sub-sums and sub-proportions, calculated for subsets of characteristics, by count-
389 ing the papers that show at least one of the characteristics present within the set: if we
390 take Table 6 as an example, the sub sum "SM cost" considers all the papers having
391 at least one \checkmark in columns "min total visit duration", or "min waiting time", or "min
392 overtime", or an "SMi" in the column "others".

393 In each of the following sections, we study and comment on the content of these
394 tables. However, in order to reach a more general conclusion than the one obtained
395 examining the tables one by one, we also conducted a complete study of the obtained
396 values, by crossing the tables. We especially observed more closely the common char-
397 acteristics between the papers presenting case studies on the one hand, and more theo-
398 retical papers on the other hand. We also observed the evolution of some characteristics
399 of the problems over the years.

400 **4. General characteristics - Tables 2 to 5**

401 This section is devoted to the presentation of the content analysis enabling us to
402 extract some general characteristics about the publication (year, journal, authors, key-
403 words), the studied problem, the proposed tools, and solutions. We thus propose a
404 quantitative evaluation of the general characteristics of the papers, based on the de-
405 tailed information about the publications (references, journal or conference title, the
406 affiliation of the first author, country for the application), the studied problem (the type
407 of study -case study or review, the other being more theoretical papers-, horizon, pres-
408 ence of uncertainties in the studied problem), the modeling and resolution approaches,

409 and the instances used for numerical tests, displayed in Tables 2 and 3, for journal pa-
410 pers, and Tables 4 and 5 for conference papers. In Section 4.1 we also considered the
411 21 redundant conference papers, which are not reported in the tables.

412 4.1. Information about the publication

413 *Evolution of the number of publications over the years.* Analyzing the journal papers'
414 publication year, we found that the first publication about routing and scheduling in
415 HHC appeared in 1997, with the work of Begur et al. (1997), but there are few papers
416 up to 2011 (zero, one or two per year). Since then, the increase in the number of papers
417 addressing HHC routing and scheduling is significant, especially in recent years (see
418 Figure 4): we found 17 journal papers in 2018, representing an increase of 76.5%
419 compared to the 4 papers published in 2011. Note that, for the first 4 months of 2019,
420 there are already 15 papers, which shows that the number of papers is still significantly
421 rising.

422 If we analyze now the conference papers (see Figure 5, where the redundant con-
423 ference papers are represented in a lighter color), we observe that the first publication
424 appeared later (in 2006), and their number increased, since then, but less regularly than
425 for journal papers.

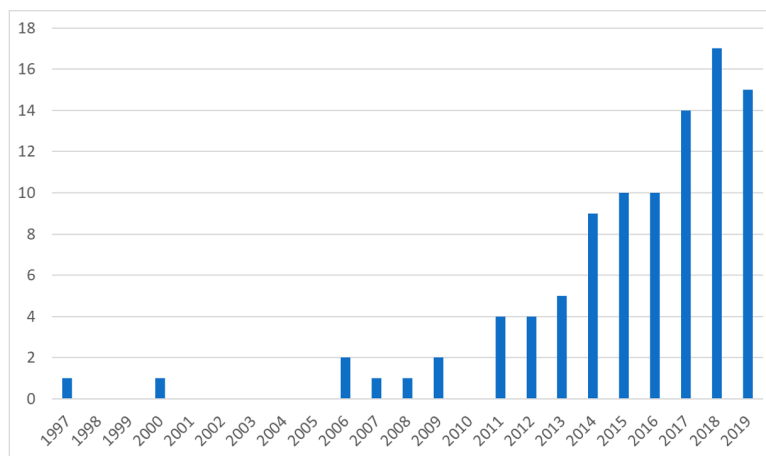


Figure 4: Evolution of published journal papers over the years (only up to mid-May for 2019)

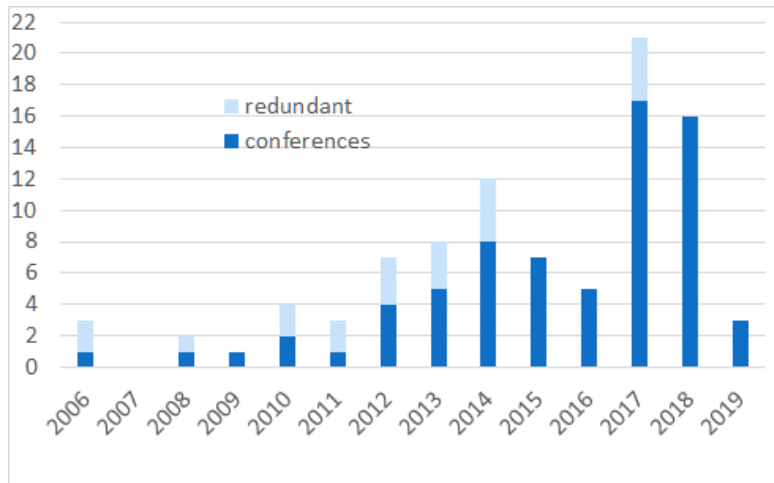


Figure 5: Evolution of conference papers over the years (only up to mid-May for 2019)

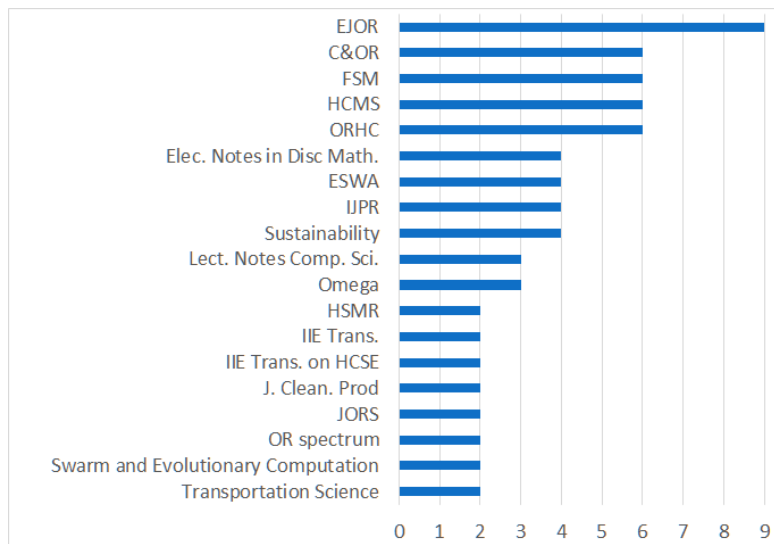


Figure 6: Journals with at least 2 publications

426 *Most common journals/conferences.* The problem of routing and scheduling in HHC
 427 has received a lot of interest and has been presented in several journals, and several
 428 national and international conferences around the world.

429 Figure 6 shows the 19 journals with at least 2 publications in the HHC context.
 430 We can note that the journals with the highest number of publications are in the fields

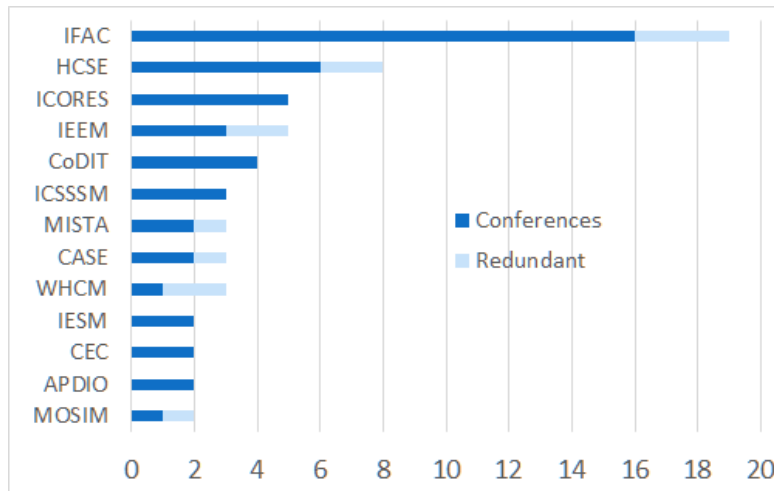


Figure 7: Conferences with at least 2 publications

431 of Operations Research, Manufacturing and Production Research, Computer Science,
 432 Mathematics, or more focused on Health Care. In addition to these 19 journals, there
 433 are 26 other journals, dealing with various subjects, which received only one publica-
 434 tion.

435 Figure 7 shows that, among the 14 conferences with at least 2 publications, most
 436 conference papers are published in the fields of Automatic Control, Health Care En-
 437 gineering and Management, Operations Research, Industrial Engineering, Engineering
 438 Management, Decision, or Scheduling. Here again, we observe a great diversity of
 439 topics and conferences, most of them (29) receiving only one publication in the HHC
 440 context.

441 *Most commonly mentioned keywords.* We are interested here in the main topics in the
 442 field of HHC routing and scheduling based on selected authors' keywords of reviewed
 443 journal and conference papers. We found a total of 244 different keywords, most of
 444 them (160) appearing only once. Only a very few of them appear 10 times or more
 445 (9). They are rather general keywords concerning the studied problem (home health
 446 care or home healthcare, home care, scheduling, routing, vehicle routing, optimization,
 447 routing, and scheduling) and the general methods used (metaheuristics, heuristics). If

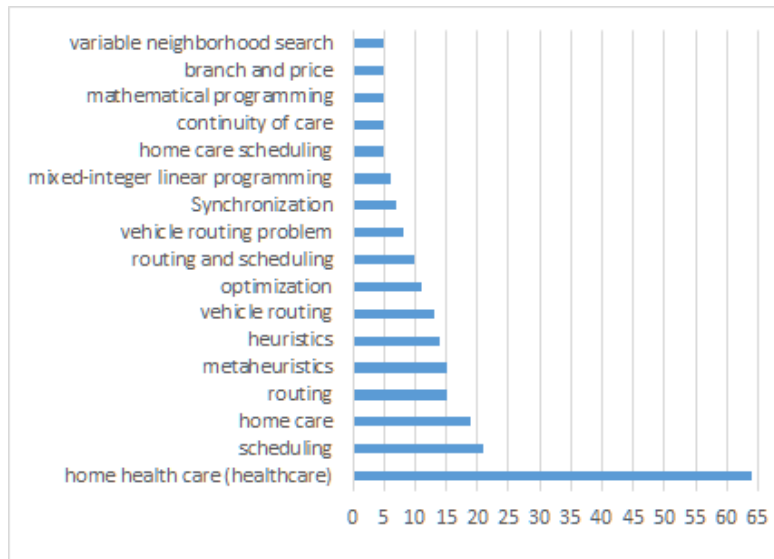


Figure 8: Most common keywords

448 we consider now the 8 keywords appearing between 5 and 9 times, we observe some
 449 general variants of the studied problem (vehicle routing problem, home care schedul-
 450 ing), some methods (mixed integer linear programming, mathematical programming,
 451 branch and price, variable neighborhood search), but also some characteristics of the
 452 problem (synchronization, continuity of care). Figure 8 shows the keywords that were
 453 found more than five times in journals and conferences papers.

454 *Country of authors' affiliation and application.* We discuss here the country of affili-
 455 ation of the first authors, as well as the country of application for case studies related
 456 to HHC. Figure 9 shows that the HHC problem concerns the entire world (30 different
 457 countries), and mainly Europe, China, and the USA. We can notice that most journal
 458 papers are written by first authors coming from France (15), China (11), Austria (10),
 459 Italy (8), USA (8), Germany (7), and UK (7) (for the countries having 5 or more publi-
 460 cations), and mostly contain applications from Austria (5), Italy (5), China (4), France
 461 (3) and USA (3).

462 For publications in conferences, most papers come from France (30), Portugal (8)
 463 and Italy (7), with, again, an interest from the entire world (20 different countries,

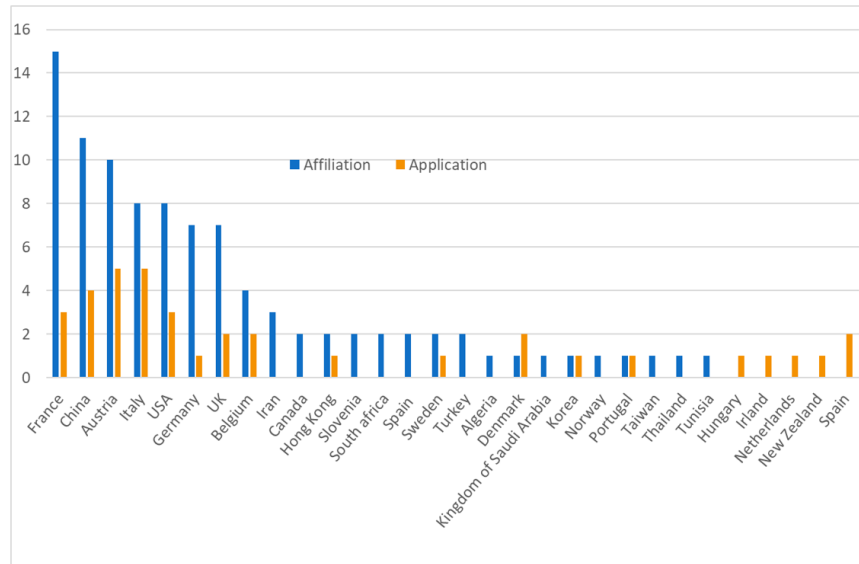


Figure 9: Analysis of authors affiliation and/or country of application for journal papers

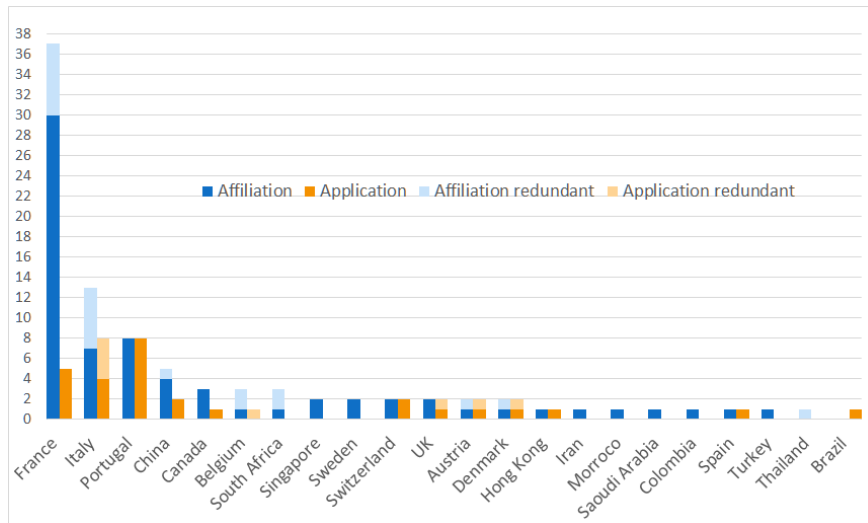


Figure 10: Analysis of authors affiliation and/or country of application for conference papers (redundant papers are lighter)

464 many of which (11) having only 1 communication). Note that new countries appear,
 465 compared to those observed in journals, such as Switzerland, Colombia, Morocco etc.

466 4.2. Studied problems

467 *Work methodology.* From Tables 2 and 4, about 6% of the analyzed journal papers and
468 9% of the conference papers are literature reviews, whereas 39% of the journal papers
469 and conference papers are dealing with case studies: a paper is classified as a case
470 study if the problem is tested on real-life instances provided by an HHC agency. We
471 can note that half of the case studies have been published in the last 4 years.

472 Hence, the problem is a topical problem for both researchers and health profession-
473 als.

474 *Planning horizon.* In HHC, the planning can be carried out on a short term (one day
475 or less) or a long term horizon (more than one day, usually one week, for most of the
476 papers, but sometimes several weeks). Table ?? shows that, as far as journal papers are
477 concerned, there is slightly the same number of studies dealing with the short horizon
478 (52%) or the long horizon (48%), whereas, for conferences, we observe that the papers
479 dealing with the short-term horizon are more numerous (65%). Note that, when we
480 focus on the papers published since the last review, we observe that there have been
481 more papers considering a long term horizon.

482 Note also that, when we focus on the case studies, we observe that most studied
483 problems are dealing with a long term horizon, especially since 2017, which is coherent
484 since, in real life, patients need more than one visit.

485 *Uncertainties and dynamic aspects.* The majority of analyzed papers (72%) are deal-
486 ing with static cases. However, since 2014, stochastic and dynamic aspects are more
487 and more present in the research in the HHC field (note that more than half of the pa-
488 pers dealing with uncertainties and dynamic aspects have been published since 2017,
489 in journals as well as in conferences, and represent around 40% of the papers published
490 since then). That is why we are focusing on this aspect in Section 7.

491 4.3. Proposed approaches and experimentations

492 *Proposed solution methods.* Tables 3 and 5, presenting detailed proposed solution
493 methods, show that a wide variety of methods has been developed. These methods,

494 which are often used for Vehicle Routing Problems (VRP) or Workforce Schedul-
495 ing and Routing Problems (WSRP), in general, can be exact methods (as Branch and
496 Bound or Branch and price, for example) or approximation ones, including dedicated
497 heuristics, or a large panel of metaheuristics (ranging from Tabu Search to population-
498 based methods as Particle Swarm Optimization, for example, or, more recently, Ant
499 Colony Optimization), or methods based on linear programming (like matheuristics
500 for example), or hybrid methods, combining several methods (like Constraint program-
501 ming and Tabu Search, for example).

502 Note that most papers propose a linear model and often test it using linear solvers
503 such as Cplex, and, as far as conferences are concerned, there are many cases for which
504 only a mathematical model is proposed (20 conference papers out of 63), metaheuris-
505 tics being often proposed in other cases.

506 We can also observe that, globally, methods proposed before 2014 were more often
507 based on greedy heuristics and local search procedures. However, since, 2015/2016
508 more advanced methods, such as benders decomposition or hybrid methods, are in-
509 creasingly being considered. We also note that, for case studies, two-phase resolution
510 methods are widely used for their simplicity and facility of adaptation for most combi-
511 natorial problems such as the case of HHC routing and scheduling.

512 In the latest published papers, we notice a growing interest for modified Ant Colony
513 Optimization algorithms (Decerle et al., 2019a; Euchi, 2020; Martin et al., 2020; Inanç
514 and Şenaras, 2020). In (Fathollahi-Fard et al., 2020), the Social Engineering Optimiza-
515 tion is applied to solve the HHCRSP for the first time, according to its authors.

516 *Tested instances.* Used instances are also an important point and show the problem
517 consideration in real life. The instances can be benchmarks that already exist in the lit-
518 erature, either for general VRP problems, like (Solomon, 1987), or for HHC scheduling
519 problem, like (Bredström and Rönnqvist, 2008), or random instances generated by the
520 authors (sometimes based on real data), or real-life instances provided by HHC agen-
521 cies (case studies). We notice that only a few works (20%), almost all of them consid-
522 ering daily planning, use instances from the literature and that almost every author uses
523 his/her own instance. These instances are most often randomly generated ones (58%)

524 rather than real instances from HHC agencies.

525 Finally, for the papers where it was explicitly specified, the size of the used in-
526 stances was also retrieved in the tables. The considered size varies a lot from one paper
527 to another. We can note that the instance sizes are usually larger when considering case
528 studies or journal papers, rather than theoretical cases, or conference papers.

529 After this global description of the papers, we now focus on the detailed charac-
530 teristics of studied problems in the analyzed papers, namely the objective function and
531 the considered constraints.

