Home Healthcare Staff Scheduling: A Taxonomic State-of-the-Art Review

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Abstract - **Home healthcare staff scheduling has become increasingly important as healthcare business becomes more service oriented and cost conscious. With the ever increasing home care needs, healthcare staff shortages, increasing world-wide pressure for improved health care, and the rising healthcare costs, developing appropriate models for optimizing home healthcare operations is imperative. Healthcare service providers require effective decision support tools to meet customer expectations in a cost effective manner, satisfy staff requirements such as flexible work shifts, shift equity, individual preferences, part-time work, and meet management goals. Various methods have been developed to solve homecare staff scheduling problems. In this paper, we make a state-of-the-art review of the models and algorithms that have been reported in the literature. In addition, we analyze the existing empirical studies, identifying the research trends and voids in home healthcare staff scheduling. Finally, we identify essential prospective research avenues.**

Keywords – **Homecare, home healthcare, homecare staff scheduling, taxonomy, modeling approaches**

I. INTRODUCTION

Home healthcare services provide health care and assistance to people in their homes, in accordance with their specific healthcare needs [1] [2]. This is necessitated by the ever-increasing need for care and support from people in the community, particularly those with physical disabilities, learning disabilities, chronic diseases, and elderly people who need assistance and medical treatment in their own homes [3] [4]. It is quite an advantage to allow elderly people and other patients (clients) with varying disabilities and chronic diseases to receive assistance and medical treatment in their homes since long-term stay in nursing homes is often much more costly than home-based care [5] [6]. Consequently, home healthcare services can provide a more cost-effective and flexible mechanism in modern communities [6] [7] [8].

External and internal pressures increasingly impact service operations of most healthcare organisations, such that it is crucial for healthcare providers to improve their operations. Externally, governments, local communities and other stakeholders push for improved service quality and reduced healthcare service costs. Additionally, homecare organizations have to improve their operations to survive the global competition. On the other hand, internal pressures arise from employees calling for flexible work environments, equitable work schedules, and consideration of employee preferences. This situation is exacerbated by the worldwide shortages of healthcare staff [9]. It has been realized that labour costs in healthcare constitute a significant percentage of the total operational costs of most organizations [8] [9] [10] [11]. In particular, optimal staff planning and scheduling can potentially provide enormous benefits to the healthcare service providers, the employees as well as the clients. In this connection, developing appropriate approaches and decision support tools for optimizing home healthcare work schedules is imperative [8] [12]. Like other organizations, home healthcare service providers face competitive pressures to reduce cost, improve service quality, and enhance productivity at the same time [12]. One effective way the homecare services can enhance their competitiveness is to develop effective methods to deploy and utilize their healthcare staff, maximizing productivity, service quality, and employee satisfaction in the long term.

Home Healthcare Staff Scheduling (HHSS) is concerned with constructing work schedules for workforce so as to satisfy customer requirements while meeting organizational goals. Homecare service providers require effective decision support tools for three main reasons: (i) to satisfy customer expectations in a cost effective manner, (ii) to satisfy staff preferences pertaining to flexible work shifts, shift equity, part-time work, and off-days, (ii) to satisfy management goals. This calls for novel homecare staff scheduling methods to provide cost-effective and satisfactory staffing levels, task assignment to individuals according to their skills, and customer service levels. In practice, work rules and other legislative laws associated with the relevant work agreements are to be observed. A handful of methods have been offered to solve homecare staff scheduling problems. The purpose of this work is to make a state-of-the-art review of existing models and algorithms so as to provide prospective research avenues. In this regards, specific objectives for this research are:

(i) To explore extant literature on homecare staff scheduling, with a focus on empirical studies;
(ii) To identify from the literature search survey, the relevant research trends and voids; and,
(iii) To analyze and highlight the essential prospective avenues for further research.

The rest of the paper is structured thus: Section II presents the literature search survey. Section III presents a

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taxonomic study of the modeling views and methods. Section IV provides research evaluations and future research directions. Finally, Section V presents concluding remarks.

II. LITERATURE SEARCH SURVEY

A. Literature search methodology

A wide selection of sources of extant studies were utilized in compiling the information on home health care scheduling, such as EBSCO Inspec, ISI Web of Science, Ei Compendex, ScienceDirect, journals, and bibliographic studies such as [13] and [14]. The main keywords used in the search process are "home health care," "homecare scheduling," "home healthcare worker scheduling", and "home care patient assignment." This reduced the number of irrelevant studies and eliminated those studies in which homecare scheduling was not the major research focus.

