Reconfiguring Computer-Supported Shift Planning to Support Nurse Well-Being

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Abstract

Algorithmic nurse shift planning has a long history in computing, yet practical implementation remains stagnant. Besides technical performance issues, one major challenge is the appropriate consideration of real-world requirements. These seem especially challenging if they are incompatible with a fully automated planning paradigm or hard to quantify (e.g., fairness as actually experienced by nurses). Taking a nurse-centered design approach, we set out to reimagine computer-supported shift planning with a strong focus on real-world requirements, but also to benefit from previously overlooked resources that can improve the quality of schedules.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**; • **Applied computing → Life and medical sciences**.

Keywords

computer-supported shift planning, nurse scheduling problem, user-centered design, conflict prevention

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1 Introduction

Nurse shift planning (NSP) is among the oldest application areas for computers, with publications dating back to the 1950s (e.g., [1]). In part, NSP was such an early contender because it is both essential for a functioning healthcare system and thereby impacts the well-being of entire societies, and also highly complex. Shift planners need to consider a long list of constraints, starting with legal requirements such as work regulations and quality standards, to economic efficiency and risk, and individual factors like work contracts, qualifications, and personal preferences, to just name a few [2, 12]. Computers seemed to be a perfect fit to solve this problem, because they can consider many constraints simultaneously and, for example, maximize the system for efficiency, fairness, and worker well-being [4, 13].

However, despite this long history and what computer-supported shift planning has to offer, it is still not widely used in practice [3, 6]. In part, this can be explained with technical performance issues inherent to the complexity of the problem, especially for larger groups and multi-week schedules. But beyond that, introducing such a fundamental change in how work is organized in a real-world setting surfaces various socio-technical challenges. For example, some of the people involved follow fundamentally conflicting interests: Healthcare managers strive for efficiency, which often undermines nurses' well-being and job satisfaction [7]. But also the nurses themselves compete with each other, for example when planning the free shifts on public holidays. Another issue is stakeholder miscommunication. In a previous project, we observed that nurses and engineers mean different things when using key concepts, such as "fairness" or "conflict" [8, 11]. Finally, from a Human-Centered Design perspective, the lack of user (as in "nurse", not "nurse manager") involvement in the design of almost all proposed systems is striking (for exceptions, see e.g., [5, 8]). All of this taken together, we can look back at this long history of research that has so far not succeeded to realize its full potential in practice.

2 Challenges and Insights from Previous Work

Based on our previous research, we have identified various challenges and some opportunities of current computer-supported shift planning, including:

- Fairness in decision-making, as experienced by nurses, is a) difficult to quantify in principle (because it is based on a hard-to-quantify fairness norm), and b) it requires direct involvement in decision-making processes [11]. This is incompatible with the current dominating paradigm of fully automated shift planning. As a consequence, shift planning systems that actually strive to improve fairness cannot be fully automated.
- While computer-supported shift planning systems focus on solving "conflicts" between several formulaic constraints, nurses in real-world planning perform various practices to *prevent* such conflicts before they arise. For example, imagine two nurses who want to take the same day off, which may turn into a conflict later. If one of them plans to meet

with a friend, she can call that friend and meet them on the following day, thereby preventing the planning conflict from arising in the first place. Computers cannot easily perform such practices, for example due to privacy concerns and opportunity costs of entering all potentially relevant context information (e.g., this solution would not work if the nurse's plan cannot easily be rescheduled, like a concert; see e.g., [9]).

- Most existing systems frame the shift planning problem from a managerial perspective, not a nurse perspective. For managers, the central challenge is to reduce costs while maintaining a given quality of care and keeping an eye on risks (e.g., that a nurse calls in sick)—in other words, to maximize economic efficiency. The central, meaningful way to do that is to reduce "slack", or the amount of time nurses are assigned to work but have nothing to do. Arguably, this problem is far from the current reality of nurses' work conditions in most countries, and the efficiency gains achieved in current systems are mainly based on other grounds, including indirect worker exploitation (see [7] for a detailed argument of this point). One conclusion we can draw is that instead of economic efficiency, it makes more sense for shift planning research to advance with regards to other criteria, such as the nurses' working conditions or subjective autonomy about their time.
- Each real-world healthcare context can have its own specific characteristics that affect shift planning and nurses' well-being. For example, stationary care can come with a strong team spirit among nurses, which can be a resource to support conflict resolution (e.g., [11]). Conversely, it can also put social pressure on nurses to act in ways that harm their own physical health, by habitually standing in for their colleagues instead of taking a rest. Other healthcare contexts such as outpatient care may profit less from such team spirit because nurses often work alone. But this lower social pressure can make it easier to reject inconvenient shifts as a means of self-care (see e.g., [10]).
- On the positive side, computer support can help plan the majority of "uncritical" shifts, where fairness is not the main concern. A useful criterion from [8] was that nurses can intervene for each shift they consider important, and the computer plans the rest.

3 Redesigning Nurse-Centered Shift Planning

In this early-stage project, we plan to develop a new NSP system, informed by the above insights and centrally focused on the nurse perspective on shift planning. Although the first iteration was already based on a nurse-centered design process, we only learned about for example the conflict prevention practices indirectly, and support is currently not implemented. We currently plan to develop an interface to support these practices, and to integrate them with ways to reduce the complexity of planning with a computer. On the backend, we have been enhancing the efficiency of our algorithm, particularly for larger nurse groups, which has resolved several computational bottlenecks (currently under review). This algorithm incorporates a range of constraints commonly addressed in existing studies, including restrictions on consecutive shifts within a day, shift coverage requirements, unavailability constraints, weekly shift limits, prohibited shift rotations, and nurses' shift preferences. However, to ensure real-world applicability, the system will be further aligned with practical constraints encountered in healthcare settings. A key feature of our approach is that the algorithm has been developed from scratch, making it fully customizable for future enhancements. This flexibility allows for the integration of additional constraints based on nurse feedback, ensuring the system effectively addresses real-world challenges. Our ultimate goal is to create a scheduling system that offers high performance in schedule generation, while also prioritizing nurse well-being based on real-world user research.

We are currently initiating a collaborative research plan to test a redesigned prototype in a Japanese healthcare context, through a local collaboration with a care facility.

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