532 **5. Objective function - Tables 6 and 7**

533 We identified around 30 different criteria that we divided into two categories, namely
534 costs and preference. For each category, we have sub-categories (Route, Staff Mem-
535 bers, Patients) and the columns of tables 6 and 7 show the criteria appearing at least
536 three times. The criteria appearing only once or twice are listed in columns named
537 "Other" and are named SM, if they refer to Staff Members, C, if they refer to Cost in
538 general, Pa, if they refer to Patients (details are given at the bottom of table 7). Note
539 that, recently, a few additional criteria which are neither cost, nor preference criteria,
540 appeared; they are linked with disruptions - minimize response time to disruptions (Du
541 et al., 2017b)-, clustering - minimize total number of clusters (Quintana et al., 2017),
542 or maximize clustering efficiency (Mutingi and Mbohwa, 2014) -, or environmental
543 pollution (Fathollahi-Fard et al., 2018a), and appear each only once. They are named
544 O in the tables.

545

546 The research conducted on articles published after May 2019 showed that sustain-
547 ability is getting more attention lately (Ros-McDonnell et al., 2019; Quintanilla et al.,
548 2020). In (Cinar et al., 2019), a new criterion is studied: they maximize the global
549 priority of the visited patients, who are ranked depending on then their condition, their
550 dependency and the last time they were visited.

551

552 In the tables, the sub-sums and sub-percentages for patients and staff members are

553 calculated by including the criteria SM or Pa appearing once or twice and placed in
554 columns "Other".

555 *5.1. Cost optimization*

556 We identified more than 10 different cost optimization criteria (see tables 6 and 7),
557 and observed that 90% of the studied papers consider at least one cost criterion. We
558 summarized below the most frequently considered ones:

- 559 • **Route costs (77%)**

- 560 minimize travel time/cost/distance (76%)

- 561 • **Staff member cost (42%)**

- 562 minimize overtime costs (15%)

- 563 minimize visit duration/working time (14%)

- 564 minimize waiting times (13%)

565 We observe that the minimization of travel costs, distances or travel times is con-
566 sidered by almost all the authors, whether in journal or conference papers, which is not
567 surprising since it is a standard criterion for the VRP problem and also a real concern
568 for HHC agencies. However, there are also several papers considering costs related
569 to staff members, which are more specific to HHC routing and scheduling problems.
570 Note that journal papers mostly consider the minimization of overtime cost, whereas
571 conference papers deal mostly with the minimization of visit duration/working time.

572 *5.2. Optimization of the quality of service and well-being at work*

573 Preference criteria are a very important point in improving quality of service and
574 well-being at work for HHC agencies but are less present than cost criteria (58% of the
575 studied papers consider at least one preference criterion). They can be divided into two
576 types, namely patient and staff member preferences. We summarize below the most
577 used preference criteria, among the identified ones (more than 15 different ones):

- 578 • **Patient preferences (48%)**

579 maximize patient preferences (16%)

580 minimize TW violation (12%)

581 minimize uncovered visits (11%)

582 maximize continuity of care (10%)

583 • **Staff member preferences (19%)**

584 balance workload (17%)

585 As far as patient preference is considered, most journal contributions consider the
586 minimization of uncovered visits, which is not present at all in conferences. Note that,
587 when this objective function is not present, it means that we have a constraint ensuring
588 that all the visits are covered. Another important criterion for both journal and confer-
589 ence papers is the maximization of patient preferences, related to the appreciation level
590 of the assigned staff member. Generally, a patient assigns a score to each staff member,
591 and this last is strongly desired if he/she has a high preference score. Criteria related
592 to the minimization of non-respect of soft time windows are also considered in many
593 papers.

594 Note that the continuity of care, which is very important in real life, has known less
595 interest in the literature when considering both criteria and constraints (as seen also in
596 section 6). This criterion often results in assigning the same staff member to a patient,
597 or, otherwise, minimizing the number of different staff members over the horizon, and
598 usually complicates a lot the problem. Finally, we can note that some criteria appear
599 only once or twice, and especially in recent conference papers.

600 The second preference category concerns the staff members and is mainly measured
601 by balancing the workload. A few papers also consider the clustering efficiency, which
602 could be found as avoiding the assignment of staff members far from their area, or the
603 region priority, which means that a staff member has a preference for working in some
604 zones, and the model should maximize this preference.

605 *5.3. Discussion on the objective function*

606 *Criteria.* Since almost all the analyzed papers model the problem of routing and schedul-
607 ing in the HHC context as an extension of the VRP, travel criteria are almost always

608 considered. However, most of the papers consider a multiple-criteria objective (almost
609 all from 2 to 4, one journal paper considering 7 criteria, one conference paper consid-
610 ering 5 criteria, and one conference paper considering 7 criteria). Note that 34% of the
611 studied papers consider only one criterion (which is cost, for 81% of the cases with
612 only one criterion, 35% of the papers consider 2 criteria, 19% consider 3 criteria, and
613 12% consider 4 criteria. Note also that in many cases (55%), the objective functions
614 include both cost and preference criteria, but there are many studies considering only
615 cost criteria (37%) or only preference criteria (8%).

616 *Multi-objective function vs mono-objective function.* As seen above, most papers (66%)
617 consider at least 2 criteria in their objective function, which is usually expressed as a
618 weighted sum of several criteria. It is only from 2015 that we can find some papers con-
619 sidering several objectives, without aggregating them, and using thus multi-objective
620 resolution methods. For the short-term planning, we can cite (Ait Haddadene et al.,
621 2016b) and (Braekers et al., 2016) who have studied the trade-off between minimiz-
622 ing travel costs and maximizing the preference of patients in home care agencies, by
623 proposing methods based on the ϵ -constraint approach and enumerating the Pareto
624 Frontier, or, more recently, (Decerle et al., 2019b), who used a memetic algorithm to
625 obtain the Pareto front for three objective functions: minimizing the total working time
626 of the staff members, maximizing the quality of service, and minimizing the maximal
627 working time difference among nurses and auxiliary nurses. For multiple period cases,
628 we can cite (Rodriguez et al., 2015) who have studied the trade-off between minimizing
629 travel costs and maximizing the staff members workload, by proposing an approximate
630 Pareto frontier, or (Liu et al., 2018), who generated approximate Pareto fronts with
631 three heuristics approaches in order to find a trade-off between cost and preference
632 criteria.

633 *Evolution through the years.* Now, if we observe the evolution of the studied criteria
634 through the years, we note a growing diversity of criteria over the years, and especially
635 since 2017. The very clearly dominant criterion remains, all over the years, the classic
636 objective function used for a VRP: Min travel time/cost/distance, but the proportion
637 of papers considering this criterion has slightly decreased since 2017. The second

638 one is patient's preference, which has known a very significant increase since 2017,
639 especially as far as journals are considered. For conferences, we also observe that
640 the staff member cost is considered in many papers since 2010. More generally, we
641 can say that preference criteria, although not insignificant since 2006, and increasing
642 since 2017, are still clearly dominated by the cost criteria. Moreover, more recently,
643 as already mentioned above, we also observe some criteria which are neither cost nor
644 preference but are linked to environmental considerations, clustering or disruptions.

645 *Case studies vs theoretical papers.* If we compare the criteria used for case studies
646 and those used for more theoretical papers, table 1 shows no specific particularity.
647 We can however note that the criteria "max continuity of care" or "min reassignment"
648 are studied in only 4% and 2% of the theoretical journal papers, whereas we can find
649 them respectively in 13% and 8% of the case studies. The criteria concerning patient
650 preference are studied in a larger proportion of papers, whether case studies or the-
651 oretical studies (47% and 36% respectively) than staff member preference (19% and
652 21% respectively). In general, a greater proportion of papers are concerned with cost
653 optimization compared to the optimization of preference criteria, but the proportion
654 of papers that focus on preference criteria is far from being negligible, for theoretical
655 papers (58%) or case studies (43%). In conference papers, we observe that, in the case
656 studies, a significant proportion of papers (22%) optimize the criterion Max continuity
657 of care, whereas only 5% of theoretical papers consider this criterion, which corrob-
658 orates what has been observed for journals; finally, we note that authors give more
659 attention to the patient and staff member preference in case studies (41% and 33%)
660 than in theoretical papers (35% and 14%).

661 **6. Constraints - Tables 8 to 13**

662 We now present the various constraints considered in the analyzed papers, that we
663 have chosen to divide into three categories: those related to visits, those related to
664 patients, and those related to staff members. Each category of constraints is presented
665 in a separate table. Note that in the following, we summarize the most considered

Table 1: Criteria comparison between real cases and theoretical papers (percentages of each subgroup)

Objective function	Journal papers		Conference papers	
	Case Study	Theory	Case Study	Theory
Route costs	79%	75%	70%	78%
Staff member costs	39%	43%	33%	27%
COSTS	79%	66%	89%	92%
Patients preference	47%	36%	41%	35%
Staff members preference	19%	21%	33%	14%
PREFERENCES	58%	43%	63%	49%

666 constraints, indicating the proportion of papers containing at least one constraint of the
 667 considered type.

668 6.1. Constraints related to visits - Tables 8 and 9

669 These constraints are present in 90% of the studied papers and are split into three
 670 categories, namely general characteristics, schedule, and dependency. General charac-
 671 teristics mainly include time windows, which can be hard, or related to the production
 672 of a certain product (as for chemotherapy at home); required qualification level, which
 673 is an important feature. The schedule can be defined by the number of required visits
 674 per day, or over the planning horizon, and this by assigning a frequency to each visit, or
 675 by a combination of desired visit days named patterns, for example (Monday, Thurs-
 676 day) in a case where two visits are desired. The dependency between visit times can be
 677 disjunction, synchronization, exact precedence, or min/max precedence, as explained
 678 in section 2.2. Finally, some other criteria, appearing only once or twice, are listed in
 679 the column named "others".

680 Thus, from Tables 8 and 9, whose information is summarized below for the most
 681 used constraints, it is clear that most considered constraints are time windows (includ-
 682 ing hard time windows (66%)), followed by the qualification required. However, con-
 683 straints related to the dependency and/or the frequency of visits are of less interest but
 684 remain significant in the HHC context. Papers published very recently both in journals
 685 and conferences confirm this trend (Euchi et al., 2020; Hashemi Doulabi et al., 2020;
 686 Nozir et al., 2020; Shahnejat-Bushehri et al., 2019).

687 • **Temporal constraints (71%)**

688 Time windows (69%)

689 Dependency (25%)

690 • **Assignment constraints (73%)**

691 Qualification required (58%)

692 Schedule (33%)

693 *6.2. Constraints related to Patients - Tables 10 and 11*

694 These constraints are less considered in the literature (46%) than those related to
695 visits (90%) or staff members (82%) and are relatively recent. Temporal constraints are
696 very varied but often considered as soft constraints; we can mention precisely soft time
697 windows -representing time windows which are preferred by the patients for receiving
698 some cares-, preferred starting time, or preferred day of visits, etc. They are not often
699 taken into account, but it can be seen that these constraints are more present since 2014,
700 so it is highly probable that they will be widely studied in the years to come.

701 Continuity of care is defined by assigning, for example, the same staff member
702 throughout the period, or visiting the patient at the same hour each time. Even though
703 these constraints are very important in improving the service quality of HHC agencies,
704 they have rarely been taken into consideration by research and also in real life before
705 2014, but have been knowing a growing interest, especially since 2018. Continuity of
706 care is most often taken into account by assigning the same staff member throughout
707 the period, especially in journal papers, but we also observe other ways to deal with
708 continuity of care, as assigning the same time slot to visits, or a preferred staff member,
709 or pre-assigning a staff member, or, more recently, considering loyalty to a staff mem-
710 ber. Note that when we consider both objective function and constraints, we observe
711 that 31% of the 153 studied papers deal with continuity of care, either as an objective
712 function, or as a constraint, or both.

713

714 In our last bibliographic update (from mid-May 2019 onwards), we did not find any
715 significant changes in the trends regarding constraint related to patients.

716 • **Temporal constraints (25%)**

717 Soft time windows (13%)

718 • **Assignment constraints (29%)**

719 Continuity of care (29%)

720 *6.3. Constraints related to Staff members - Tables 12 and 13*

721 Staff member constraints are present in 82% of the studied papers and can be di-
722 vided into several categories, namely characteristics (including skill level and availabil-
723 ity - which includes hard time windows, common in journal and conference papers, but
724 also soft time windows or soft breaks), rules (which are mostly the legislative rules,
725 according to the number of working hours per day and per week, lunch breaks... Other
726 rules can be listed, as additional work, related for example to the meetings in the HHC
727 agency, but they are very rarely considered), district/region, incompatibility with a pa-
728 tient (when for example a patient requires a gender (male/female) or the staff member
729 can refuse a visit if for example he/she has allergies for some animals which can be
730 present at the patient's home), and transport. Some transportation mode constraints
731 have appeared in some journal papers. In fact, the most often used transportation mode
732 is a personal vehicle, nevertheless, some authors have been interested in using pub-
733 lic transport, such as Rest and Hirsch (2016), or sharing vehicles, or walk, such as
734 Fikar and Hirsch (2015), or, for a few of them, considering multi-modal transportation,
735 by combining two or more transportation modes, such as Hiermann et al. (2015), who
736 combine public transport and car. In (Quintanilla et al., 2020), doctors and nurses share
737 taxis and travel together. New strategies of transportation are studied, such as walking
738 and changing during the route the sets of workers who travel together.

739

740 The most often encountered constraints are the following:

741 • **Temporal constraints (58%)**

742 Hard time window (48%)

743 • **Assignment constraints (55%)**

744 Skill level (55%)

745 • **Rules (49%)**

746 Legislative rules(39%)

747 • **District region (13%)**

748 6.4. Discussion on the constraints

749 We observe that the studied problems often deal with generic constraints usually
750 considered in VRP, and illustrated in section 2.3, such as time windows, dependencies
751 between visits, skill level, in journal papers, as well as in conference papers. Some
752 of these characteristics are less present for case studies, as time dependencies. Note
753 also that, for case studies, we find more constraints about visit frequency as well as
754 legislative rules, types of used vehicles, and continuity of care.

755

756 If we consider now the evolution of the constraints through the years, we observe
757 that, for journal papers, the proportions have been slightly the same since 2017, except
758 for the continuity of care, which increased significantly. For conference papers, we
759 observe also a decrease for constraints considering precedence.

760 7. Focus on the uncertainties and dynamic aspects - Table 14

761 7.1. Motivation

762 In most of the above-mentioned papers (72%), all parameters are assumed to be
763 known in advance, whether it is travel times, visit times, patients' availabilities, etc.
764 However, in practice, it is highly unlikely to conduct the planned schedule through-
765 out the whole horizon without any disruption. In HHC, the data is subject to a high
766 variability due to the inherent uncertainties of the area, which often lead the original
767 schedules to be unfeasible. Since the human factor is predominant in this domain, some
768 constraints make it impossible to simply cancel impacted tours, or recompute optimal
769 tours whenever a new event occurs. Therefore, it is obvious that the deterministic prob-
770 lem is not entirely suited to real-life unpredictabilities.

771 Furthermore, HHC agencies constantly face staff turnover or changes in the pool of
772 patients. In this case, again, recomputing optimal tours with the new data might not
773 be completely satisfying due to continuity constraints: they need to deal with a re-
774 planning problem. Whether on a strategic, tactical, or operational level, considering
775 uncertainties and dynamic aspects appears to be necessary to offer practical solutions
776 to the home health care routing and scheduling problem.

777

778 We examined and classified 37 papers, including 25 journal papers and 12 con-
779 ference papers among the 43 papers showing an interest in uncertainties or dynamic
780 aspects. We chose to ignore the papers dealing with uncertainties not related to deliv-
781 ery of cares, such that fuzzy demands in papers where a pick-up and delivery problem
782 is jointly addressed with the scheduling and routing problem. It led to the exclusion
783 of (Shi et al., 2017a), (Shi et al., 2017c), (Tohidifard et al., 2018) for example. We
784 also eliminated some papers, such as (Carello et al., 2018) and (Yuan et al., 2014),
785 which are extensions of previous papers by the same authors (respectively (Carello and
786 Lanzarone, 2014) and (Yuan et al., 2015)) considering different nominal problems but
787 bringing no new contribution to the methods they propose regarding the handling of
788 uncertainties since they use the same method in the extensions than in the original pa-
789 pers.

790

791 The new search we conducted to cover papers published after May 2019 provided
792 7 additional papers. Even though they are not included in the numerical data that we
793 give, they do not run counter to our global analysis unless stated otherwise.

794

795 The interest in uncertainties is quite recent since the oldest paper that we consider
796 dates back to 2011, and 68% of the selected papers were published from 2017 onwards.

797 *7.2. Types of uncertainties*

798 As previously mentioned, in the HHC context, uncertainties have different causes,
799 thus they take different forms. First, they can stem from the patients who may require a
800 change in the frequency of their visits (Mosquera et al., 2018) or in their assigned time

801 slot (Lin et al., 2018). They may also have new demands or cancel their planned vis-
802 its (Yuan and Jiang, 2017). Sometimes one-time cancellations occur (Gunawan et al.,
803 2017), but at other times, the patient is simply getting out of the system because his/her
804 health declined and he/she had to be hospitalized (Gomes and Ramos, 2019).
805 Staff members also bring their own unpredictability: when staff members are on sick
806 leave, take a day off, or change their availabilities during the horizon, their whole tour
807 is impacted even though the patients who were scheduled need to receive the planned
808 visits anyway (Xie and Wang, 2017). Six papers, (Bennett and Erera, 2011), (Demir-
809 bilek et al., 2018), (Demirbilek et al., 2019), (Nasir and Dang, 2018), (Nasir and Dang,
810 2019), (Nguyen and Montemanni, 2016), take into consideration the admission of new
811 patients, or the possibility of hiring new staff members, therefore adding another deci-
812 sion to the initial scheduling and routing problem.
813 Finally, there are uncertainties that are deeply bounded to the HHC field with uncer-
814 tain visit times (Demirbilek et al., 2019; Zhan et al., 2020), to the health sector with
815 emergencies or real-time demands (Ouertani et al., 2019), or to routing problems with
816 uncertain travel times (Nikzad et al., 2020; Shi et al., 2019). We aggregated the con-
817 sidered uncertainties or perturbations in three categories:

- 818 • Changes related to demands: 65%
- 819 • Changes related to patients: 43%
- 820 • Changes related to staff members: 22%

821 Note that changes related to patients and demands can be closely linked, but we
822 separate them according to the following criteria: if the change impacts only one visit
823 or one type of visits, then we categorize it in the demands' category. If the change
824 concerns all the visits required by the same patient during a period, then it is in the pa-
825 tients' category. We consider that cancellations of visits often happen for a full period
826 (day, week, permanent departure), therefore we put it in the patients' category.

827

828 Among all criteria, uncertainty in visit times is the most studied: 44% of selected
829 papers consider it. Then, we find the changes in the pool of patients (new patients 28%

830 and departure or cancellations of patients (25%), travel times (25%), closely followed
831 by new demands (22%). On the contrary, some criteria are marginal: changes in visit
832 frequencies (Mosquera et al., 2018) or broken vehicles (Alves et al., 2018a) are only
833 considered in one paper each.