B. Some statistical findings

A total of 55 bibliographical entities were realized, consisting of journal articles, book chapters, technical reports, and conference proceedings, as listed in Table I. Some of the articles were not accessible; publisher databases such as Springer and EBSCO provided limited access. As a result, only 49 articles were accessible.

Table II lists the journal articles with respect to the preferred journals. It can be observed that the most preferred journals are Journal of the Operations Research Society, the European Journal of Operational Research, and Interfaces. These three journals account for about 25% of the HHSS articles. Notably, all the publications are dominated by OR/MS literature.

Fig. 1 shows the number of HHSS articles published since the 70s. As realized from this analysis, there is an increasing trend in research focus in this field.

TABLE I
A CLASSIFIED L IST OF ARTICLES IN THE HHSS LITERATURE

Article	Count
Journal article	22
Conference proceeding	13
Book chapter	8
Technical report	6
Total	49

TABLE II
IDENTIFIED ARTICLES IN SELECTED ACADEMIC JOURNALS

Journal title	Count
Journal of the Operational Research Society	7
European Journal of Operational Research	3
Interfaces	3
OR Spectrum	2
Computers and Operations Research	2
Computers and Industrial Engineering	2
Central European Journal of Operations Research	1
Production Planning & Control	1
IEEE Transactions on Systems, Man, and Cybernetics A	1
Total	22

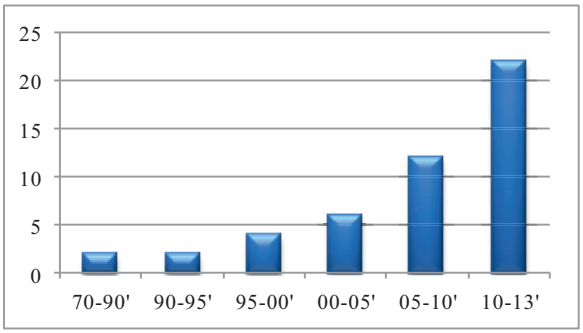

Fig. 1. Number of articles published from 1970 to 2013

III. MODELING VIEWS AND METHODOLOGIES

In this section, we highlight and present a taxonomy of the modelling views associated with homecare scheduling problems, the common objectives pursued, and the characteristic constraints. Common solution approaches and methodologies are also highlighted and classified.

A. Modeling Views

HHSS is commonly defined in terms of decision variables with two or more dimensions, expressed in terms of staff, day, task, shift, or shift patterns. Specific combinations of these dimensions depend largely on the problem context. In turn, the dimensions chosen will influence the complexity of the model. For clarity of explanation, we define the following notation:

Notation:
I number of available healthcare staff
J number of days over the planning horizon
K number of allowable shift types
T number of tasks assignable to staff
P number of patients assignable to staff
i index for staff, $1 \le i \le I$
j index for shift, $1 \le j \le J$
k index for task type, $1 \le k \le K$
p index for patients, $1 \le p \le P$

Decision variables denote the views or the types of assignment between employees, days, shifts, tasks, patients, or shift patterns. Broadly speaking, the assignments can be broadly classified into three categories: (1) two dimensional assignment, (2) three dimensional assignment, and (3) four dimensional assignment. However four dimensional assignments are limited due to their computational intractability.

1) Two-dimensional assignment: The two dimensional view of homecare staff scheduling comes in three basic forms, that is, the staff-trip or staff-task assignment, and staff-patient assignment.

