A Survey of the Nurse Rostering Solution Methodologies: The State-of-the-Art and Emerging Trends

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ABSTRACT This paper presents an overview of recent advances for the Nurse Rostering Problem (NRP) based on methodological papers published between 2012 to 2021. It provides a comprehensive review of the latest solution methodologies, particularly computational intelligence (CI) approaches, utilized in benchmark and real-world nurse rostering. The methodologies are systematically categorised (Heuristics, Meta-heuristics, Hyper-heuristics, Mathematical Optimisation, Matheuristics and Hybrid Approaches). The NRP benchmark repositories and the respective state-of-the-art methods are also presented. A distinctive feature of this survey is its focus on the emerging trends in terms of solution methodologies and benchmark datasets. Meta-heuristics are the most popular choices in addressing NRP. Matheuristics, one of most popular methodologies in addressing the NRP, has been an emerging trend in recent years (2018 onwards). The INRC-I dataset is the most popular benchmark currently in use by researchers to test their algorithms. An in-depth discussion on the challenges and research opportunities is provided. The summary and analysis of the recently published NRP methodological papers in this survey is valuable for the CI and Operational Research (OR) communities especially early career researchers seeking to find gaps and identify emerging trends in this fast-developing, important research area.

INDEX TERMS Combinatorial optimization, nurse rostering, nurse scheduling, computational intelligence, operational research.

I. INTRODUCTION

The Nurse Rostering Problem (NRP) is one of many challenging combinatorial optimisation problems (COP) [5], [6], [27], [42], [47], [67], [75]. The NRP was introduced by Miller et. al. [58] and Warner [81] in 1976 and proven to be NP-hard by Osogami and Imai [61], in 2000. The NRP is a specific type of personnel scheduling problem and plays an important role in healthcare management. It involves the assignment of shifts to nurses, with different skills, over a given planning horizon (e.g. 1 month) and requires satisfying a set of hard and soft constraints. The goal is to improve the

operational efficiency of hospital wards by aiming to have an optimal utilization of the limited resources, with a focus on the well-being of patients and the job satisfaction of nurses.

The NRP is widely researched due to its practical relevance and combinatorial complexity, making it a challenging and important problem. The importance of NRP stems from its direct application in healthcare organisations. An optimal nurse roster improves the efficiency of hospitals and addresses issues such as under & over staffing, skill matching and job satisfaction. A nurse-centred roster improves the morale of nurses, positively impacting the quality of service provided and the well-being of patients. Nurse rosters can be created manually but generating high quality schedules is challenging and time consuming [26]. Automating this

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