834 Among the 7 papers published after May 2019, uncertain visit times are considered in
835 5 of them, and uncertain travel times in 4 of them.

836 7.3. Approaches

837 There are different ways to handle uncertainty : robustness (13%), flexibility (10%),
838 stochastic optimization (32%), dynamic optimization (32%), stability (13%) etc. These
839 approaches are not necessarily incompatible, and they do not offer the same possibili-
840 ties for the decision-maker.

841

842 A first strategy consists in forecasting the contingencies and providing a robust so-
843 lution, that is to say, a solution that stays feasible in spite of disruptions. The robustness
844 of such a solution depends on the degree of conservatism of the solving approach, i.e.
845 the degree of risk the decision-maker is willing to take. For instance, Naji et al. (2017)
846 offer an extremely conservative solution that would remain feasible in any considered
847 scenario. By comparison, in (Cappanera et al., 2017) and (Carello and Lanzarone,
848 2014), the feasibility of the solution is only guaranteed for scenarios with a controlled
849 amount of disturbance. In (Shi et al., 2019), the solutions remain feasible as long as
850 service and travel times vary within predefined intervals.

851 Flexible parameters also give more possibilities in the creation of a schedule: in (Mos-
852 quera et al., 2018), the visit times and frequency of the visits are adjustable; in (Nasir
853 and Dang, 2018), the possibility of hiring nurses and accepting new patients is offered;
854 in (Restrepo et al., 2019), the decision-maker can ask staff members on rest days to
855 come back to work, etc.

856 These models make it possible to anticipate the disturbances, thus they are mostly used
857 at a strategic or tactical level.

858

859 To deal with uncertainties on the operational level, other strategies are used. They

860 could be qualified as "corrective" strategies: an original schedule is built, and when-
861 ever a contingency occurs, we proceed in the alteration of the initial schedule. This
862 dynamic approach offers the advantage of only taking into account the disruptions that
863 actually occur, and thus the solution remains optimal as long as there are no uncertain-
864 ties. However, the corrections may be extremely expensive or completely inefficient.
865 In (Kandakoglu et al., 2020), floating nurses can replace absent nurses on short notice.
866 Dynamic problems can be handled with a stability objective, which consists in staying
867 as close as possible to the initial schedule: it offers a continuity highly appreciated by
868 both staff members and patients. In (Yuan and Jiang, 2017) for example, the stability is
869 maximized for all stakeholders: the patients, the staff, but also the company. Starting
870 and ending times or assignment of staff members are the main criteria of stability.

871

872 It is to be noted that dynamic approaches can offer solutions for re-planning prob-
873 lems, in the longer term. (Gomes and Ramos, 2019) needs to deal with changes in the
874 pool of patients (departure and new arrivals) along with unusual continuity and non-
875 loyalty constraints.

876

877 *7.4. Modeling*

878 Depending on what strategy is chosen to cope with uncertainty, the variability can
879 be reflected either in the expression of the variables or in the model and the solving
880 methods.

881

882 In stochastic approaches, random variables are used in 75% of the cases to express
883 uncertainty, whereas a discrete set of scenarios is preferred in other cases, such as in
884 (Naji et al., 2017) and (Rodriguez et al., 2015). In robust or flexible cases, variables
885 may belong to a specific interval: in (Mosquera et al., 2018), visit times are mod-
886 eled as decision variables with a preferred duration (upper bound) and a minimum
887 duration (lower bound), the aim being to be as close as possible to the upper bound,
888 allowing smaller times if necessary. On the contrary, in (Carello and Lanzarone, 2014)
889 and (Carello et al., 2017), visit times are characterized by their expected value (lower

890 bound) and maximum value (upper bound), the aim being to be as close as possible to
891 the lower bound, allowing higher times if necessary.

892

893 A traditional method in robust optimization consists in using a cardinality-constrained
894 model. It enables the decision-maker to decide what level of conservatism he/she wants
895 in the solution. For example, in (Cappanera et al., 2017), the conservatism degree
896 bounds the number of uncertain demands per tour; in (Carello and Lanzarone, 2014)
897 and (Carello et al., 2017), control is kept over the number of clients whose visit time
898 does not meet the expected value; in (Nguyen and Montemanni, 2016), the number of
899 missing nurses is limited. In cardinality-constrained models, the solutions are guaran-
900 teed to be feasible as long as these limitations are observed.

901 Stochastic programming seems to be appreciated by the authors: 32% of selected pa-
902 pers use stochastic models. The latest papers (not included in the tables) tend to confirm
903 this trend (Zhan et al., 2020; Shi et al., 2019; Hashemi Doulabi et al., 2020).

904 In dynamic cases, the initial schedule is built from a deterministic method and is then
905 altered to remain feasible in spite of contingencies. As a consequence, the differ-
906 ences occur in the solving methods: we can find an insertion heuristic (Bennett and
907 Erera, 2011), multi-agent simulation with recourse action (Marcon et al., 2017), a re-
908 pair method (Xie and Wang, 2017) or a scenario-based approach (Demirbilek et al.,
909 2019).

910

911 *7.5. Objectives*

912 The objective functions often reflect the different motivations behind the consid-
913 eration of uncertainties. In 67% of the papers, the objective function does not change
914 from the one used in the deterministic problem. Travel, working and idle times are min-
915 imized, workloads are balanced, general costs are minimized, etc. It should be noted
916 that these objective functions are mostly considered when the uncertainty is handled
917 with stochastic or robust models. In (Carello et al., 2017) and (Naji et al., 2017), the
918 objective function is minimized in the worst-case scenario.

919 In the remaining 33% of papers, the objective function directly depends on the changes

920 induced by the contingencies.

921

922 A frequent objective is also to minimize the deviation from the original schedule.
923 The calculation of such a deviation differs according to the papers: Nickel et al. (2012)
924 consider the changes in the starting times of the cares, while Shi et al. (2017b) compute
925 extra-working times and delayed visits. In (Yuan and Jiang, 2017), three criteria are
926 jointly minimized: (1) changes in starting times of care, (2) changes in the length of the
927 tour, and the succession of patients, (3) additional costs due to late penalties, overtime
928 costs, etc. Costs induced by the changes in the initial planning are taken into account
929 in 19% of papers: it includes delayed visit penalties or reassignment costs.

930

931 Du et al. (2017b) consider a different problem with patients requiring a visit in an
932 emergency. Their goal is to minimize the response time, i.e. to provide the visit as soon
933 as possible after the request is sent by the patient in need.

934 *7.6. Discussion on uncertainties and dynamic aspects*

935 The interest in dynamic aspects and uncertainties is extremely recent: the first paper
936 of our selection dates back to 2011. Therefore we lack some hindsight to analyze the
937 evolution of the studied criteria throughout the years. However, it is to be noted that
938 flexibility has not been given much attention, unlike stochastic or dynamic problems.
939 Furthermore, whether it is in the objectives or the contingencies, staff members are
940 clearly not the main focus of the authors: they prefer considering patient preference,
941 or economic aspects. Even though the preferences of the staff members do not appear
942 to be a priority, the HHC field has a high turnover of staff because of the extremely
943 hard working conditions. Granting more importance to the workers' well-being would
944 probably reduce the number of contingencies and would bring more stability to HHC
945 agencies.

946 **8. Discussion and Future research directions**

947 Due to its crucial contribution to society, the problem of routing and scheduling in
948 the HHC context has received increasing attention in recent years. Figure 11 indicates

949 the proportion of papers considering the main features we identified. The darker the
 950 feature is represented, the more it is studied in our selection of papers. As shown in Fig-
 951 ure 11, this problem covers a variety of applicative research involving HHC agencies.
 952 Authors often use real-life instances to validate their methods. Objective functions and
 953 constraints are numerous. The results of this literature survey also show the large vari-
 954 ety of problems addressed when considering planning in HHC agencies. Most of these
 955 are extensions of the VRP, with classically considered objectives (such as travel costs)
 956 or constraints (such as time windows, legislative rules, skills, etc.). This survey also
 957 shows some recent uncommon constraints (like dependency constraints, continuity of
 958 care, etc.), which are very close to real-life cases.

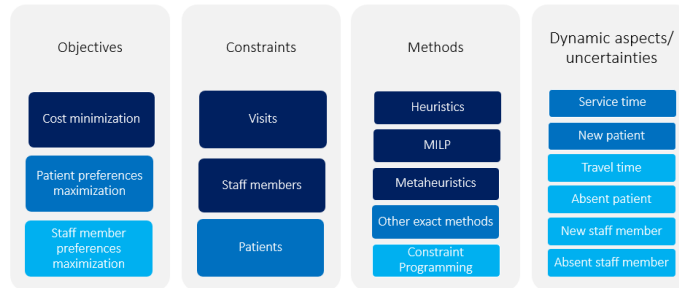


Figure 11: Illustration of the main characteristics of the analyzed papers

959 In the most recent papers, we observed the emergence of several trends. Some
 960 research avenues were already identified in the latest literature reviews (Cissé et al.,
 961 2017) and (Grieco et al., 2020). As we will show below, some of the main trends
 962 observed recently go in the direction of the already identified avenues, others in these
 963 avenues are still relevant, and furthermore, new ones appear.

964 We structure the main trends and research questions according to five areas: ap-
 965 proaches and benchmarks, specific constraints, uncertainties, sustainability and means
 966 of transportation, and finally, multi-objective methods to consider all stakeholders.

967 8.1. Approaches and benchmarks

968 As far as methods are concerned, we observe an evolution: whereas the first studies
 969 traditionally proposed methods based either on mathematical programming, in particu-

lar, the MILP, or on dedicated heuristics, efficient methods for the other VRP extensions have since been developed. Thus, several authors propose advanced optimization methods based on Lagrangian relaxation, such as (Fathollahi-Fard et al., 2019), or Benders decomposition, such as (Heching et al., 2019). Metaheuristics, like in (Fathollahi-Fard et al., 2020), or in (Inanç and Şenaras, 2020) and memetic approaches, such as (Decerle et al., 2019b) are also booming. These new methods make it possible to deal with larger instances and longer planning horizons. We also note the appearance of more emerging approaches, such as multi-agent (Hamdani et al., 2019) or AI methods to take into account or better model certain uncertainties inherent in the field of home care and service. This trend is all set to continue in the coming years. Indeed, this evolution of methods follows a classical pattern in the development of operational research methods for a given type of problem. For methods that allow better consideration of available data and/or that allow the development of dynamic approaches, this corresponds to a much more general current trend and, once again, this trend is all set to continue.

Furthermore, each author usually develops their specific method for their problem and tests it on their data. It could be interesting to work on more generic models, as already suggested in (Cissé et al., 2017), but also to provide some new benchmarks, containing all the characteristics of interest of an HHC scheduling and routing problem in HHC agencies.

Finally, the need identified in (Grieco et al., 2020) to consider routing and scheduling in the HHC sector as a whole (including contextual and environmental factors) and in all its dimensions (strategic, tactical, and operational) remains a topical issue.

8.2. *Specifics constraints*

The constraints considered are numerous. Nevertheless, some of them have been paid more attention. Some are already subject to VRP extensions, while others are specific to the HHCRSP. We will focus here on these and, more especially, on continuity of care, preferences, and synchronization and dependency constraints.

Continuity of care: we noted that patient constraints, particularly those related to continuity of care, were not often considered, although they have an impact on improving the quality of service of HHC agencies. There are two types of continuity of care:

1000 human continuity and temporal continuity. We can define ‘Temporal continuity’ by
1001 visiting the patient at the same hour each time. Only a few recent papers consider this
1002 type of continuity despite the fact that it directly affects patient satisfaction. We can
1003 define ‘Human continuity’ by assigning the same staff member (or the same pool of
1004 staff members) to a given patient throughout the period. Usually, even in the most re-
1005 cent papers, such as (Demirbilek et al., 2019) or (Entezari and Mahootchi, 2020), only
1006 the first aspect is considered. Continuity of care is a reality and a concern for HCC
1007 agencies. Considering a pool of staff members is the only way to consider continuity
1008 of care and day-off simultaneously. Therefore, this point is crucial in the quality of
1009 service, and increasingly more studies should make this point central key one.

1010 *Patient and Staff Member preferences:* We observed that even if cost criteria are
1011 the most studied criteria, there is an increasing interest in maximization of patient and
1012 staff member preferences, as in (Zhu et al., 2019) or (Liu et al., 2019c), for instance.
1013 We think that it is significant to take these aspects further, for the HHC agencies to
1014 remain competitive by providing a good quality of service for their patients, and a
1015 conducive working environment for their staff members. Moreover, this will facilitate
1016 the acceptance of the proposed methods and tools.

1017 *Synchronization and dependency constraints:* A major trend in the most recent pa-
1018 pers is the consideration of dependency constraints as in (Frifita and Masmoudi, 2020),
1019 (Liu et al., 2019c), Nozir et al. (2020), or Euchl et al. (2020), for example. Indeed, the
1020 HHC sector has a specificity in the VRP field. Some patients require, in the context
1021 of their care, the simultaneous or successive presence of several staff members. Syn-
1022 chronization of tours combined with flexible or hard time windows linked to the care,
1023 to the patient, or to the staff members is a challenging and promising avenue. Recent
1024 papers focus on the need for some services to have two staff members present at the
1025 same time with the patient. Other types of temporal dependencies exist in the HHC en-
1026 vironment, including precedence or even strict precedence. Indeed, some care requires
1027 the intervention of a staff member with specific skills, followed almost immediately by
1028 another staff member with other skills. Taking these kinds of constraints into account
1029 is challenging. In (Cissé et al., 2017), the need, to carry out studies taking the different
1030 types of time windows into account, has already been highlighted. This avenue is still

1031 relevant. Recent studies have clearly shown that besides the different types of time
1032 windows, the different types of dependencies and synchronization are key constraints.

1033 *8.3. Uncertainties*

1034 One of the main promising avenues of research is the consideration of uncertainties
1035 since these uncertainties are inherent to the HHC sector. In real life, several uncertain-
1036 ties can affect the solutions, as seen in section 7. Concerning these uncertainties, most
1037 papers focus mainly on classical uncertainties about duration of services and travel
1038 times. Most papers propose a stochastic approach to these uncertainties (Nikzad et al.,
1039 2020), (Shi et al., 2019) and more recently a few papers propose a dynamic approach
1040 (Ouertani et al., 2019) to address this type of uncertainties. In this sense, these studies
1041 are initial answers to the avenues of research identified by Cissé et al. (2017). How-
1042 ever, the HHC sector presents specific uncertainties. Thus, as in all medical sectors,
1043 home care facilities and services must deal with emergencies: a patient not foreseen
1044 in the tour to visit or a staff member absent at the last minute when it is not possible
1045 to cancel his/her visits. These unexpected inflows/outflows of patients and staff mem-
1046 bers are present daily in the HHC structures and require the development of dynamic
1047 approaches as already pointed out in (Cissé et al., 2017), as well as robust planning
1048 methods. Patients of HHC agencies are fragile people who need stability and no unex-
1049 pected events, so robust approaches to uncertainties or at least flexible models continue
1050 to be essential to improve the quality of service provided by HHC agencies.

1051 *8.4. Sustainability and means of transportation*

1052 Some recent papers consider sustainability aspects. Two main ways are proposed:
1053 minimization of gas emissions, or environmentally friendly means of transportation.
1054 Hence, some recent studies consider the minimization of environmental pollution such
1055 as (Fathollahi-Fard et al., 2018a). Others consider the combination of means of trans-
1056 portation, such as public transportation, combined with walking, such as (Rest and
1057 Hirsch, 2016) or the combination of walking and car/trip sharing for staff members,
1058 such as (Fikar and Hirsch, 2015), or the use of electric cars or bicycles such as (Zan-
1059 der et al., 2019), or (Erdem and Koç, 2019). Sustainability is a crucial societal problem,

1060 and we believe that it is relevant to develop new approaches considering this aspect in
1061 future research, especially from the perspective of mobility, as has already begun in
1062 some studies like (Voegl and Hirsch, 2019).

1063 Consideration of different means of transportation used by staff members is rarely
1064 addressed in the literature, where most works focus on the private transportation mode,
1065 i.e. cars. In this, the research trail proposed in (Cissé et al., 2017) continues to apply.
1066 Some authors have considered public transportation modes, or some combinations of
1067 car, public transport, and walking. Combining transportation modes could significantly
1068 improve services and reduce costs. Furthermore, especially in urban areas, innovative
1069 modes of transportation are emerging, and new kinds of mobility are booming: car,
1070 bicycle or scooter sharing, as well as carpooling, are some examples.

1071 Mobility of staff members will evolve, and proposing planning methods able to
1072 take these new modes of mobility into account is a very promising avenue. Since each
1073 of these transportation modes has its own specific constraints and restrictions, a key
1074 avenue is to propose realistic schedules.

1075 *8.5. Multi-objective approaches to consider all the stakeholders*

1076 Most papers consider multiple criteria, but usually with a single objective function,
1077 often a weighted sum. However, assigning some weights may be difficult and not
1078 satisfying for decision makers. Moreover, it could be more interesting to obtain a set of
1079 alternative solutions rather than only one solution, representing some tradeoff between
1080 the different criteria of interest, and to develop methods helping to choose the most
1081 suitable solution out of those provided. For this reason, a few papers recently developed
1082 some multi-objective resolution methods. We think that to propose new multi-objective
1083 resolution methods for the scheduling and routing problem in HHC agencies is an
1084 interesting avenue. In (Cissé et al., 2017), this point was already highlighted, and it is
1085 still current.

1086 Over and beyond the multi-objective method aspect, other aspects related to multi-
1087 objective are real avenues of ambitious research. The home care and service sector
1088 is no exception to the rule of the presence of several stakeholders with conflicting in-
1089 terests. Many papers focus on the financial aspects by minimizing a classic criterion

1090 for VRP distance traveled, a topical economic objective for HHC agencies. Patients
1091 also receive special attention, with several papers focusing on patient satisfaction and
1092 quality of service. However, the third stakeholder, the staff members, are still too often
1093 forgotten, even if some studies are beginning to propose objective functions that are
1094 staff member-centered such as (Zhang et al., 2019), (Khodabandeh et al., 2020). In-
1095 deed, few studies focus on staff member satisfaction, although they play a topical role
1096 in the quality of service and patient satisfaction and thus on the economic sustainabil-
1097 ity of the HHC agency. As the HHC sector suffers from the large turnover of its staff
1098 members, proposing methods aiming at staff members' satisfaction is an important av-
1099 enue. Developing studies that find tradeoffs and reconcile the interests of the different
1100 stakeholders is a crucial challenge.

1101 **9. Conclusions**

1102 In this paper, we propose a literature survey on the routing and scheduling problem
1103 in the HHC context, a field that has received increasing attention in the recent years.
1104 The main contributions of our literature survey are as follows:

- 1105 • We provide a synthesis of the literature dealing with routing and scheduling in
1106 the HHC context, through a numerical analysis and a classification of the pa-
1107 pers, emphasizing the large variety of problems studied and solutions proposed,
1108 objective functions considered (cost and preference for patients or staff mem-
1109 bers), constraints considered (related to visits, patients, or staff members), and
1110 highlighting the uncertain and dynamic aspects.
- 1111 • We provide some discussions on current trends in HHC routing and scheduling,
1112 showing several new recent characteristics, such as multi-modality or sustain-
1113 ability.
- 1114 • We propose future research directions to solve realistic problems and help HHC
1115 agencies provide increasingly better services for their patients, ensuring a good
1116 working environment for their staff members, while being sustainable.