TABLE III
SELECTED EMPIRICAL STUDIES AND THEIR CLASSIFICATIONS

No.	Ref.	Model view	Objective Function	Problem Type	Approach
1.	[6]	[Staff-Task]	Cost, Distance	Deterministic	Metaheuristic
2.	[7]	[Staff-Shift-Task]	Unscheduled tasks, Patient-staff loyalty, Overtime	Deterministic	Metaheuristic
3.	[8]	[Staff-Shift-Patient]	Cost, Distance	Deterministic	Heuristic-repeated matching
4.	[12]	[Staff-Patient]	Cost, Distance	Deterministic	Heuristic
5.	[15]	[Staff-Patient]	Cost, Workload	Deterministic	Linear Programming, Heuristics
6.	[18]	[Staff-Patient]	Workload, Workload imbalance	Deterministic	Metaheuristic
7.	[20]	[Staff-Patient]	Workload imbalance	Deterministic	Metaheuristic – Tabu search
8.	[27]	[Staff-Patient]	Constraint violation, Care continuity	Deterministic	Linear Programming
9.	[28]	[Staff-Patient]	Constraint violation	Deterministic	Metaheuristic
10	[29]	[Staff-Patient]	Workload imbalance	Deterministic	Linear Integer Programming
11	[33]	[Staff-Shift-Task]	Workload	Stochastic	Markov chains
12	[34]	[Staff-Patient]	Cost	Deterministic	Integer Programming
13	[36]	[Staff-Task-Patient]	Cost	Non-deterministic	Multi-agent system

Staff-Task. In this context, a task can represent a single contiguous duty or a trip consisting of a number of visits to patients to perform duties such as medical treatment and drug deliveries [6] [5] [8] [12] [17] [21]. This problem is also known as task assignment problem. The employee-task view, x_{ik}, is a two-dimensional problem defining the assignment of a task to a staff;

$$x_{ik} = \begin{cases} 1 & \text{If staff } i \text{ receives task } k \\ 0 & \text{Otherwise} \end{cases} \quad (1)$$

This view includes the case where task sequencing is not done *a priori*. Thus, staff-task assignment is when a staff i is supposed to receive task k [21].

Staff-Patient. Employee-patient assignment, commonly known as patient assignment problem, considers the assignment of patients to healthcare staff for specific homecare services [20]. A typical objective in this regard is to balance the workload of staff while assigning the patients to staff in a cost-effective manner. Therefore, the employee-patient view is a two-dimensional problem defined by variable x_{ip};

$$x_{ip} = \begin{cases} 1 & \text{If staff } i \text{ is assigned patient } p \\ 0 & \text{Otherwise} \end{cases} \quad (2)$$

2) Three-dimensional assignment: The three-dimensional view of the homecare scheduling involves the staff, the shift, and task or patient to be assigned. In this connection, we have the staff-shift-task assignment and staff-shift-patient.

Staff-Shift-Task. This category is an extension of the staff-task assignment, concerned with simultaneous assignment of shifts and tasks to staff. As such, the assignment problem can be defined by the variable x_{ijk};

$$x_{ijk} = \begin{cases} 1 & \text{If staff } i \text{ works shift } j \text{ on task } k \\ 0 & \text{Otherwise} \end{cases} \quad (3)$$

Staff-Shift-Patient. The staff-shift-patient assignment is an extension of the staff-patient view, involving the staff, the shift, and the patient. In practice, the assignment problem can be defined by a three-dimensional variable x_{ijp},

$$x_{ijp} = \begin{cases} 1 & \text{If staff } i \text{ is assigned patient } p \text{ in shift } j \\ 0 & \text{Otherwise} \end{cases} \quad (4)$$

The next step is to model the objective functions.

B. Objective Functions

Most homecare scheduling models use standard objective functions, especially in mathematical programming models. Other models use evaluation functions that are used to guide the generation and search of good solutions. For instance, a penalty cost p_{ij} may be used to evaluate the assignment of worker i to shift type j, with the objective of minimizing the total penalty cost [20]. In some situations, penalty functions are used where feasibility cannot be guaranteed. Such functions can be expressed in terms of the number of uncovered tasks, the number of violated time windows, which can then be used to evaluate possible solutions. Broadly, cost functions are calculated in terms of one or more of the following: (1) workload variation [20] [21], (2) total distance travelled by the staff [6], (3) total scheduled staff, (3) unscheduled tasks [7], (4) patient-staff loyalty, which seeks to always assign each patient to the same staff [7]. These objective functions evaluate solutions subject to constraints.

C. Constraints

Our literature survey revealed that common constraints in homecare scheduling can be broadly classified into two categories, that is, hard constraints and soft constraints. Hard constraints must be satisfied. They usually include demand coverage requirements, for instance, staff demand specified per shift type for each skill category. On the other hand, soft constraints may be violated; however, this is generally unfavourable to do so. Soft constraints entail time preferences on individual schedules. The main objective is to schedule resources so that hard constraints are satisfied while respecting to soft constraints. Broadly, we classify constraints as (i) time-based, (ii) demand-based, and (iii) preference-based constraints.