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Table 2: Considered problem (Journal papers)

Year	First Author	References	Publication			Studied problem				
			Journal title	Affiliation	Application	Type of study		Horizon		Uncertainties
						Case study	Review	Short	Long	
1997	begur	Begur et al. (1997)	Interfaces	USA	USA	✓	-	-	✓	-
2000	hindle	Hindle et al. (2000)	HSMR	UK	Ireland	✓	-	✓	-	-
2006	bertels	Bertels and Fahle (2006)	C&OR	Germany	-	-	-	✓	-	-
2006	eveborn	Eveborn et al. (2006)	EJOR	Sweden	Sweden	✓	-	✓	-	-
2007	akjiratikar	Akjiratikar et al. (2007)	C&OR	Thailand	UK	✓	-	✓	-	-
2008	bredstrom	Bredström and Rönnqvist (2008)	EJOR	Norway	-	-	-	✓	-	-
2009	chahed	Chahed et al. (2009)	HCMS	UK	-	-	-	-	✓	-
2009	hindle	Hindle et al. (2009)	HSMR	UK	UK	✓	-	✓	-	-
2011	ben bachouch	Ben Bachouch et al. (2011)	Supply Chain Forum	France	-	-	-	-	✓	-
2011	bennett	Bennett and Erera (2011)	IIE Trans. on HCSE	USA	-	-	-	-	✓	✓
2011	trautsamwieser	Trautsamwieser and Hirsch (2011)	JAOR	Austria	Austria	✓	-	✓	-	-
2011	trautsamwieser	Trautsamwieser et al. (2011)	OR spectrum	Austria	-	-	-	✓	-	-
2012	an	An et al. (2012)	JORS	Korea	Korea	✓	-	-	✓	-
2012	nickel	Nickel et al. (2012)	EJOR	Germany	Denmark	✓	-	-	✓	✓
2012	rasmussen	Rasmussen et al. (2012)	EJOR	Denmark	Denmark	✓	-	✓	-	-
2012	shao	Shao et al. (2012)	IIE Trans.	USA	-	-	-	-	✓	-
2013	allaoua	Allaoua et al. (2013)	Elec. Notes in Disc Math.	France	-	-	-	✓	-	-
2013	bard	Bard et al. (2013)	SEPS	USA	-	-	-	-	✓	-
2013	cappanera	Cappanera and Scutellà (2013)	Elec. Notes in Disc Math.	Italy	Italy	✓	-	-	✓	-
2013	mutingi	Mutingi and Mbohwa (2013a)	Lect. Notes Eng. Comp.	South africa	-	-	-	✓	-	-
2013	sahin	Sahin et al. (2013)	Kybernetes	France	-	-	-	✓	-	-
2014	bard	Bard et al. (2014a)	J. Sched	USA	USA	✓	-	-	✓	-
2014	bard	Bard et al. (2014b)	IIE Trans.	USA	-	-	-	-	✓	-
2014	cappanera	Cappanera and Scutellà (2014)	Transportation Science	Italy	-	-	-	-	✓	✓
2014	carello	Carello and Lanzarone (2014)	EJOR	Italy	-	-	-	-	✓	✓
2014	di gaspero	Di Gaspero and Urli (2014)	Lect. Notes Comp. Sci.	Italy	-	-	-	-	✓	-
2014	lanzarone	Lanzarone and Matta (2014)	ORHC	Italy	Italy	✓	-	✓	-	✓
2014	mankowska	Mankowska et al. (2014)	HCMS	Germany	-	-	-	✓	-	-
2014	mutingi	Mutingi and Mbohwa (2014)	IIE Trans. on HCSE	South africa	-	-	-	✓	-	-
2014	trautsamwieser	Trautsamwieser and Hirsch (2014)	Networks	Austria	-	-	-	-	✓	-
2015	bowers	Bowers et al. (2015)	HCMS	UK	-	-	-	-	✓	-
2015	fikar	Fikar and Hirsch (2015)	J. Clean. Prod	Austria	Austria	✓	-	✓	-	-
2015	hiermann	Hiermann et al. (2015)	Central EJOR	Austria	Austria	✓	-	✓	-	-
2015	issaoui	Issaoui et al. (2015a)	Elec. Notes in Disc Math.	Tunisia	-	-	-	-	✓	-
2015	lieder	Lieder et al. (2015)	ORHC	Germany	Netherlands	✓	-	✓	-	-
2015	mayu duque	Maya Duque et al. (2015)	EJOR	Belgium	Belgium	✓	-	-	✓	-
2015	misir	Misir et al. (2015)	JORS	Belgium	-	-	-	✓	-	-
2015	rodriguez	Rodriguez et al. (2015)	IJPR	France	France	✓	-	-	✓	✓
2015	sahin	Sahin and Matta (2015)	Int. J. Logist-Res. App.	France	-	-	-	✓	-	-
2015	yuan	Yuan et al. (2015)	IJPR	China	-	-	-	-	✓	✓
2016	ait haddadene	Ait Haddadene et al. (2016a)	ESWA	France	-	-	-	-	✓	-
2016	braekers	Braekers et al. (2016)	EJOR	Belgium	-	-	-	-	✓	-
2016	fikar	Fikar et al. (2016)	European J. Indus. Eng.	Austria	-	-	-	-	✓	✓
2016	heching	Heching and Hooker (2016)	Lect. Notes Comp. Sci.	USA	USA	✓	-	-	✓	✓
2016	lin	Lin et al. (2016)	ESWA	Hong Kong	Hong Kong	✓	-	-	✓	-
2016	redjem	Redjem and Marcon (2016)	FSM	France	-	-	-	-	✓	-
2016	rest	Rest and Hirsch (2016)	FSM	Austria	Austria	✓	-	-	✓	-
2016	wirmitzer	Wirmitzer et al. (2016)	ORHC	Germany	Germany	✓	-	-	✓	-
2016	yalcindag	Yalcindag et al. (2016b)	FSM	Italy	Italy	✓	-	-	✓	-
2016	yalcindag	Yalcindag et al. (2016a)	C&OR	Turkey	Italy	✓	-	-	✓	-
2017	cappanera	Cappanera et al. (2017)	Omega	Italy	-	-	-	-	✓	✓
2017	cisse	Cissé et al. (2017)	ORHC	France	-	-	-	✓	-	-
2017	du	Du et al. (2017b)	J. Comb Optim	China	China	✓	-	-	✓	✓
2017	du	Du et al. (2017a)	Sustainability	China	China	✓	-	-	✓	-
2017	erdem	Erdem and Bulkan (2017)	S. Afr. J. Ind. Eng	Turkey	-	-	-	-	✓	-
2017	fikar	Fikar and Hirsch (2017)	C&OR	Austria	-	-	-	-	✓	-
2017	frifita	Frifita et al. (2017)	Elec. Notes in Disc Math.	France	-	-	-	-	✓	-
2017	guericke	Guericke and Suhl (2017)	OR Spectrum	Germany	-	-	-	-	✓	-
2017	liu	Liu et al. (2017)	IJPR	China	China	✓	-	-	✓	-
2017	luna	Luna et al. (2017)	Cluster comput.	Spain	Spain	✓	-	-	✓	-
2017	marcon	Marcon et al. (2017)	Simul. Model. Pract. Th.	France	France	✓	-	-	✓	✓
2017	quintana	Quintana et al. (2017)	Appl. Intell.	Spain	Spain	✓	-	-	✓	-
2017	shi	Shi et al. (2017c)	ESWA	France	-	-	-	-	✓	✓
2017	yuan	Yuan and Jiang (2017)	Sustainability	China	China	✓	-	-	✓	✓
2018	carello	Carello et al. (2018)	ORHC	Italy	Italy	✓	-	-	✓	✓
2018	decerle	Decerle et al. (2018b)	ORHC	France	France	✓	-	-	✓	✓
2018	demirbilek	Demirbilek et al. (2018)	HCMS	UK	-	-	-	-	✓	✓
2018	fathollahi-fard	Fathollahi-Fard et al. (2018a)	J. Clean. Prod	Iran	-	-	-	-	✓	-
2018	fathollahi-fard	Fathollahi-Fard et al. (2018b)	IJE	Iran	-	-	-	-	✓	-
2018	fikar	Fikar and Hirsch (2018)	FSM	Austria	Austria	✓	-	-	✓	-
2018	hirsch	Hirsch (2018)	Die Bodenkultur J.L.M.F.E.	Austria	-	-	-	-	✓	-
2018	lin	Lin et al. (2018)	C&IE	Taiwan	-	-	-	-	✓	✓
2018	liu	Liu et al. (2018)	Comp. Appl. Math.	China	-	-	-	-	✓	-
2018	mosquera	Mosquera et al. (2018)	Omega	Belgium	Belgium	✓	-	-	✓	✓
2018	nasir	Nasir and Dang (2018)	Sustainability	China	-	-	-	-	✓	✓
2018	sinthamrongruk	Sinthamrongruk et al. (2018)	Int J. Agile Systems and Management	UK	-	-	-	-	✓	-
2018	szander	Szander et al. (2018b)	Lect. Notes Manag. Ind. Eng	Slovenia	Hungary	✓	-	-	✓	-
2018	szander	Szander et al. (2018a)	Sustainability	Slovenia	-	-	-	-	✓	-
2018	yuan	Yuan et al. (2018)	IJPR	China	-	-	-	-	✓	-
2018	zhan	Zhan and Wan (2018)	C&OR	China	-	-	-	-	✓	✓
2019	becker	Becker et al. (2019)	Lect. Notes Comp. Sci.	Germany	-	-	-	-	✓	-
2019	chaieb	Chaieb et al. (2019)	HCMS	Saudi Arabia	New Zealand	✓	-	-	✓	-
2019	decerle	Decerle et al. (2019a)	Swarm and Evolutionary Computation	France	-	-	-	-	✓	-
2019	decerle	Decerle et al. (2019b)	Swarm and Evolutionary Computation	France	-	-	-	-	✓	-
2019	dekhici	Dekhici et al. (2019)	Canadian J. of Elec. And Computer Eng.	Algeria	-	-	-	-	✓	-
2019	demirbilek	Demirbilek et al. (2019)	FSM	UK	-	-	-	-	✓	✓
2019	fathollahi-fard	Fathollahi-Fard et al. (2019)	Neural Computing and Applications	Iran	-	-	-	-	✓	-
2019	gomes	Gomes and Ramos (2019)	EJOR	Portugal	Portugal	✓	-	-	✓	✓
2019	grenouilleau	Grenouilleau et al. (2019)	EJOR	Canada	-	-	-	-	✓	-
2019	heching	Heching et al. (2019)	Transportation Science	USA	-	-	-	-	✓	-
2019	liu	Liu et al. (2019a)	C&OR	China	-	-	-	-	✓	-
2019	liu	Liu et al. (2019b)	FSM	China	-	-	-	-	✓	✓
2019	moussavi	Moussavi et al. (2019)	ESWA	France	-	-	-	-	✓	-
2019	nasir	Nasir and Dang (2019)	HCMS	Hong Kong	-	-	-	-	✓	✓
2019	restrepo	Restrepo et al. (2019)	Omega	Canada	-	-	-	-	✓	✓
2019	riazi	Riazi et al. (2019)	IEEE TASE	Sweden	-	-	-	-	✓	-
Sum						38	6	46	43	27
Percentage (%)						39.58	6.32	51.11	47.78	30.00

Table 3: Considered problem (Journal papers) - 2

Year	First Author	References	Modeling and Resolution approach	Instances	
				Benchmark	Instances size (max)
1997	begur	Begur et al. (1997)	Heuristic	-	7 SM - 200 V
2000	hindle	Hindle et al. (2000)	Heuristic	-	-
2006	bertels	Bertels and Fahle (2006)	CP-TS and CP-SA and CP-LP	-	50 SM - 200 Pa - 600 V
2006	eveborn	Eveborn et al. (2006)	Repeated matching algorithm	-	123 Pa - 20 SM
2007	akjiratikar	Akjiratikar et al. (2007)	MILP - PSO	-	100 Pa - 12 SM
2008	bredstrom	Bredström and Rönnqvist (2008)	MILP - B&P	-	90 Pa - 16 SM
2009	chahed	Chahed et al. (2009)	MILP	-	-
2009	hindle	Hindle et al. (2009)	Heuristic	-	125 Pa - 23 districts
2011	ben bachouch	Ben Bachouch et al. (2011)	MILP	-	7 SM - 20 Pa
2011	bennett	Bennett and Erera (2011)	Rolling horizon planning approach	-	-
2011	trautsamwieser	Trautsamwieser and Hirsch (2011)	MILP - VNS	-	512 V - 420 Pa - 75 SM
2011	trautsamwieser	Trautsamwieser et al. (2011)	MILP - VNS - LS	-	75 SM - 512 V
2012	an	An et al. (2012)	2 phase heuristic approach - mip	-	20 Pa - 1 SM
2012	nickel	Nickel et al. (2012)	ALNS - CP	-	361 Pa - 12 SM
2012	rasmussen	Rasmussen et al. (2012)	MILP - B&P	Bredström and Rönnqvist (2008)	15 V - 150 Pa
2012	shao	Shao et al. (2012)	GRASP - ALNS	-	-
2013	allaoua	Allaoua et al. (2013)	MILP - Matheuristic	Kergosien et al. (2014)	30 Pa - 9 SM
2013	bard	Bard et al. (2013)	MILP	-	20 SM - 280 Pa
2013	cappanera	Cappanera and Scutellà (2013)	MILP	-	163 Pa
2013	mutingi	Mutingi and Mbohwa (2013a)	MILP - Genetic algorithm	-	-
2014	bard	Bard et al. (2014a)	MILP - GRASP	-	45 Pa
2014	bard	Bard et al. (2014b)	MILP - DA - B&P - B&C	-	-
2014	cappanera	Cappanera and Scutellà (2014)	-	Nickel et al. (2012)	11 SM - 162 V
2014	carello	Carello and Lanzarone (2014)	CC	Lanzarone and Matta (2014)	-
2014	di gaspero	Di Gaspero and Urti (2014)	CP - adaptive LNS	-	32 SM - 40 V/day
2014	lanzarone	Lanzarone and Matta (2014)	-	-	-
2014	mankowska	Mankowska et al. (2014)	AVNS - MILP	-	300 Pa - 40 SM
2014	mutingi	Mutingi and Mbohwa (2014)	MILP - FSE	Trabelsi et al. (2011)	-
2014	trautsamwieser	Trautsamwieser and Hirsch (2014)	B&P&C - VNS - MILP	-	45 Pa - 9 SM - 203 V
2015	bowers	Bowers et al. (2015)	C&W	-	6 SM - 168 V
2015	fikar	Fikar and Hirsch (2015)	2 stage Matheuristics	-	125 V
2015	hiermann	Hiermann et al. (2015)	two stage approach: MILP- CP (MA, SAHH, SS, VNS)	-	518 SM - 717 V
2015	issaoui	Issaoui et al. (2015a)	3 phase metaheuristic based on VND and LPT - MILP	Trautsamwieser and Hirsch (2011)	30 Pa - 4 SM
2015	lieder	Lieder et al. (2015)	DP - mip	-	5 SM - 42 V
2015	maya duque	Maya Duque et al. (2015)	2 stage approach (set partitioning) - MILP	-	109 Pa - 21 SM - 562 V
2015	misir	Misir et al. (2015)	-	-	-
2015	rodriguez	Rodriguez et al. (2015)	MILP - 2 stage approach	-	-
2015	yuan	Yuan et al. (2015)	MILP - CG - B-P	Solomon (1987)	-
2016	ait haddadene	Ait Haddadene et al. (2016a)	MILP - GRASP-ILS	Bredström and Rönnqvist (2008)	73 Pa - 16 SM
2016	braekers	Braekers et al. (2016)	MILP - epsilon-const - ALNS	Hiermann et al. (2015)	171 Pa - 89 SM - 300 V
2016	fikar	Fikar et al. (2016)	Matheuristic	Fikar and Hirsch (2015);	125V
2016	heching	Heching and Hooker (2016)	MIP - CP - LBBDD	-	60 Pa - 18 SM
2016	lin	Lin et al. (2016)	MILP	-	560 Pa - 12 SM - 643 V
2016	redjem	Redjem and Marcon (2016)	Heuristics	-	60 Pa - 30 SM
2016	rest	Rest and Hirsch (2016)	MILP - TS	-	127 Pa - 46 SM - 202 V
2016	wirmitzer	Wirmitzer et al. (2016)	MIP Approach	-	143 Pa - 37 SM - 1114 V/week
2016	yalcindag	Yalcindag et al. (2016b)	MILP - 2 stage approach	-	-
2016	yalcindag	Yalcindag et al. (2016a)	Two-phase approach	-	300 Pa - 16 SM - 557 V
2017	cappanera	Cappanera et al. (2017)	CC	-	3 SM - 60 Pa
2017	du	Du et al. (2017b)	IMA	-	50 Pa
2017	du	Du et al. (2017a)	GA-LS	-	-
2017	erdem	Erdem and Bulkan (2017)	MILP-VNS	Hiermann et al. (2015)	-
2017	frifita	Frifita et al. (2017)	G-VNS	Bredström and Rönnqvist (2008)	16 SM - 80 V
2017	guericke	Guericke and Suhl (2017)	MILP - ALNS	Trautsamwieser and Hirsch (2014); Cappanera and Scutellà (2013); Cappanera and Scutellà (2014)	-
2017	liu	Liu et al. (2017)	MILP - B&P	Solomon (1987)	100 Pa - 12 SM
2017	luna	Luna et al. (2017)	EA	-	374 SM
2017	marcon	Marcon et al. (2017)	Sim - MaS	-	130 SM - 300 Pa
2017	quintana	Quintana et al. (2017)	Heuristics - CM	-	9365 Pa
2017	shi	Shi et al. (2017c)	MILP Genetic	Solomon (1987)	-
2017	yuan	Yuan and Jiang (2017)	TS	-	9 SM - 50 Pa
2018	carello	Carello et al. (2018)	CC	-	-
2018	decerle	Decerle et al. (2018b)	MA	Bredström and Rönnqvist (2008)	80V
2018	demirbilek	Demirbilek et al. (2018)	SBA	-	-
2018	fathollahi-fard	Fathollahi-Fard et al. (2018a)	MILP - Heuristics - memetic Matheuristics - epsilon constraint event-driven biased-randomised Heuristic and Matheuristic	Fikar and Hirsch (2015); Solomon (1987)	20 SM - 200 Pa - 8 types of vehicles
2018	fikar	Fikar and Hirsch (2018)	Matheuristic	-	100 Pa - 125 V
2018	lin	Lin et al. (2018)	epsilon constraint method, heuristics	-	38 SM - 95 Pa - 361 V
2018	liu	Liu et al. (2018)	Metaheuristic	-	18 SM - 65 Pa
2018	mosquera	Mosquera et al. (2018)	IP-LS	-	28 SM - 127 Pa
2018	nasir	Nasir and Dang (2018)	VNS	-	91 SM - 260
2018	szander	Szander et al. (2018b)	MILP	-	9 SM - 56 Pa
2018	szander	Szander et al. (2018a)	Heuristic	-	11 SM - 73 Pa
2018	yuan	Yuan et al. (2018)	B&P	-	9 SM - 50 Pa
2018	zhan	Zhan and Wan (2018)	scenario-based MIP - heuristic based on TS	-	40 Pa
2018	fathollahi-fard	Fathollahi-Fard et al. (2018b)	MILP-Lagrangian relaxation-based algorithm	-	20 SM - 200 Pa - 8 types of vehicles
2018	sinthamrongruk	Sinthamrongruk et al. (2018)	Fuzzy logic - heuristic	-	88M - 40 V
2019	chaieb	Chaieb et al. (2019)	MILP - k-means - hungarian algorithm - TS	Rasmussen et al. (2012)	15 SM - 154 V
2019	decerle	Decerle et al. (2019a)	MILP-MA- ACO	Bredström and Rönnqvist (2008)	20 SM, 80V
2019	decerle	Decerle et al. (2019b)	MILP- MAMO- trade off analysis	Bredström and Rönnqvist (2008)	20 SM, 80V
2019	dekhici	Dekhici et al. (2019)	Firefly algorithm	-	4 SM - 20 V
2019	demirbilek	Demirbilek et al. (2019)	SBA	-	-
2019	fathollahi-fard	Fathollahi-Fard et al. (2019)	Lagrangian relaxation-based algorithm - Heuristics	-	20 SM - 200 Pa - 8 types of vehicles
2019	gomes	Gomes and Ramos (2019)	MILP	-	9 SM - 190 Pa
2019	grenouilleau	Grenouilleau et al. (2019)	Heuristic - LNS	-	20 SM - 150 Pa - 430 V
2019	heching	Heching et al. (2019)	LBBDD - MILP- CP	Rasmussen et al. (2012)	60 Pa - 270 V
2019	liu	Liu et al. (2019a)	ANS	Solomon (1987), Gehring and Homberger (1999)	200 Pa
2019	liu	Liu et al. (2019b)	MILP - B&P	-	9 SM - 50 Pa
2019	moussavi	Moussavi et al. (2019)	Matheuristic	-	10 SM - 30 Pa
2019	nasir	Nasir and Dang (2019)	MILP-VNS- ROC Curves	-	120 SM-300 Pa
2019	restrepo	Restrepo et al. (2019)	Context-free grammar, Stochastic programming	-	500V
2019	riazi	Riazi et al. (2019)	gossip algorithm, CG, Dantzig Wolf Decomposition, MILP	Solomon (1987),Gehring and Homberger (2002)	200 Pa
Sum				23	
Percentage (%)				25.56	

V: Visits; SM: Staff member; Pa: Patients;
ALNS: Adaptive Large Neighborhood Search; **ANS**: Adaptive Neighborhood Search; **BB**: Branch & Bound; **BD**: Bender Decomposition; **BP**: Branch & Price; **BPC**: Branch & Price & Cut; **CC**: Cardinality Constraints; **CG**: Column Generation; **CP**: Constraints Programming; **CW**: Clarke & Wright; **DA**: Decomposition Approach; **DP**: Dynamic Programming; ϵ C: ϵ -Constraints; **2S**: 2 Stage; **FSE**: Fuzzy Simulated Evolutionary; **GA**: Genetic Algorithm; **GRASP**: Greedy Randomized Adaptive Search Procedure; **ILS**: Iterated Local Search; **LNS**: Large Neighborhood Search; **LBBDD**: Logic Based Benders Decomposition; **LS**: Local Search; **MA**: Memetic Algorithm; **MAMO**: Memetic Algorithm for Evolutionary Multiobjective Optimization; **MaS**: Multi-agent System; **MILP**: Mixed Integer Linear Programming; **PSO**: Particle Swarm Optimization; **ROC**: Receiver Operating Characteristic; **RHP**: Rolling Horizon Planning; **RMA**: Repeated Matching Algorithm; **SA**: Simulated Annealing; **Sim**: Simulation; **SS**: Scatter Search; **TS**: Tabu Search; **VND**: Variable Neighborhood Descent; **VNS**: Variable Neighborhood Search;

Table 4: Considered problem (Conference papers) - 1

Year	First author	References	Publication			Studied problem				
			Conference name	Affiliation	Application	Type of study		Horizon		Uncertainties
						Case study	Review	Short	Long	
2006	borsani	Borsani et al. (2006)	ICSSSM	Italy	Italy	✓	-	-	✓	-
2008	elbenani	Elbenani et al. (2008)	IEEM	Morocco	Canada	✓	-	✓	-	-
2009	kergosien	Kergosien et al. (2009)	MISTA	France	-	-	-	✓	-	-
2010	misir	Misir et al. (2010)	CEC	Belgium	-	-	-	-	✓	-
2011	redjem	Redjem et al. (2011)	CASE	France	-	-	-	✓	-	-
2012	bashir	Bashir et al. (2012)	MOSIM	France	-	-	-	✓	-	-
2012	cattafi	Cattafi et al. (2012)	ICLP	Italy	Italy	✓	-	✓	-	-
2012	gamst	Gamst and Jensen (2012)	Op. Res. Proc.	Denmark	Denmark	✓	-	-	✓	-
2012	gutierrez	Gutiérrez and Vidal (2012)	IEOM	Colombia	-	-	✓	-	-	-
2013	errarhout	Errarhout et al. (2013)	IESM	France	-	-	-	-	✓	-
2013	gayraud	Gayraud et al. (2013)	ProcediaTech.	France	-	-	-	-	✓	-
2013	jemai	Jemai et al. (2013)	ICMSAO	Saudi Arabia	-	-	-	✓	-	-
2013	luna	Luna et al. (2013)	3PGCIC	Spain	Spain	✓	-	-	✓	-
2013	mutingi	Mutingi and Mbohwa (2013b)	IEEM	South Africa	-	-	-	✓	-	-
2014	cappanera	Cappanera et al. (2014)	HCSE	Italy	-	-	-	-	✓	✓
2014	di mascolo	Di Mascolo et al. (2014)	HCSE	France	France	✓	-	✓	-	-
2014	espinouse	Espinouse et al. (2014)	CIE	France	France	✓	-	✓	-	-
2014	kergosien	Kergosien et al. (2014)	HCSE	France	-	-	-	-	✓	-
2014	labadie	Labadie et al. (2014)	ICORES	France	-	-	-	✓	-	-
2014	masmoudi	Masmoudi and Mellouli (2014)	CoDIT	France	-	-	-	✓	-	-
2014	riazi	Riazi et al. (2014)	IFAC	Sweden	-	-	-	✓	-	-
2014	yuan	Yuan et al. (2014)	CASE	China	-	-	-	-	✓	✓
2015	aiane	Aiane et al. (2015)	IESM	France	-	-	-	✓	-	-
2015	cattafi	Cattafi et al. (2015)	AI Comm.	Italy	Italy	✓	-	-	✓	-
2015	en-nahli	En-nahli et al. (2015)	IFAC	France	-	-	-	✓	-	-
2015	issaoui	Issaoui et al. (2015b)	ISDA	France	-	-	-	✓	-	-
2015	laesanklang	Laesanklang et al. (2015)	ICORES	UK	UK	✓	-	✓	-	-
2015	rest	Rest and Hirsch (2015)	IFAC	Austria	Austria	✓	-	✓	-	✓
2015	xie	Xie and Wang (2015)	ISC2	Canada	-	-	-	✓	-	-
2016	ait haddadene	Ait Haddadene et al. (2016b)	IFAC	France	-	-	-	✓	-	-
2016	decerle	Decerle et al. (2016)	IFAC	France	-	-	-	✓	-	-
2016	en-nahli	En-nahli et al. (2016)	IFAC	France	-	-	-	✓	-	-
2016	manerba	Manerba and Mansini (2016)	IFAC	Italy	-	-	-	✓	-	-
2016	nguyen	Nguyen and Montemanni (2016)	WCEC	Switzerland	Switzerland	✓	-	-	✓	✓
2017	alves	Alves et al. (2017)	ICCSA	Portugal	Portugal	✓	-	✓	-	-
2017	baumann	Baumann (2017)	IEEM	Switzerland	Switzerland	✓	-	-	✓	-
2017	carello	Carello et al. (2017)	HCSE	Italy	-	-	-	-	✓	✓
2017	chen	Chen et al. (2017)	ICAPS	Singapore	USA	✓	-	-	✓	✓
2017	decerle	Decerle et al. (2017)	CODIT	France	-	-	-	✓	-	-
2017	di mascolo	Di Mascolo et al. (2017b)	HCSE	France	France	✓	-	-	✓	✓
2017	di mascolo	Di Mascolo et al. (2017a)	IFAC	France	-	-	-	✓	-	-
2017	el hajri	El Hajri et al. (2017)	IFAC	France	France	✓	-	-	✓	-
2017	emiliano	Emiliano et al. (2017)	MESIC	Portugal	Portugal/Brazil	-	✓	-	-	-
2017	gunawan	Gunawan et al. (2017)	MISTA	Singapore	-	-	-	✓	-	✓
2017	lahrichi	Lahrichi et al. (2017)	HCSE	Canada	-	-	-	-	✓	-
2017	naji	Naji et al. (2017)	CODIT	France	-	-	-	✓	-	✓
2017	shi	Shi et al. (2017a)	ICORES	France	-	-	-	✓	-	✓
2017	shi	Shi et al. (2017b)	IFAC	France	-	-	-	✓	-	✓
2017	sinthamrongruk	Sinthamrongruk et al. (2017)	ICDAMT	UK	-	-	-	✓	-	-
2017	xie	Xie and Wang (2017)	CSCWD	Canada	-	-	-	✓	-	✓
2017	yalcindag	Yalcındağ and Matta (2017)	HCSE	Turkey	-	-	-	-	✓	-
2018	alves	Alves et al. (2018b)	BIOMA	Portugal	Portugal	✓	-	-	✓	-
2018	alves	Alves et al. (2018a)	PAAMS	Portugal	Portugal	✓	-	✓	-	✓
2018	decerle	Decerle et al. (2018c)	IFAC	France	-	-	-	✓	-	-
2018	decerle	Decerle et al. (2018a)	IFAC	France	-	-	-	✓	-	-
2018	di mascolo	Di Mascolo et al. (2018)	IFAC	France	-	-	-	✓	-	-
2018	eliseu	Eliseu et al. (2018)	APDIO	Portugal	Portugal	✓	-	✓	-	-
2018	feng	Feng and Wang (2018)	ICSSSM	China	China	✓	-	✓	-	-
2018	garaix	Garaix et al. (2018)	IFAC	France	-	-	-	✓	-	-
2018	martinez	Martinez et al. (2018)	CODIT	France	-	-	-	-	✓	-
2018	riazi	Riazi et al. (2018)	ETFA	Sweden	-	-	-	✓	-	-
2018	siu	Siu et al. (2018)	PICMET	Hong Kong	Hong Kong	✓	-	✓	-	-
2018	tohidifard	Tohidifard et al. (2018)	IFAC	Iran	-	-	-	✓	-	✓
2018	Xiao	Xiao et al. (2018)	IFAC	France	France	✓	-	-	✓	-
2018	yang	Yang et al. (2018)	ICSSSM	China	-	-	-	✓	-	✓
2018	zhang	Zhang et al. (2018)	ICNSC	China	China	✓	-	✓	-	✓
2019	alves	Alves et al. (2019b)	ICORES	Portugal	Portugal	✓	-	✓	-	-
2019	alves	Alves et al. (2019a)	ICORES	Portugal	Portugal	✓	-	-	✓	-
2019	espadinha	Espadinha and Cardoso-Grilo (2019)	APDIO	Portugal	Portugal	✓	-	✓	-	-
Sum						26	6	41	22	16
Percentage (%)						37.68	8.70	65.08	35.48	25.40
Global Sum						64	12	87	65	43
Global Percentage (%)						38.79	7.27	56.86	42.76	28.10

Table 5: Considered problem (Conference papers) - 2

Year	First author	References	Modeling and Resolution approach	Instances	
				Benchmark	Instances size
2006	borsani	Borsani et al. (2006)	MILP	-	382 Pa - 25 SM
2008	elbenani	Elbenani et al. (2008)	MILP – TS	-	-
2009	kegrosien	Kegrosien et al. (2009)	MILP	-	40 V
2010	misir	Misir et al. (2010)	MILP – Heuristics	-	-
2011	redjem	Redjem et al. (2011)	MILP	-	14 Pa - 4 SM
2012	cattafi	Cattafi et al. (2012)	-	-	-
2012	gamst	Gamst and Jensen (2012)	MILP – BP	-	-
2013	errarhout	Errarhout et al. (2013)	MILP	-	-
2013	gayraud	Gayraud et al. (2013)	MILP	-	30 Pa - 4 SM
2013	jemai	Jemai et al. (2013)	MILP – Tabu search	-	-
2013	luna	Luna et al. (2013)	MILP	-	10654 V - 1375 Pa
2014	cappanera	Cappanera et al. (2014)	Sim - MILP	-	6 SM - 80 Pa
2014	di mascolo	Di Mascolo et al. (2014)	MILP	-	-
2014	espinouse	Espinouse et al. (2014)	MILP	-	64 V - 30 SM - 80 Pa
2014	kegrosien	Kegrosien et al. (2014)	MILP - TS-VNS	-	250 Pa - 20 SM - 5 labo
2014	labadie	Labadie et al. (2014)	MILP – ILS	Bredström and Rönnqvist (2008)	16 SM - 45 Pa
2014	masmoudi	Masmoudi and Mellouli (2014)	MILP – 2 stage MILP Heuristic	-	88 V - 15 SM - 50 Pa
2014	riazi	Riazi et al. (2014)	MILP - Gossip algorithm and Relaxation	-	30 V - 5 SM
2014	yuan	Yuan et al. (2014)	MILP – B&P&C – CG	Solomon (1987)	-
2015	aiane	Aiane et al. (2015)	MILP	-	15 Pa - 5 SM
2015	cattafi	Cattafi et al. (2015)	CP - LNS with restart	-	-
2015	en-nahli	En-nahli et al. (2015)	MILP	-	40 Pa - 8 SM
2015	laesanklang	Laesanklang et al. (2015)	MILP – DA	-	1011 SM - 1726 V
2015	rest	Rest and Hirsch (2015)	TS based metaheuristic	-	46 SM - 202 V
2015	xie	Xie and Wang (2015)	MILP	-	-
2016	ait haddadene	Ait Haddadene et al. (2016b)	NSGAI	Bredström and Rönnqvist (2008)	16 SM - 73 Pa
2016	decerle	Decerle et al. (2016)	MIP – Two phase Matheuristic	-	60 V
2016	en-nahli	En-nahli et al. (2016)	MILP – RVND-ILS	Bredström and Rönnqvist (2008)	20 Pa - 4 SM
2016	manerba	Manerba and Mansini (2016)	MILP – B&P	-	12 SM - 15 Pa - 20 V
2016	nguyen	Nguyen and Montemanni (2016)	MILP – GA	-	-
2017	alves	Alves et al. (2017)	GA-PSO	-	12SM-31Pa
2017	baumann	Baumann (2017)	MILP	-	-
2017	carello	Carello et al. (2017)	IAA	-	98 Pa
2017	chen	Chen et al. (2017)	MILP-SAA-LR	-	199 SM - 2062 Pa
2017	decerle	Decerle et al. (2017)	MA	Bredström and Rönnqvist (2008)	80 Pa
2017	di mascolo	Di Mascolo et al. (2017b)	2OPT-Heuristic	-	10 SM
2017	el hajri	El Hajri et al. (2017)	MILP	-	4 SM-14 Pa
2017	gunawan	Gunawan et al. (2017)	ILS	-	4 SM - 228 Pa
2017	lahrichi	Lahrichi et al. (2017)	DA	-	20 SM -300 Pa
2017	naji	Naji et al. (2017)	MILP	-	15 SM
2017	shi	Shi et al. (2017a)	FCCP- HGA	A-series	-
2017	shi	Shi et al. (2017b)	SPR-HGA	-	25 Pa
2017	sinthamrongruk	Sinthamrongruk et al. (2017)	GA-ALS	-	-
2017	xie	Xie and Wang (2017)	Sim-Repair Method	-	-
2017	yalcindag	Yalcindag and Matta (2017)	MILP- DA	-	2 SM- 15 Pa
2018	alves	Alves et al. (2018b)	GA	-	78V
2018	alves	Alves et al. (2018a)	MaS - GA	-	5 SM - 15 Pa
2018	decerle	Decerle et al. (2018c)	MILP - multidimensional LS	Bredström and Rönnqvist (2008)	80 V
2018	decerle	Decerle et al. (2018a)	MILP - Matheuristic	Solomon (1987)	50 Pa
2018	di mascolo	Di Mascolo et al. (2018)	MILP	-	18 SM - 30 Pa
2018	eliseu	Eliseu et al. (2018)	Greedy heuristic, biased (randomization process, local search, MIRHA approach)	-	6 SM - 23 Pa
2018	feng	Feng and Wang (2018)	MILP	-	-
2018	garaix	Garaix et al. (2018)	MILP	-	177 SM - 1077 V
2018	martinez	Martinez et al. (2018)	MILP-Heuristic	-	35 SM - 200 Pa -742 V
2018	riazi	Riazi et al. (2018)	MILP-CG	-	10 SM -100 Pa
2018	siu	Siu et al. (2018)	MILP, GA	-	16 SM - 90 Pa
2018	tohidifard	Tohidifard et al. (2018)	MILP- GA-PSO	-	25 SM - 175 Pa
2018	Xiao	Xiao et al. (2018)	MILP	-	15 SM- 23 V
2018	yang	Yang et al. (2018)	Best-Worst ACO	-	7 SM - 30 Pa - 60V
2018	zhang	Zhang et al. (2018)	mip, modified ACO	-	8 SM-105 V
2019	alves	Alves et al. (2019b)	Tchebycheff method - Genetic algorithm	-	5 SM - 22 Pa
2019	alves	Alves et al. (2019a)	MILP	-	5SM - 15 Pa
2019	espadinha	Espadinha and Cardoso-Grilo (2019)	MILP	-	-
Sum				8	
Percentage (%)				12.70	
Global Sum				31	
Global Percentage (%)				20.26	

V: Visits; SM: Staff member; Pa: Patients;

2S: 2 Stage; ACO: Ant Colony Optimisation BP: Branch & Price; BPC: Branch & Price & Cut; CG: Column Generation; CP: Constraints Programming; DA: Decomposition Approach; FCCP: Fuzzy Chance Constraint Programming; (H)GA: (Hybrid) Genetic Algorithm; IAA: Implementor Adversarial Approach; ILS: Iterated Local Search; LNS: Large Neighborhood Search; LR: Lagrangian Relaxation; MILP: Mixed Integer Linear Programming; NSGAI: Non-Dominated Sorting Genetic Algorithm 2; PEA: Parallel Evolutionary Algorithm; PSO : Particle Swarm Optimisation; RVND: Random Variable Neighborhood Descent; SAA: Sample Average Approximation; SPR: Stochastic Programming model with Recourse; Sim: Simulation; TS: Tabu Search; VNS: Variable Neighborhood Search

Table 7: Objective function (Conference papers)