1) Time-based constraints: These constrains are restrict staff working hours per period, and time window constraints. Time-based constraints are two-fold:

T1. Staff workload: Workload limits are set according to organizational and legislative requirements.
T2. Task sequence: Specific healthcare tasks may have to be executed according to a defined sequence.
T3. Time window: Tasks are defined by earliest start and finish times, within the staff working time intervals.

2) Demand-based constraints: These ensure that client requirements are met;
D1. Skill category: Task assignment is restricted to the available skills set.
D2. Staff requirement: This ensures that the minimum requirement of staff is available to complete the duties.

3) Preference-based constraints: Concerned with satisfying desires of the staff, patients and management;
P1. Patient-staff loyalty. Patients prefer to be served by the same staff continually.
P2. Time window. Patients have predefined time for healthcare service.
P3. Management goals. Management goals set according to organizational requirements.
P4. Staff preferences on workloads and schedule times.

TABLE IV
CONSTRAINT CATEGORIES IN RRECENT STUDIES

Constraint Category	Constraint Type	Selected References
Time-based	T1	[6] [15] [17] [18] [20] [29] [30] [31]
	T2	[8] [15] [17] [20] [28] [29] [30]
	T3	[6] [7] [8] [15] [17] [18] [20] [27] [28] [29] [30] [31] [38]
Demand-based	D1	[7] [8] [15] [17] [20] [27] [28] [31]
	D2	[6] [7] [8] [15] [17] [18] [20] [28] [29] [31]
Preference-based	P1	[7] [8] [15] [18] [20] [27] [28] [31]
	P2	[15] [17] [18] [20] [27] [28] [30] [31]
	P3	[20]
	P4	[15] [20] [27] [28]

IV. RESEARCH EVALUATIONS AND DIRECTIONS

Table II presents a list of recent empirical studies and their classifications. An evaluation of recent studies shows research voids in home care studies, particularly in the joint consideration of preferences of the patient, the staff, and the management or decision maker. Realizing that homecare systems involve human elements with evolving human judgments and preferences, novel solution approaches are essential. In the presence of complex evolving human preferences, the use of satisficing approaches is crucial, encouraging more realistic and interactive modeling. Similarly, human systems, such as home healthcare systems, are inundated with fuzzy variables which are difficult to model precisely. In the presence of imprecision, the use of fuzzy approaches is called for so as to incorporate the decision maker's choices and judgments, patient preferences as well as staff preferences. With the ever increasing complexity and size of homecare scheduling problems, the development of efficient hybrid heuristic algorithms for handling large scale problems is essential. In the same vein, it is necessary to design more intelligent and interactive expert approaches that can incorporate expert opinion, and offer flexible decision support.

In view of the above facts and findings, it is highly expected that further research in these directions may assist in coming up with enhanced decision support systems for homecare staff planning and scheduling decisions. Such decision support systems should be able to satisfy organizational requirements, staff preferences, client expectations, reduce healthcare operations costs, and improve business competitiveness.

V. CONCLUDING REMARKS

The home care scheduling problem is a global concern. Various methods and approaches have been applied to solve specific problem situations. This paper focused on the state-of-the-art review of the scheduling problem, with a focus on empirical studies. It has been realized that problems cases were either deterministic or stochastic. Modeling approaches can be categorized into two-dimensional, three-dimensional views, depending on the feasible combinatorial assignments between the staff, the patient, and the task. In addition, constraints can be broadly classified into hard or soft constraints, and more strictly, into time-based, demand-based, and preference-based constraints. Furthermore, the objectives of the case studies varied from workload imbalance, total distance travelled, to total unscheduled tasks, and patient staff loyalty. Extant solution approaches fall into artificial intelligence, heuristic, metaheuristic, and optimization.

A closer look at the trends of home care studies revealed that there is need for further research in the following directions: (i) simultaneous consideration of the preferences of the patient, the staff, and the management. (ii) the use of satisficing approaches, rather than optimization approaches, which encourage more realism in modeling, (iii) the use of fuzzy approaches, due to the presence of human judgment of the decision maker, the staff, and the patient in a homecare environment, (iv) the use of efficient hybrid heuristic algorithms that are more robust and effective on large scale problems, and (v) the use of more intelligent and interactive expert approaches that incorporate expert opinion, and offer flexible decision support. Overall, it is anticipated that research in these directions will provide enhanced decision support to homecare service providers, satisfy organizational requirements, staff preferences, client expectations, and reduce healthcare operations costs, while improving business competitiveness in the global environment.