Year	First Author	References	Costs						Preference							
			Route		Staff members (SM)				Patients (Pa)				Staff members (SM)		Other	
			Min travel time/cost/distance	Max benefits	Min total visit duration/ working time	Min waiting time	Min overtime/overcosts	Other	Max patient preferences	Max continuity of care	Min uncovered visits / Max nb visits	Min TW violation	Balance workload	Max clustering efficiency		
																Other
2006	borsani	Borsani et al. (2006)	✓	-	-	-	-	-	-	✓	-	-	✓	Pa4		
2008	elbenani	Elbenani et al. (2008)	✓	-	-	-	-	-	-	-	-	-	-	-		
2009	kerjosien	Kerjosien et al. (2009)	✓	-	-	-	-	-	-	-	-	-	-	-		
2010	misir	Misir et al. (2010)	✓	-	-	-	-	-	-	✓	-	-	-	-		
2011	redjem	Redjem et al. (2011)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2012	gamst	Gamst and Jensen (2012)	✓	-	-	-	-	-	-	✓	-	✓	-	-		
2013	errarhout	Errarhout et al. (2013)	✓	-	-	-	-	-	-	-	-	✓	-	-		
2013	gayraud	Gayraud et al. (2013)	✓	-	-	-	-	-	SM1	-	-	-	-	-		
2013	jemai	Jemai et al. (2013)	✓	-	-	-	-	-	-	-	-	-	-	-		
2013	luna	Luna et al. (2013)	✓	-	-	-	-	-	-	-	-	✓	-	-		
2014	cappanera	Cappanera et al. (2014)	✓	-	-	-	-	-	-	-	-	✓	-	-		
2014	di mascolo	Di Mascolo et al. (2014)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2014	espinouse	Espinouse et al. (2014)	✓	-	-	-	-	-	-	✓	-	-	-	-		
2014	kerjosien	Kerjosien et al. (2014)	✓	-	-	-	-	-	SM5	-	-	✓	-	Pa7		
2014	labadie	Labadie et al. (2014)	✓	-	-	-	-	-	-	✓	-	-	-	-		
2014	masmoudi	Masmoudi and Mellouli (2014)	✓	-	-	-	-	-	-	-	-	-	-	-		
2014	riazi	Riazi et al. (2014)	✓	-	-	-	-	-	-	-	-	-	-	-		
2014	yuan	Yuan et al. (2014)	✓	-	-	-	-	-	-	-	-	-	-	Pa3		
2015	aiane	Aiane et al. (2015)	✓	-	-	-	-	-	-	-	-	-	-	-		
2015	cattafi	Cattafi et al. (2015)	✓	-	-	✓	-	-	-	✓	-	-	-	-		
2015	en-nahli	En-nahli et al. (2015)	✓	-	-	✓	-	-	-	✓	-	-	-	-		
2015	laesanklang	Laesanklang et al. (2015)	✓	-	-	✓	-	-	SM6	✓	-	✓	✓	Pa9		
2015	rest	Rest and Hirsch (2015)	✓	-	-	✓	-	-	-	✓	-	-	-	-		
2015	xie	Xie and Wang (2015)	✓	-	-	-	-	✓	-	-	-	-	-	-		
2016	ait haddadene	Ait Haddadene et al. (2016b)	✓	-	-	-	-	-	-	✓	-	-	-	-		
2016	decerle	Decerle et al. (2016)	✓	-	-	✓	-	-	SM6	-	-	-	-	-		
2016	en-nahli	En-nahli et al. (2016)	✓	-	-	-	-	-	-	✓	-	-	-	-		
2016	manerba	Manerba and Mansini (2016)	✓	-	✓	-	-	-	-	-	-	-	-	-		
2016	nguyen	Nguyen and Montemanni (2016)	✓	-	-	-	✓	-	-	✓	-	-	-	-		
2017	alves	Alves et al. (2017)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2017	baumann	Baumann (2017)	✓	-	-	✓	-	-	-	-	-	-	-	Pa4		
2017	carello	Carello et al. (2017)	✓	-	-	-	✓	-	-	-	-	-	-	Pa8		
2017	chen	Chen et al. (2017)	✓	✓	-	-	-	-	-	-	-	-	-	-		
2017	decerle	Decerle et al. (2017)	✓	-	-	✓	-	-	-	-	-	✓	-	-		
2017	di mascolo	Di Mascolo et al. (2017b)	✓	-	-	-	-	-	-	✓	-	✓	-	-		
2017	el hajri	El Hajri et al. (2017)	✓	-	-	✓	-	-	-	✓	-	✓	-	-		
2017	gunawan	Gunawan et al. (2017)	✓	✓	-	-	-	-	-	✓	-	-	-	-		
2017	lahrichi	Lahrichi et al. (2017)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2017	naji	Naji et al. (2017)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2017	shi	Shi et al. (2017a)	✓	-	-	-	-	-	-	-	-	-	-	-		
2017	shi	Shi et al. (2017b)	✓	-	-	-	✓	-	-	-	-	-	-	-		
2017	sinthamrongruk	Sinthamrongruk et al. (2017)	✓	-	-	-	✓	-	-	-	✓	-	-	-		
2017	xie	Xie and Wang (2017)	✓	-	-	-	-	-	-	-	-	-	-	-		
2017	yalcındağ	Yalcındağ and Matta (2017)	✓	-	-	-	-	-	-	-	-	✓	-	SM4		
2018	alves	Alves et al. (2018b)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2018	alves	Alves et al. (2018a)	✓	-	-	-	-	-	-	-	-	-	-	-		
2018	decerle	Decerle et al. (2018c)	✓	-	-	-	-	-	SM6	-	-	✓	-	Pa6		
2018	decerle	Decerle et al. (2018a)	✓	-	-	-	-	-	-	-	✓	✓	-	Pa6		
2018	di mascolo	Di Mascolo et al. (2018)	✓	-	-	-	-	-	-	✓	-	✓	-	-		
2018	eliseu	Eliseu et al. (2018)	✓	-	-	-	-	-	-	-	-	-	-	-		
2018	feng	Feng and Wang (2018)	✓	-	-	-	-	-	-	-	-	-	-	Pa11		
2018	garaix	Garaix et al. (2018)	✓	-	-	-	-	-	SM6, SM7	✓	-	✓	-	Pa6, Pa10		
2018	martinez	Martinez et al. (2018)	✓	-	-	✓	-	-	-	✓	-	-	-	-		
2018	riazi	Riazi et al. (2018)	✓	-	-	-	-	-	-	-	-	-	-	-		
2018	siu	Siu et al. (2018)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2018	tohidifard	Tohidifard et al. (2018)	✓	-	-	-	-	-	-	-	-	-	-	-		
2018	Xiao	Xiao et al. (2018)	✓	-	-	✓	-	-	SM5	-	-	-	-	Pa6		
2018	yang	Yang et al. (2018)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2018	zhang	Zhang et al. (2018)	✓	-	-	✓	✓	-	-	-	-	-	-	-		
2019	alves	Alves et al. (2019b)	✓	-	-	✓	-	-	-	-	-	-	-	-		
2019	alves	Alves et al. (2019a)	✓	-	-	-	-	-	-	-	-	-	-	-		
2019	espadinha	Espadinha and Cardoso-Grilo (2019)	✓	-	-	-	-	-	-	-	✓	-	-	Pa10		
Sum			45	3	13	8	5	7		10	8	0	10	11	3	13
Percentage			71.4	4.76	21	12.7	7.937	11.1		15.9	12.7	0	15.9	17.5	4.76	20.6
Sub-Sum			48		29			0			29			14		0
Sub-Percentage			76.19		46.03			0			46.03			22.22		0
TOTAL SUM and %			COST: 58 (92.06%)						PREFERENCES: 35 (55.56%)							
Global Sum			116	3	21	20	23	15		24	15	17	19	26	4	42
Global Percentage			75.82	1.96	13.73	13.07	15.03	9.80		15.69	9.80	11.11	12.42	16.99	2.61	27.45
Global Sub-Sum			119		64			15			74			30		0
Global Sub-Percentage			77.27		41.56			9.74			48.05			19.48		0
TOTAL SUM and %			COST: 137 (89.54%)						PREFERENCES: 89 (58.17%)							

Pa1: max fairness among patients; **Pa2:** max patient preference; **Pa3:** min earliest arrival; **Pa4:** max preferred time slot; **Pa5:** max continuity of care; **Pa6:** min penalties of shared-visits non satisfied; **Pa7:** max number of demands; **Pa8:** min reassignment; **Pa9:** min skill level; **SM1:** min number of staff members; **SM2:** min reimbursed km; **SM3:** min overqualification; **SM4:** min the number of visits per staff member; **SM5:** min subcontracting cost; **SM6:** min payment for worker to perform a task; **O1:** min response time to disruptions; **O2:** min total number of clusters; **O3:** min environmental pollution; **O4:** max clustering efficiency **C1:** min therapy cost; **C2:** min labor cost (fixed cost of assigning a visit team);

Table 8: Constraints related to visits (Journal papers)

Year	First author	References	Visits									
			Characteristics(Ch)		Schedule (Sc)			Dependency (De)			Others	
			Hard time window (TW)	Qualification required	Multiple visits per period	Visit frequency	Visit patterns	Disjunction	Synchronization	Precedence		
1997	begur	Begur et al. (1997)	✓	✓	-	-	-	-	-	-	-	-
2000	hindle	Hindle et al. (2000)	✓	✓	-	-	-	-	-	-	-	-
2006	bertels	Bertels and Fahle (2006)	✓	✓	-	-	-	-	-	-	-	-
2006	eveborn	Eveborn et al. (2006)	✓	✓	-	-	-	-	-	-	-	-
2007	akjiratikarl	Akjiratikarl et al. (2007)	✓	✓	-	-	-	-	-	-	-	-
2008	bredstrom	Bredström and Rönnqvist (2008)	✓	✓	-	-	-	-	✓	-	-	-
2009	chahed	Chahed et al. (2009)	✓	✓	-	-	-	-	-	-	-	TW1
2009	hindle	Hindle et al. (2009)	✓	✓	-	-	-	-	-	-	-	-
2011	ben bachouch	Ben Bachouch et al. (2011)	✓	✓	-	-	-	-	✓	-	-	-
2011	bennett	Bennett and Erera (2011)	✓	✓	-	✓	✓	-	-	-	-	-
2011	trautsamwieser	Trautsamwieser and Hirsch (2011)	✓	✓	-	-	-	-	-	-	-	-
2011	trautsamwieser	Trautsamwieser et al. (2011)	✓	✓	-	✓	-	-	-	-	-	-
2012	an	An et al. (2012)	✓	✓	-	-	-	-	-	-	-	-
2012	nickel	Nickel et al. (2012)	✓	✓	-	✓	✓	-	-	-	-	-
2012	rasmussen	Rasmussen et al. (2012)	✓	✓	-	-	-	-	-	Min	-	-
2012	shao	Shao et al. (2012)	✓	✓	-	-	-	-	-	-	-	Ch1
2012	allaoua	Allaoua et al. (2013)	✓	✓	-	✓	✓	-	-	-	-	-
2013	bard	Bard et al. (2013)	✓	✓	-	-	-	-	-	-	-	-
2013	cappanera	Cappanera and Scutellà (2013)	✓	✓	-	✓	✓	-	-	-	-	-
2013	motingi	Motingi and Mbohwa (2013a)	✓	✓	-	-	-	-	-	-	-	-
2014	bard	Bard et al. (2014a)	✓	✓	-	-	-	-	-	-	-	-
2014	bard	Bard et al. (2014b)	✓	✓	-	-	-	-	-	Min	-	-
2014	cappanera	Cappanera and Scutellà (2014)	✓	✓	-	-	✓	-	✓	-	-	-
2014	carello	Carello and Lanzarone (2014)	✓	✓	-	-	-	-	-	-	-	-
2014	di gaspero	Di Gaspero and Urfi (2014)	✓	✓	-	-	✓	-	-	-	-	-
2014	lanzarone	Lanzarone and Matta (2014)	✓	✓	-	-	-	-	-	-	-	-
2014	mankowska	Mankowska et al. (2014)	✓	✓	-	-	-	-	✓	Min	-	-
2014	motingi	Motingi and Mbohwa (2014)	✓	✓	-	-	-	-	✓	-	-	-
2014	trautsamwieser	Trautsamwieser and Hirsch (2014)	✓	✓	-	-	-	-	-	-	-	-
2015	bowers	Bowers et al. (2015)	✓	✓	-	-	-	-	-	-	-	-
2015	fikar	Fikar and Hirsch (2015)	✓	✓	-	-	-	-	-	-	-	-
2015	hiermann	Hiermann et al. (2015)	✓	✓	-	-	-	-	-	-	-	-
2015	issaoui	Issaoui et al. (2015a)	✓	✓	-	-	-	-	-	-	-	-
2015	lieder	Lieder et al. (2015)	✓	✓	-	-	-	-	-	-	-	-
2015	maya duque	Maya Duque et al. (2015)	✓	✓	-	✓	✓	-	-	-	-	Sc1
2015	misir	Misir et al. (2015)	✓	✓	-	-	-	-	-	-	-	-
2015	rodriguez	Rodriguez et al. (2015)	✓	✓	-	-	-	-	-	-	-	-
2015	yuan	Yuan et al. (2015)	✓	✓	-	-	-	-	-	-	-	-
2016	ait haddadene	Ait Haddadene et al. (2016a)	✓	✓	-	-	-	-	✓	Exact	-	-
2016	braekers	Braekers et al. (2016)	✓	✓	-	-	-	-	-	-	-	-
2016	fikar	Fikar et al. (2016)	✓	✓	-	-	-	-	-	-	-	-
2016	heching	Heching and Hooker (2016)	✓	✓	-	✓	-	-	-	-	-	-
2016	lin	Lin et al. (2016)	✓	✓	-	-	-	✓	-	-	-	-
2016	redjem	Redjem and Marcon (2016)	✓	✓	-	✓	-	✓	-	Min	-	-
2016	rest	Rest and Hirsch (2016)	✓	✓	-	-	-	-	-	-	-	-
2016	wirmitzer	Wirmitzer et al. (2016)	✓	✓	-	-	✓	-	-	-	-	-
2016	yalcindag	Yalcindag et al. (2016b)	✓	✓	-	-	-	-	-	-	-	-
2016	yalcindag	Yalcindag et al. (2016a)	✓	✓	-	-	✓	-	-	-	-	-
2017	cappanera	Cappanera et al. (2017)	✓	✓	-	-	✓	-	-	-	-	-
2017	du	Du et al. (2017b)	✓	✓	-	-	-	-	-	-	-	-
2017	du	Du et al. (2017a)	✓	✓	-	-	-	-	-	-	-	-
2017	erdem	Erdem and Bulkan (2017)	✓	✓	-	-	-	-	✓	-	-	-
2017	frifita	Frifita et al. (2017)	✓	✓	-	✓	-	-	✓	-	-	-
2017	guericke	Guericke and Suhl (2017)	✓	✓	-	-	-	-	-	-	-	-
2017	liu	Liu et al. (2017)	✓	✓	-	-	-	-	-	-	-	-
2017	luna	Luna et al. (2017)	✓	✓	-	-	-	-	-	-	-	-
2017	marcon	Marcon et al. (2017)	✓	✓	-	✓	-	✓	-	-	-	-
2017	quintana	Quintana et al. (2017)	✓	✓	-	-	-	-	-	-	-	-
2017	shi	Shi et al. (2017c)	✓	✓	-	-	-	-	-	-	-	-
2017	yuan	Yuan and Jiang (2017)	✓	✓	-	-	✓	-	-	-	-	-
2018	carello	Carello et al. (2018)	✓	✓	-	-	-	-	-	-	-	-
2018	decerle	Decerle et al. (2018b)	✓	✓	-	-	-	-	✓	-	-	-
2018	demirbilek	Demirbilek et al. (2018)	✓	✓	-	✓	✓	-	-	-	-	TW3
2018	fathollahi-fard	Fathollahi-Fard et al. (2018a)	✓	✓	-	-	-	-	-	-	-	O1
2018	fathollahi-fard	Fathollahi-Fard et al. (2018b)	✓	✓	-	-	-	-	-	-	-	-
2018	fikar	Fikar and Hirsch (2018)	✓	✓	-	-	-	-	-	-	-	-
2018	lin	Lin et al. (2018)	✓	✓	-	-	-	-	-	-	-	-
2018	liu	Liu et al. (2018)	✓	✓	-	-	✓	-	-	-	-	O2
2018	mosquera	Mosquera et al. (2018)	✓	✓	-	✓	✓	-	-	-	-	-
2018	nasir	Nasir and Dang (2018)	✓	✓	-	-	-	-	-	-	-	-
2018	sinthamrongruk	Sinthamrongruk et al. (2018)	✓	✓	-	-	-	-	✓	-	-	-
2018	szander	Szander et al. (2018b)	✓	✓	-	-	-	-	-	-	-	-
2018	szander	Szander et al. (2018a)	✓	✓	-	-	✓	-	-	-	-	-
2018	yuan	Yuan et al. (2018)	✓	✓	-	-	-	-	-	-	-	-
2018	zhan	Zhan and Wan (2018)	✓	✓	-	-	-	-	-	-	-	TW2
2019	chaieb	Chaieb et al. (2019)	✓	✓	-	-	-	-	-	✓	-	-
2019	decerle	Decerle et al. (2019a)	✓	✓	-	-	-	-	✓	-	-	-
2019	decerle	Decerle et al. (2019b)	✓	✓	-	-	-	-	✓	-	-	-
2019	dekhici	Dekhici et al. (2019)	✓	✓	-	✓	-	-	✓	-	-	-
2019	demirbilek	Demirbilek et al. (2019)	✓	✓	-	✓	✓	-	-	-	-	-
2019	fathollahi-fard	Fathollahi-Fard et al. (2019)	✓	✓	-	-	-	-	-	-	-	-
2019	gomes	Gomes and Ramos (2019)	✓	✓	-	✓	-	-	-	-	-	-
2019	grenouilleau	Grenouilleau et al. (2019)	✓	✓	-	-	-	-	-	-	-	-
2019	heching	Heching et al. (2019)	✓	✓	-	✓	✓	-	-	-	-	-
2019	liu	Liu et al. (2019a)	✓	✓	-	✓	-	-	✓	-	-	-
2019	liu	Liu et al. (2019b)	✓	✓	-	-	-	-	-	-	-	-
2019	moussavi	Moussavi et al. (2019)	✓	✓	-	✓	-	-	-	-	-	TW2
2019	nasir	Nasir and Dang (2019)	✓	✓	-	-	-	-	-	-	-	-
2019	restrepo	Restrepo et al. (2019)	✓	✓	-	-	-	-	-	-	-	-
2019	riazi	Riazi et al. (2019)	✓	✓	-	-	-	-	-	-	-	-
Sum			60	52	10	15	14	3	14	6		8
Percentage (%)			66.67	57.78	11.11	16.67	15.56	3.33	15.56	6.67		8.99
SubSum			63	52		27			20			2
Sub Percentage (%)			70.00	57.78			30.00			22.22		2.25
TOTAL VISITS: sum - (%)									81	-	(90.00)	

TW1: TW for production of drugs; TW2: appointment time/fixed visit; TW3: set of possible appointment times; Sc1: forbidden patterns; CH1: visit duration depends on qualification; O1: each patient needs a specific drug; O2: required minimum visit length for patients

Table 9: Constraints related to visits (Conference papers)

Year	First authors	References	Visits							Others	
			Characteristics (Ch)			Schedule (Sc)		Dependency (De)			
			Hard visit TW	qualification required	visit duration depends on qualification	Multiple visits per period	visit frequency	Visit patterns	Synchronization		Precedence
2006	borsani	Borsani et al. (2006)	-	✓	-	✓	✓	-	-	-	-
2008	elbenani	Elbenani et al. (2008)	✓	✓	-	✓	✓	-	-	-	TW1
2009	kergosien	Kergosien et al. (2009)	✓	✓	-	-	-	✓	-	-	De1
2010	misir	Misir et al. (2010)	-	✓	-	-	-	-	-	-	-
2011	redjem	Redjem et al. (2011)	✓	✓	-	✓	-	-	-	Min	-
2012	cattafi	Cattafi et al. (2012)	✓	✓	-	-	-	-	-	-	-
2012	gamst	Gamst and Jensen (2012)	-	✓	-	-	-	-	-	-	-
2013	errarhout	Errarhout et al. (2013)	✓	✓	-	-	-	-	-	-	-
2013	gayraud	Gayraud et al. (2013)	✓	✓	✓	-	-	-	-	-	-
2013	jemai	Jemai et al. (2013)	✓	✓	-	-	-	-	-	-	-
2013	luna	Luna et al. (2013)	✓	✓	-	-	-	✓	-	-	-
2014	cappanera	Cappanera et al. (2014)	-	✓	-	-	-	✓	-	-	-
2014	di mascolo	Di Mascolo et al. (2014)	✓	✓	-	-	-	✓	-	-	-
2014	espinouse	Espinouse et al. (2014)	✓	✓	-	-	-	✓	-	Exact	De1
2014	kergosien	Kergosien et al. (2014)	✓	✓	-	-	✓	-	-	Exact	-
2014	labadie	Labadie et al. (2014)	✓	✓	-	-	-	✓	-	-	-
2014	masmoudi	Masmoudi and Mellouli (2014)	✓	✓	-	-	-	✓	-	-	-
2014	riazi	Riazi et al. (2014)	✓	✓	-	-	-	-	-	-	-
2014	yuan	Yuan et al. (2014)	-	-	-	-	-	-	-	-	-
2015	aiane	Aiane et al. (2015)	✓	-	-	-	-	-	-	-	-
2015	cattafi	Cattafi et al. (2015)	✓	-	-	-	✓	-	-	-	-
2015	en-nahli	En-nahli et al. (2015)	✓	✓	-	-	-	-	-	-	-
2015	laesanklang	Laesanklang et al. (2015)	✓	✓	-	-	-	-	-	-	-
2015	rest	Rest and Hirsch (2015)	✓	✓	-	✓	-	-	-	-	-
2015	xie	Xie and Wang (2015)	✓	✓	-	-	-	-	-	-	-
2016	ait haddaene	Ait Haddadene et al. (2016b)	✓	✓	-	✓	-	✓	-	Max	-
2016	decerle	Decerle et al. (2016)	✓	✓	-	-	-	✓	-	Max	-
2016	en-nahli	En-nahli et al. (2016)	✓	-	-	-	-	✓	-	-	-
2016	manerba	Manerba and Mansini (2016)	✓	-	-	✓	-	-	-	-	TW2
2016	nguyen	Nguyen and Montemanni (2016)	✓	✓	-	-	-	-	-	-	-
2017	alves	Alves et al. (2017)	-	✓	-	✓	-	-	-	-	-
2017	baumann	Baumann (2017)	-	✓	-	-	-	-	-	-	-
2017	carello	Carello et al. (2017)	-	-	-	-	-	-	-	-	-
2017	chen	Chen et al. (2017)	✓	✓	-	-	-	✓	-	-	-
2017	decerle	Decerle et al. (2017)	-	✓	-	-	-	✓	-	-	-
2017	di mascolo	Di Mascolo et al. (2017b)	-	✓	-	-	-	-	-	-	De1
2017	el hajri	El Hajri et al. (2017)	✓	-	-	-	-	-	-	-	-
2017	gunawan	Gunawan et al. (2017)	✓	✓	-	-	-	-	-	-	-
2017	lahrichi	Lahrichi et al. (2017)	-	-	-	-	-	✓	-	-	-
2017	naji	Naji et al. (2017)	✓	-	-	-	-	✓	-	-	-
2017	shi	Shi et al. (2017a)	-	-	-	-	-	-	-	-	-
2017	shi	Shi et al. (2017b)	-	-	-	-	-	-	-	-	-
2017	sinthamrongruk	Sinthamrongruk et al. (2017)	✓	-	-	-	-	-	-	-	-
2017	xie	Xie and Wang (2017)	✓	-	-	-	-	-	-	-	-
2017	yalcindağ	Yalçındağ and Matta (2017)	✓	-	-	-	-	✓	-	-	-
2018	alves	Alves et al. (2018b)	-	-	-	-	-	-	-	-	-
2018	alves	Alves et al. (2018a)	-	-	-	-	-	-	-	-	-
2018	decerle	Decerle et al. (2018c)	-	✓	-	✓	-	✓	-	-	O7
2018	decerle	Decerle et al. (2018a)	✓	✓	-	✓	-	✓	-	-	O7
2018	di mascolo	Di Mascolo et al. (2018)	✓	✓	-	✓	-	✓	✓	-	De1
2018	eliseu	Eliseu et al. (2018)	✓	-	-	✓	-	-	-	-	-
2018	feng	Feng and Wang (2018)	✓	-	-	-	-	-	-	-	-
2018	garaix	Garaix et al. (2018)	✓	✓	-	✓	-	✓	-	-	-
2018	martinez	Martinez et al. (2018)	✓	✓	-	✓	-	-	-	-	-
2018	riazi	Riazi et al. (2018)	✓	✓	-	-	-	-	-	-	-
2018	siu	Siu et al. (2018)	-	-	-	-	-	-	-	-	TW3
2018	tohidifard	Tohidifard et al. (2018)	✓	✓	-	-	-	-	-	-	O7
2018	Xiao	Xiao et al. (2018)	✓	✓	-	-	-	✓	-	-	-
2018	yang	Yang et al. (2018)	-	✓	✓	✓	-	-	-	-	-
2018	zhang	Zhang et al. (2018)	-	✓	✓	-	-	-	-	-	-
2019	alves	Alves et al. (2019b)	-	-	-	✓	-	-	-	-	-
2019	alves	Alves et al. (2019a)	-	-	-	-	-	✓	-	-	-
2019	espadinha	Espadinha and Cardoso-Grilo (2019)	-	-	-	-	-	✓	-	-	-
Sum			41	36	3	14	3	7	15	6	10
Percentage (%)			65.08	57.14	4.76	22.22	4.76	11.11	23.81	9.52	16.13
SubSum			42	36			23		18		3
Sub Percentage (%)			66.67	57.14			36.51		28.57		4.84
TOTAL VISITS: sum - - %			57 - - (91.94)								
Global Sum			101	88	4	24	18	21	29	12	21
Global Percentage (%)			66.01	57.52	2.61	15.69	11.76	13.73	18.95	7.84	13.73
Global Sub Sum			105	88			51		38		5
Global Sub Percentage (%)			68.63	57.52			33.33		24.84		3.27
GLOBAL VISITS: sum - - %			138 - - (90.20)								

TW1 : time window for producing drugs; TW2 : appointment time/fixed visit; TW3 : Max and Min Working Time; De1: Disjunction; O7: multiple home health care offices

Table 10: Constraints related to patients (Journal papers)

Year	First author	References	Patient preference constraints			
			Continuity of care (CC)		Time (T)	
			Same staff member	Soft TW	Preferred starting time	Other
1997	begur	Begur et al. (1997)	-	-	-	-
2000	hindle	Hindle et al. (2000)	-	-	-	-
2006	bertels	Bertels and Fahle (2006)	-	✓	-	-
2006	eveborn	Eveborn et al. (2006)	-	-	✓	-
2007	akjiraikarl	Akjiraikarl et al. (2007)	-	-	-	-
2008	bredstrom	Bredström and Rönnqvist (2008)	-	-	-	-
2009	chahed	Chahed et al. (2009)	-	-	-	-
2009	hindle	Hindle et al. (2009)	-	-	-	-
2011	ben bachouch	Ben Bachouch et al. (2011)	✓	-	-	-
2011	bennett	Bennett and Elera (2011)	-	-	-	-
2011	trautsamwieser	Trautsamwieser and Hirsch (2011)	-	-	-	-
2011	trautsamwieser	Trautsamwieser et al. (2011)	-	✓	-	-
2012	an	An et al. (2012)	-	-	-	T4
2012	nickel	Nickel et al. (2012)	✓	-	-	-
2012	rasmussen	Rasmussen et al. (2012)	-	-	-	-
2012	shao	Shao et al. (2012)	-	-	-	-
2013	allaoua	Allaoua et al. (2013)	-	-	-	-
2013	bard	Bard et al. (2013)	-	-	-	-
2013	cappanera	Cappanera and Scutellà (2013)	-	-	-	-
2013	mutingi	Mutingi and Mbohwa (2013a)	-	✓	-	-
2014	bard	Bard et al. (2014a)	-	-	-	-
2014	bard	Bard et al. (2014b)	-	-	-	-
2014	cappanera	Cappanera and Scutellà (2014)	✓	-	-	-
2014	carello	Carello and Lanzarone (2014)	✓	-	-	-
2014	di gaspero	Di Gaspero and Urli (2014)	-	-	-	T3
2014	lanzarone	Lanzarone and Matta (2014)	✓	-	-	-
2014	mankowska	Mankowska et al. (2014)	-	✓	-	-
2014	mutingi	Mutingi and Mbohwa (2014)	-	-	-	-
2014	trautsamwieser	Trautsamwieser and Hirsch (2014)	-	-	-	-
2015	bowers	Bowers et al. (2015)	✓	-	-	-
2015	fikar	Fikar and Hirsch (2015)	-	-	-	-
2015	hiermann	Hiermann et al. (2015)	-	✓	✓	-
2015	issaoui	Issaoui et al. (2015a)	-	-	-	-
2015	lieder	Lieder et al. (2015)	-	-	✓	T2
2015	maya duque	Maya Duque et al. (2015)	✓	-	✓	CC1
2015	misir	Misir et al. (2015)	-	✓	-	-
2015	rodriguez	Rodriguez et al. (2015)	-	-	-	-
2015	yuan	Yuan et al. (2015)	-	-	-	-
2016	ait haddadene	Ait Haddadene et al. (2016a)	-	-	-	CC2
2016	braekers	Braekers et al. (2016)	-	-	✓	CC2
2016	fikar	Fikar et al. (2016)	-	-	-	-
2016	heching	Heching and Hooker (2016)	✓	-	-	T1
2016	lin	Lin et al. (2016)	✓	✓	✓	-
2016	redjem	Redjem and Marcon (2016)	-	-	-	-
2016	rest	Rest and Hirsch (2016)	-	-	-	-
2016	wirmitzer	Wirmitzer et al. (2016)	✓	-	-	-
2016	yalcindag	Yalcindag et al. (2016b)	-	-	-	-
2016	yalcindag	Yalcindag et al. (2016a)	✓	-	-	-
2017	cappanera	Cappanera et al. (2017)	✓	-	-	-
2017	du	Du et al. (2017b)	-	-	-	-
2017	du	Du et al. (2017a)	-	-	✓	-
2017	erdem	Erdem and Bulkan (2017)	-	-	✓	-
2017	frifita	Frifita et al. (2017)	-	-	-	-
2017	guericke	Guericke and Suhl (2017)	-	-	-	-
2017	liu	Liu et al. (2017)	✓	-	-	-
2017	luna	Luna et al. (2017)	✓	-	-	-
2017	marcon	Marcon et al. (2017)	-	-	-	-
2017	quintana	Quintana et al. (2017)	✓	-	-	-
2017	shi	Shi et al. (2017c)	-	-	-	-
2017	yuan	Yuan and Jiang (2017)	✓	✓	-	-
2018	carello	Carello et al. (2018)	✓	-	-	-
2018	decerle	Decerle et al. (2018b)	-	✓	-	-
2018	demirbilek	Demirbilek et al. (2018)	✓	-	-	CC1
2018	fathollahi-fard	Fathollahi-Fard et al. (2018a)	-	-	-	-
2018	fathollahi-fard	Fathollahi-Fard et al. (2018b)	-	-	-	-
2018	fikar	Fikar and Hirsch (2018)	-	-	-	-
2018	lin	Lin et al. (2018)	-	-	-	-
2018	liu	Liu et al. (2018)	✓	-	-	-
2018	mosquera	Mosquera et al. (2018)	✓	-	-	-
2018	nasir	Nasir and Dang (2018)	-	-	-	-
2018	sinthamrongruk	Sinthamrongruk et al. (2018)	-	-	-	-
2018	szander	Szander et al. (2018b)	-	-	-	-
2018	szander	Szander et al. (2018a)	-	-	-	-
2018	yuan	Yuan et al. (2018)	-	-	-	-
2018	zhan	Zhan and Wan (2018)	-	-	-	-
2019	chaieb	Chaieb et al. (2019)	✓	-	-	CC2
2019	decerle	Decerle et al. (2019a)	-	✓	-	-
2019	decerle	Decerle et al. (2019b)	-	✓	-	-
2019	dekhici	Dekhici et al. (2019)	-	✓	-	-
2019	demirbilek	Demirbilek et al. (2019)	✓	-	-	CC1
2019	fathollahi-fard	Fathollahi-Fard et al. (2019)	-	-	-	-
2019	gomes	Gomes and Ramos (2019)	-	-	-	CC3
2019	grenouilleau	Grenouilleau et al. (2019)	-	-	-	-
2019	heching	Heching et al. (2019)	-	-	-	-
2019	liu	Liu et al. (2019a)	-	-	-	-
2019	liu	Liu et al. (2019b)	-	✓	-	-
2019	moussavi	Moussavi et al. (2019)	-	-	-	-
2019	nasir	Nasir and Dang (2019)	-	-	-	-
2019	restrepo	Restrepo et al. (2019)	-	-	-	-
2019	riazi	Riazi et al. (2019)	-	-	-	T4
Sum			22	13	8	13
Percentage (%)			24.44	14.44	8.89	14.61
SubSum			25	23		0
Sub Percentage (%)			27.78	25.56		0
TOTAL PATIENTS: sum - - (%)						41 - - (45.55)

CC1: same time slot; CC2: preferred staff member; CC3 : non loyalty T1: preferred day of visit; T2: earliest time; T3: latest time; T4: fixed care interval

Table 11: Constraints related to patients (Conference papers)

			Patients preference constraints				
			Continuity of care		Time		
Year	First authors	References	same staff member(s)	preferred staff member	Soft /Mixed TW	Preferred day/time of visits	Others
2006	borsani	Borsani et al. (2006)	✓	-	-	✓	-
2008	elbenani	Elbenani et al. (2008)	-	-	-	-	-
2009	kergosien	Kergosien et al. (2009)	-	-	-	-	CC4
2010	misir	Misir et al. (2010)	-	-	-	-	CC1, T5
2011	redjem	Redjem et al. (2011)	-	-	-	-	-
2012	cattafi	Cattafi et al. (2012)	-	-	-	-	-
2012	gamst	Gamst and Jensen (2012)	-	-	✓	-	-
2013	errarhout	Errarhout et al. (2013)	✓	-	-	-	-
2013	gayraud	Gayraud et al. (2013)	-	-	-	-	-
2013	jemai	Jemai et al. (2013)	-	-	-	-	-
2013	luna	Luna et al. (2013)	-	-	-	-	-
2014	cappanera	Cappanera et al. (2014)	-	-	-	-	-
2014	di mascolo	Di Mascolo et al. (2014)	-	-	-	-	-
2014	espinouse	Espinouse et al. (2014)	-	-	-	-	-
2014	kergosien	Kergosien et al. (2014)	-	-	-	-	-
2014	labadie	Labadie et al. (2014)	-	-	-	-	-
2014	masmoudi	Masmoudi and Mellouli (2014)	-	-	-	-	-
2014	riazi	Riazi et al. (2014)	-	-	-	-	-
2014	yuan	Yuan et al. (2014)	-	-	-	-	T3
2015	aiane	Aiane et al. (2015)	-	-	-	-	-
2015	cattafi	Cattafi et al. (2015)	-	-	-	✓	-
2015	en-nahli	En-nahli et al. (2015)	-	✓	-	-	-
2015	laesanklang	Laesanklang et al. (2015)	-	-	-	-	-
2015	rest	Rest and Hirsch (2015)	-	-	-	✓	-
2015	xie	Xie and Wang (2015)	-	-	-	-	-
2016	ait haddaene	Ait Haddadene et al. (2016b)	-	✓	-	-	-
2016	decerle	Decerle et al. (2016)	-	-	-	-	-
2016	en-nahli	En-nahli et al. (2016)	-	-	-	-	-
2016	manerba	Manerba and Mansini (2016)	-	-	-	-	-
2016	nguyen	Nguyen and Montemanni (2016)	-	-	-	✓	-
2017	alves	Alves et al. (2017)	-	-	-	-	-
2017	baumann	Baumann (2017)	✓	-	-	-	-
2017	carello	Carello et al. (2017)	✓	-	-	-	-
2017	chen	Chen et al. (2017)	✓	-	-	-	-
2017	decerle	Decerle et al. (2017)	-	-	✓	-	-
2017	di mascolo	Di Mascolo et al. (2017b)	✓	-	-	-	-
2017	el hajri	El Hajri et al. (2017)	-	-	-	-	-
2017	gunawan	Gunawan et al. (2017)	-	-	-	-	-
2017	lahrichi	Lahrichi et al. (2017)	-	-	-	-	-
2017	naji	Naji et al. (2017)	-	-	-	-	-
2017	shi	Shi et al. (2017a)	-	-	-	-	-
2017	shi	Shi et al. (2017b)	-	-	-	-	-
2017	sinthamrongruk	Sinthamrongruk et al. (2017)	-	-	-	-	-
2017	xie	Xie and Wang (2017)	-	-	-	-	-
2017	yalcindag	Yalçındağ and Matta (2017)	✓	-	-	-	-
2018	alves	Alves et al. (2018b)	-	-	-	-	-
2018	alves	Alves et al. (2018a)	-	-	-	-	-
2018	decerle	Decerle et al. (2018c)	-	-	✓	-	-
2018	decerle	Decerle et al. (2018a)	-	-	-	-	-
2018	di mascolo	Di Mascolo et al. (2018)	-	-	✓	-	O8
2018	eliseu	Eliseu et al. (2018)	-	✓	✓	-	-
2018	feng	Feng and Wang (2018)	-	-	-	-	T5
2018	garaix	Garaix et al. (2018)	-	✓	-	-	-
2018	martinez	Martinez et al. (2018)	✓	-	-	-	-
2018	riazi	Riazi et al. (2018)	-	-	-	-	-
2018	siu	Siu et al. (2018)	✓	-	-	-	T3
2018	tohidifard	Tohidifard et al. (2018)	-	-	-	-	-
2018	Xiao	Xiao et al. (2018)	-	✓	-	-	-
2018	yang	Yang et al. (2018)	-	✓	✓	-	-
2018	zhang	Zhang et al. (2018)	-	-	✓	-	-
2019	alves	Alves et al. (2019b)	✓	-	-	-	-
2019	alves	Alves et al. (2019a)	✓	-	-	-	-
2019	espadinha	Espadinha and Cardoso-Grilo (2019)	-	-	-	✓	-
Sum			11	6	7	5	6
Percentage (%)			17.46	9.52	11.11	7.94	9.52
SubSum			19		16		1
Sub Percentage (%)			30.16		25.40		1.59
TOTAL PATIENTS: sum -- (%)			30 -- (47.62)				
Global Sum			33	9	20	6	19
Global Percentage (%)			21.57	5.88	13.07	3.92	12.42
Global SubSum			44		39		1
Global Sub Percentage (%)			28.76		25.49		0.65
GLOBAL PATIENTS: sum -- (%)			71 -- (46.41)				