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REFERENCES

[1] E. Lanzarone, A. Matta, E. Sahin, "Operations management for homecare services: Problem of assigning human resources to patients," *IEEE Trans Sys Man Cyber A*, 2012.

[2] A. Matta, S. Chahed, E, Sahin, Y, Dallery. "Modelling home care organisations from an operations management perspective," *Flex. Serv. and Manufacturing Journal,* 2012.

[3] K, D., Rest, A. Trautsamwieser, P. Hirsch, "Trends and risks in home health care. *Journal of Humanitarian Log. and Supply Chain Management*, vol. 2, 34–53, 2012.

[4] P. Drake, B. M. Davies. "Home care outsourcing strategy," *Journal of Health Organization and Management*, vol. 20, no. 3, pp 175–193, 2006.

[5] P. Eveborn, M. Rönnqvist, H. Einarsdóttir, M. Eklund, K. Lidén, M. Almroth," O.s Research Improves Quality and Efficiency in Home Care," *Interfaces*, 39, 18-34, 2009.

[6] C. Akjiratikarl, P. Yenradee, P.R. Drake, "PSO-based algorithm for home care worker scheduling in the UK," *Comp. & Ind. Engineering*, vol. 53, pp. 559-583, 2007.

[7] S. Nickel, Schroder, M., J. Steeg, "Planning for home healthcare services," Technical report, Berichte des Fraunhofer ITWM, Nr. 173, pp. 1-23, 2009.

[8] P. Eveborn, P. Flisberg, M. Ronnqvist.. Laps Care—an operational system for staff planning of home care. *Eur. Journal of Op. Research*, vol.171, no.3, pp. 962–976, 2006.

[9] M. Mutingi, C. Mbohwa, "Dynamic simulation of healthcare manpower systems: A market-based perspective*," IASTED Conference on Modeling and Simulation*, Botswana, Sept, pp. 221-228, 2012.

[10] S. Topaloglu, S. Selim, "Nurse scheduling using fuzzy modeling*" Fuzzy Sets. Sys*, vol.161, pp. 1543–1563, 2010.

[11] P. Drake, B. M Davies, "Home care outsourcing strategy," *Journal of Health Organization and Management*, vol. 20, no. 3, pp. 175–193, 2006.

[12] S.V. Begur, D.M. Miller, J.R. Weaver, "An integrated spatial DSS for scheduling and routing home-health-care nurses," *Interfaces*, vol. 27, no. 4, pp. 35-48, 1997.

[13] A.T. Ernst, H. Jiang, M. Krishnamoorthy, D. Sier, "Staff scheduling and rostering: A review of applications, methods and models," *European Journal of Operational Research*, vol. 153, pp. 3–27, 2004.

[14] B. Cheang, H. Li, A. Lim, B. Rodrigues, "Nurse rostering problems-–a bibliographic survey," *Eur Journal of Op Research* 151, pp. 447–460, 2003.

[15] S. Bertels, T. Fahle, "A hybrid setup for a hybrid scenario: combining heuristics for the home health care problem," *Comp & Op Research*, vol.33, no.10, pp. 2866-2890, 2006.

[16] E. Cheng, J. L. Rich. "A Home health care routing and scheduling problem," Technical report, Rice University, Houston, Texas, USA, 1998.

[17] R.B. Bachouch, A.G., Liesp, L. Insa, S. Hajri-Gabouj. "An optimization model for task assignment in home healthcare," *IEEE Workshop on WHCM*, pp. 1-6, 2010.

[18] D. I. Tapia, J. Bajo, F. D. Paz, J. M. Corchado, "Hybrid Multi-agent System for Alzheimer Health Care," *Proceedings of HAIS* 2006. In S. O. Rezende, A. Carlos Roque da S. Filho (Eds.), Ribeirao Preto, Brasil.