CC1: same time slot; CC4: pre-assigned staff member ; T3: latest time; T5: preferred starting time; O8: preferred staff member gender

Table 12: Constraints related to staff members (Journal papers)

Year	First author	References	Staff Members' constraints									
			Characteristics (Ch)			Rules (R.)		Transport				
			Skill level	Hard TW/ availability	Soft TW	Legislative rules : break lunch, max working time, Max working time before/after break	Limited number of visited patients	district / region	Incompatibility with patients	Mode	Others	
1997	begur	Begur et al. (1997)	✓	-	-	-	-	-	-	-	-	
2000	hindle	Hindle et al. (2000)	-	✓	-	-	-	-	-	-	-	
2006	bertels	Bertels and Fahle (2006)	✓	✓	-	-	-	-	-	-	-	
2006	eveborn	Eveborn et al. (2006)	-	✓	-	✓	-	✓	-	-	-	
2007	akjiratkarl	Akjiratkarl et al. (2007)	-	-	✓	-	-	-	-	-	-	
2008	bredstrom	Bredström and Rönqvist (2008)	-	✓	-	-	-	-	-	-	-	
2009	chahed	Chahed et al. (2009)	-	-	-	-	-	-	-	-	-	
2009	hindle	Hindle et al. (2009)	-	✓	-	-	-	-	-	-	-	
2011	ben bachouch	Ben Bachouch et al. (2011)	✓	-	-	✓	-	✓	-	-	-	
2011	bennett	Bennett and Erera (2011)	-	✓	-	-	-	-	-	-	-	
2011	trautsamwieser	Trautsamwieser and Hirsch (2011)	✓	-	✓	✓	-	✓	-	-	R1	
2011	trautsamwieser	Trautsamwieser et al. (2011)	✓	-	✓	✓	-	✓	-	-	-	
2012	an	An et al. (2012)	-	✓	-	✓	-	-	-	-	-	
2012	nickel	Nickel et al. (2012)	-	✓	-	✓	-	-	-	-	-	
2012	rasmussen	Rasmussen et al. (2012)	-	✓	-	✓	-	-	-	-	-	
2012	shao	Shao et al. (2012)	-	✓	-	✓	-	-	-	-	-	
2013	allaoua	Allaoua et al. (2013)	-	✓	-	✓	-	-	-	-	-	
2013	bard	Bard et al. (2013)	-	✓	-	✓	-	-	-	-	-	
2013	cappanera	Cappanera and Scutellà (2013)	-	✓	-	✓	-	-	-	-	-	
2013	mutingi	Mutingi and Mbohwa (2013a)	-	✓	-	✓	-	-	-	-	-	
2014	bard	Bard et al. (2014a)	-	✓	-	✓	-	-	-	-	-	
2014	bard	Bard et al. (2014b)	-	✓	✓	✓	-	-	-	-	-	
2014	cappanera	Cappanera and Scutellà (2014)	-	✓	-	✓	-	-	-	-	-	
2014	carello	Carello and Lanzarone (2014)	-	✓	-	✓	-	✓	-	-	-	
2014	di gaspero	Di Gaspero and Urli (2014)	-	✓	-	✓	-	-	-	-	-	
2014	lanzarone	Lanzarone and Matta (2014)	-	✓	-	✓	-	-	-	-	-	
2014	mankowska	Mankowska et al. (2014)	-	✓	-	✓	-	-	-	-	-	
2014	mutingi	Mutingi and Mbohwa (2014)	-	✓	✓	✓	-	-	-	-	-	
2014	trautsamwieser	Trautsamwieser and Hirsch (2014)	-	✓	✓	✓	-	✓	-	-	-	
2015	bowers	Bowers et al. (2015)	-	✓	-	✓	-	-	-	-	-	
2015	fikar	Fikar and Hirsch (2015)	-	✓	-	✓	✓	-	sharing vehicles, walk	-	R3, R4	
2015	hiermann	Hiermann et al. (2015)	-	✓	-	✓	-	✓	Public or car	-	R2	
2015	issaoui	Issaoui et al. (2015a)	-	✓	-	✓	-	-	-	-	-	
2015	lieder	Lieder et al. (2015)	-	✓	-	✓	-	-	-	-	-	
2015	maya duque	Maya Duque et al. (2015)	-	✓	-	✓	-	-	-	-	-	
2015	misir	Misir et al. (2015)	-	✓	✓	✓	-	-	-	-	-	
2015	rodriguez	Rodriguez et al. (2015)	-	✓	-	✓	-	✓	-	-	-	
2015	yuan	Yuan et al. (2015)	-	✓	-	✓	✓	-	-	-	-	
2016	ait haddadene	Ait Haddadene et al. (2016a)	-	✓	✓	✓	-	-	-	-	-	
2016	braeckers	Braeckers et al. (2016)	-	✓	-	✓	-	-	public - car	-	-	
2016	fikar	Fikar et al. (2016)	-	✓	-	✓	-	-	sharing vehicles, walk	-	R4	
2016	heching	Heching and Hooker (2016)	-	✓	✓	✓	-	-	-	-	-	
2016	lin	Lin et al. (2016)	-	✓	-	✓	-	-	-	-	-	
2016	redjem	Redjem and Marcon (2016)	-	✓	✓	✓	-	-	-	-	-	
2016	rest	Rest and Hirsch (2016)	-	✓	-	✓	-	✓	public mode	-	-	
2016	wirmitzer	Wirmitzer et al. (2016)	-	✓	-	✓	-	✓	-	-	R2	
2016	yalcindag	Yalcindag et al. (2016b)	-	✓	✓	✓	-	-	-	-	-	
2016	yalcindag	Yalcindag et al. (2016a)	-	✓	✓	✓	-	-	-	-	-	
2017	cappanera	Cappanera et al. (2017)	-	✓	-	✓	-	-	-	-	-	
2017	du	Du et al. (2017b)	-	✓	-	✓	-	-	-	-	-	
2017	du	Du et al. (2017a)	-	✓	-	✓	-	-	-	-	-	
2017	erdem	Erdem and Bulkan (2017)	-	✓	-	✓	-	✓	public-car	-	-	
2017	frifita	Frifita et al. (2017)	-	✓	-	✓	-	-	-	-	-	
2017	guericke	Guericke and Suhl (2017)	-	✓	✓	✓	-	-	-	-	-	
2017	liu	Liu et al. (2017)	-	✓	-	✓	-	-	-	-	-	
2017	luna	Luna et al. (2017)	-	✓	-	✓	-	-	-	-	-	
2017	marcon	Marcon et al. (2017)	-	✓	-	✓	-	-	-	-	-	
2017	quintana	Quintana et al. (2017)	-	✓	-	✓	-	✓	-	-	-	
2017	shii	Shi et al. (2017c)	-	✓	-	✓	-	-	-	-	-	
2017	yuan	Yuan and Jiang (2017)	-	✓	-	✓	-	-	-	-	-	
2018	carello	Carello et al. (2018)	-	✓	-	✓	-	✓	-	-	-	
2018	decerle	Decerle et al. (2018b)	-	✓	✓	✓	-	-	-	-	-	
2018	demirbilek	Demirbilek et al. (2018)	-	✓	-	✓	-	-	-	-	-	
2018	fathollahi-fard	Fathollahi-Fard et al. (2018a)	-	✓	-	✓	-	-	public-car-other	-	R6	
2018	fathollahi-fard	Fathollahi-Fard et al. (2018b)	-	✓	-	✓	-	-	public-car-other	-	-	
2018	fikar	Fikar and Hirsch (2018)	-	✓	-	✓	✓	-	sharing vehicles, walk	-	R3, R4	
2018	lin	Lin et al. (2018)	-	✓	-	✓	-	-	-	-	-	
2018	liu	Liu et al. (2018)	-	✓	-	✓	-	-	-	-	R5	
2018	mosquera	Mosquera et al. (2018)	-	✓	✓	✓	-	✓	-	-	-	
2018	nasir	Nasir and Dang (2018)	-	✓	-	✓	-	-	-	-	-	
2018	sinthamrongruk	Sinthamrongruk et al. (2018)	-	✓	-	✓	-	-	-	-	-	
2018	szander	Szander et al. (2018b)	-	✓	-	✓	✓	-	-	-	-	
2018	szander	Szander et al. (2018a)	-	✓	-	✓	-	-	public - car	-	-	
2018	yuan	Yuan et al. (2018)	-	✓	-	✓	-	-	-	-	-	
2018	zhan	Zhan and Wan (2018)	-	✓	-	✓	-	-	-	-	-	
2019	chaieb	Chaieb et al. (2019)	-	✓	✓	✓	-	✓	public - car	-	-	
2019	decerle	Decerle et al. (2019a)	-	✓	-	✓	-	-	car	-	-	
2019	decerle	Decerle et al. (2019b)	-	✓	-	✓	-	-	car	-	-	
2019	dekhici	Dekhici et al. (2019)	-	✓	-	✓	-	-	-	-	-	
2019	demirbilek	Demirbilek et al. (2019)	-	✓	✓	✓	-	✓	public - car	-	-	
2019	fathollahi-fard	Fathollahi-Fard et al. (2019)	-	✓	-	✓	-	-	-	-	-	
2019	gomes	Gomes and Ramos (2019)	-	✓	-	✓	-	-	-	-	-	
2019	grenouilleau	Grenouilleau et al. (2019)	-	✓	✓	✓	-	-	-	-	-	
2019	heching	Heching et al. (2019)	-	✓	-	✓	-	-	-	-	-	
2019	liu	Liu et al. (2019a)	-	✓	-	✓	-	-	-	-	-	
2019	liu	Liu et al. (2019b)	-	✓	-	✓	-	-	-	-	-	
2019	moussavi	Moussavi et al. (2019)	-	✓	-	✓	-	-	-	-	-	
2019	nasir	Nasir and Dang (2019)	-	✓	-	✓	-	-	-	-	-	
2019	restrepo	Restrepo et al. (2019)	-	✓	-	✓	-	✓	-	-	-	
2019	riazi	Riazi et al. (2019)	-	✓	✓	✓	-	-	-	-	-	
Sum				50	41	4	41	7	11	9	14	8
Percentage (%)				56.56	45.56	4.44	45.56	7.78	12.22	10.00	15.56	8.89
SubSum				50	45		46		11	9	14	0
Sub Percentage (%)				55.56	50.00		51.11		12.22	10.00	15.56	0
TOTAL STAFF MEMBERS sum - (%)									77	-	(85.56)	

R1: soft time window break; R2: additional jobs : meeting, administrative, etc.; R3: maximum walking duration; R4: maximum number of downgrading allowed per nurse; R5: fixed working days for nurses; R6: limited traveling time for each nurse

Table 13: Constraints related to staff members (Conference papers)

			Staff Member constraints				
			Characteristics (Ch)		Rules (R)		
Year	First authors	References	Skill level	Hard staff member TW	Legislative rules : break lunch, max working time, max working time before/after break	district/region	Others
2006	borsani	Borsani et al. (2006)	✓	-	✓	✓	-
2008	elbenani	Elbenani et al. (2008)	-	✓	-	✓	-
2009	kergosien	Kergosien et al. (2009)	✓	✓	✓	-	-
2010	misir	Misir et al. (2010)	✓	-	-	-	-
2011	redjem	Redjem et al. (2011)	-	✓	-	-	-
2012	cattafi	Cattafi et al. (2012)	✓	✓	-	-	-
2012	gamst	Gamst and Jensen (2012)	✓	✓	-	✓	-
2013	errarhout	Errarhout et al. (2013)	✓	✓	✓	✓	-
2013	gayraud	Gayraud et al. (2013)	✓	✓	-	-	-
2013	jemai	Jemai et al. (2013)	✓	✓	-	✓	-
2013	luna	Luna et al. (2013)	-	✓	✓	✓	-
2014	cappanera	Cappanera et al. (2014)	-	✓	-	-	-
2014	di mascolo	Di Mascolo et al. (2014)	-	✓	-	-	-
2014	espinouse	Espinouse et al. (2014)	✓	-	-	-	R7
2014	kergosien	Kergosien et al. (2014)	✓	✓	✓	-	O9, O3
2014	labadie	Labadie et al. (2014)	✓	✓	-	-	-
2014	masmoudi	Masmoudi and Mellouli (2014)	-	-	-	-	-
2014	riazi	Riazi et al. (2014)	✓	✓	-	-	-
2014	yuan	Yuan et al. (2014)	-	✓	-	-	-
2015	aiane	Aiane et al. (2015)	-	✓	✓	✓	-
2015	cattafi	Cattafi et al. (2015)	✓	✓	-	-	-
2015	en-nahli	En-nahli et al. (2015)	✓	-	✓	-	-
2015	laesanklang	Laesanklang et al. (2015)	✓	✓	-	✓	-
2015	rest	Rest and Hirsch (2015)	✓	-	✓	-	O4,Ch1
2015	xie	Xie and Wang (2015)	✓	✓	-	-	-
2016	ait haddaene	Ait Haddadene et al. (2016b)	✓	✓	-	-	-
2016	decerle	Decerle et al. (2016)	✓	✓	-	-	-
2016	en-nahli	En-nahli et al. (2016)	-	✓	-	-	-
2016	manerba	Manerba and Mansini (2016)	-	-	✓	-	-
2016	nguyen	Nguyen and Montemanni (2016)	✓	-	✓	-	Ch1
2017	alves	Alves et al. (2017)	✓	-	-	-	-
2017	baumann	Baumann (2017)	-	✓	✓	-	-
2017	carello	Carello et al. (2017)	-	-	-	-	-
2017	chen	Chen et al. (2017)	✓	✓	-	-	-
2017	decerle	Decerle et al. (2017)	✓	✓	-	-	-
2017	di mascolo	Di Mascolo et al. (2017b)	✓	✓	✓	-	-
2017	el hajri	El Hajri et al. (2017)	-	-	-	-	-
2017	gunawan	Gunawan et al. (2017)	✓	✓	✓	-	-
2017	lahrichi	Lahrichi et al. (2017)	-	-	-	-	-
2017	naji	Naji et al. (2017)	-	-	-	-	-
2017	shi	Shi et al. (2017a)	-	-	-	-	O5
2017	shi	Shi et al. (2017b)	-	-	✓	-	O5
2017	sinthamrongruk	Sinthamrongruk et al. (2017)	-	-	-	-	O4,R7
2017	xie	Xie and Wang (2017)	-	-	-	-	-
2017	yalcindag	Yalcındağ and Matta (2017)	-	-	-	-	-
2018	alves	Alves et al. (2018b)	-	-	-	-	-
2018	alves	Alves et al. (2018a)	-	-	-	-	-
2018	decerle	Decerle et al. (2018c)	✓	✓	-	-	-
2018	decerle	Decerle et al. (2018a)	-	✓	-	-	-
2018	di mascolo	Di Mascolo et al. (2018)	✓	✓	-	-	-
2018	eliseu	Eliseu et al. (2018)	-	✓	✓	-	O6
2018	feng	Feng and Wang (2018)	-	-	-	-	-
2018	garaix	Garaix et al. (2018)	✓	✓	-	-	-
2018	martinez	Martinez et al. (2018)	✓	✓	✓	-	O6
2018	riazi	Riazi et al. (2018)	✓	✓	-	-	-
2018	siu	Siu et al. (2018)	-	-	✓	-	-
2018	tohidifard	Tohidifard et al. (2018)	✓	-	-	-	O5
2018	Xiao	Xiao et al. (2018)	✓	✓	✓	-	-
2018	yang	Yang et al. (2018)	✓	-	-	-	-
2018	zhang	Zhang et al. (2018)	✓	-	-	✓	-
2019	alves	Alves et al. (2019b)	-	-	-	-	-
2019	alves	Alves et al. (2019a)	-	-	-	-	-
2019	espadinha	Espadinha and Cardoso-Grilo (2019)	-	-	-	-	-
Sum			34	33	18	9	10
Percentage (%)			53.97	52.38	28.57	14.29	15.87
SubSum			44		21		
Sub Percentage (%)			69.84		33.33		
TOTAL STAFF MEMBERS sum - - (%)			48 - - (76.19)				
Global Sum			84	89	59	20	18
Global Percentage (%)			54.90	58.17	38.56	13.07	11.76
SubSum			76.00		21.00		
Sub Percentage (%)			49.67		13.64		
TOTAL STAFF MEMBERS sum - - (%)			125 - - (81.70)				

R7 : limited number of patients visited per nurse; O3: stops at drop off points; O4:transport mode personal car & walk; O5 : vehicle capacity; O6 : nurses in team of 7 or less, traveling in different vehicles; O9: maximum transport delay for some blood samples; Ch1: soft SM time window

Table 14: Uncertainties and dynamic changes

Year	References	Uncertainties/Changes							Modeling												
		Demands	Patients	Staff	Other	Type	Variables	Model	Objective function												
2011	bennett	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2012	nickel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2014	<i>cappanera</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2014	carello	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2014	lazarone	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2015	<i>rest</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2015	rodriguez	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2015	yuán	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2016	fikar	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2016	heching	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2016	<i>nygren</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2016	<i>yalding</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	cappanera	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>carello</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>chen</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>di mascolo</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	du	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>gunawan</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	marcon	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>naji</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>shi</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	<i>xie</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2017	yuán	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	alves	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	demirbilek	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	lin	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	mosquera	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	nasir	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	<i>wang</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	yuán	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	zhan	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2018	<i>zhang</i>	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2019	demirbilek	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2019	liu	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2019	gomes	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2019	nasir	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
2019	restrepo	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sum		9	16	8	11	9	2	2	5	2	-	-	-	-	-	-	-	-	-	-	
Percentage (%)		24.3	43.2	21.6	29.7	24.3	5.4	5.4	13.5	5.4	3	10	6	11	14	6	4	4	3	5	
											8.1	27.0	16.2	29.7	38.9	16.7	11.1	11.1	8.3	13.5	14.3

Conference papers are in *italic*.

CaCM: Cardinality constrained model; **ChCM:** Chance constrained model; **SBA:** Scenario based approach; **SMR :** Stochastic model with recourse; **SP:** Stochastic programming; **MaS:** Multi-agent Simulation; **DE-meta:** discrete event driven metaheuristic
U1: broken vehicle; **U2:** change of visit frequency; **O1:** Min reassignment costs; **O2:** Min nb tours impacted; **O3:** Min response time; **O4:** Min deviation from preferred time and frequency;

HIGHLIGHTS

- Synthesis of the literature dealing on routing and scheduling in HHC context
- Numerical analysis and classification of the papers
- Focus on the uncertain and dynamic aspects
- Discussions on current trends in HHC routing and scheduling
- Future research directions