[19] J.A. Fraile, J. Bajo, J. Abraham, J.M. Corchado, "HoCaMA: Home care hybrid multiagent architecture," In A.E. Hassanien et al. (eds.), *Pervasive Computing: Innovations in Intelligent Multimedia and Applications, Computer Communications and Networks*, Springer-Verlag London Limited, pp. 259-285, 2009

[20] A. Hertz, N. Lahrichi. "A patient assignment algorithm for home care services," *The Journal of the Op Res Society*, vol. 60, no. 4, pp. 481-495, 2009

[21] M. Mutingi, C. Mbohwa 2013. Home Healthcare Worker Scheduling: A Group Genetic Algorithm Approach. *World Congress on Engineering*, 2013, Vol. 1, July 3-5, 2013, London, U.K., pp. 721-725.

[22] J. Steeg, "Mathematical models and algorithms for home health care services," Dissertation, Technische Universit at Kaiserslautern, 2008.

[23] R.E. Bellman, L.A. Zadeh, "Decision making in a fuzzy environment," *Man. Science*, vol. 17, pp. 141–164, 1970.

[24] J. C. Bezdek, "Editorial: fuzzy models-what are they and why?" *IEEE Trans on Fuzzy Sys*, vol.1, no.1, pp.1–6, 1993.

[25] Sakawa, M. Fuzzy Sets and Interactive Multi-objective Optimization, Plenum Press, New York, 1993.

[26] Y-J. An, Y-D. Kim, B.J. Jeong, S-D Kim, "Scheduling healthcare services in a home healthcare system," *Journal of the Op. Res Society*, vol. 63, pp. 1589–1599, 2012.

[27] V. Borsani, A. Matta, G. Beschi, F. Sommaruga, "A home care scheduling model for human resources," *Third IEEE/International Conference Service Systems And Serv Management*, Troyes, France, pp.449-454, 2006.

[28] G. Hiermann, M. Prandtstetter, et al. "Metaheuristics for solving a multimodal home-healthcare scheduling problem," *Cent Eur Journal of Op. Research,* 2013.

[29] S. Trabelsi, R. Larbi, A. H. Alouane. "Linear Integer Programming for the Home Health Care Problem", in F. Daniel et al. (Eds.): BPM 2011 Workshops, Part II, LNBIP 100, Springer-Verlag Berlin Heidelberg, pp.143–151, 2012.

[30] A. Trautsamwieser , M. Gronalt, P. Hirsch, "Securing home health care in times of natural disasters," *OR Spectrum*, vol. 33, pp. 787–813, 2011

[31] A. Trautsamwieser, P. Hirsch, "Optimization of daily scheduling for home health care services. *Journal of Applied Operational Research*, vol. 3, 124–136, 2011.

[32] C.J. Woodward, A.S. Tedford, B. Hutchison. "What is important to continuity in home care? Perspectives of key stakeholders," *Soc Sci & Med*, vol.58, no.1, 177–192, 2004.

[33] E. Lanzarone, A. Matta, G. Scaccabarozzi, "A patient stochastic model to support human resource planning in home care," *Prod Plan & Cont*, vol.21, no.1, 3–25, 2010.

[34] M.S. Rasmussen, T. Justesen, A. Dohn, J. Larsen, "The Home Care Crew Scheduling Problem: Preference-based visit clustering and temporal dependencies," *European Journal of Operational Research*, vol. 219, 598–610, 2012.

[35] J. F. Bard, Y. Shao, H. Wang, "Weekly scheduling models for travelling therapists," *Socio-Eco Plan Scie* (in press).

[36] J.M. Corchado, J. Bajo, A. Abraham, "GerAmi: Improving Healthcare Deliveryin Geriatric Residences," *Ambient Intelligence, IEE Intelligent Systems*, 19-25, 2008

[37] J. Bajo, J.A. Fraile, B. Pérez-Lancho, J. M. Corchado, "The THOMAS architecture in Home Care scenarios: A case study," *Exp. Syst with Appl.*, vol. 37, 3986–3999, 2010

[38] Y. Kergosien, C. Lent´e, J.C. Billaut. Home health care problem: an extended multiple traveling salesman problem. *In: MISTA 2009*, pp 85–92, 2009

[39] P. Rivett, P. Roberts, 1995. Community Health Care in Rochdale Family Health Services Authority. *Journal of the Op. Research Society*, vol.46,pp 1079-108,

[40] T.M. Williams 1981. "Allocating the Home Help Services," *Journal of the Op. Research Society*, 32, pp331-331.

[41] M. Mutingi, Mbohwa, C. 2013. A home healthcare multi-agent system in a multi-objective environment. *25th Annual Conf of the SAIIE*, 9-11 July, Stellenbosch, SA, pp 1-10.