

A Nurse-Centered Approach to Computer-Supported Healthcare Shift Planning

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Abstract

Nurse shift planning is a central work organization process in hospitals and other healthcare institutions. The shift plan provides a frame for all further healthcare activities by regulating staffing levels and group compositions at all times and on each day of the week. In addition, it fundamentally shapes each individual nurse's life, often disturbs their circadian rhythms, and limits their ability to organize social activities. As a result, shift planning often brings challenges for nurses' physical and psychological health, and it can reduce their subjective well-being.

There is a long history of research on how to improve the shift planning process, with two contrasting approaches. The first approach focuses on efficiency and full automation of the shift planning process. Its central motivation is that more efficient shift planning may free time and resources that can be used for other healthcare tasks, and that it helps to optimize staffing levels to meet the demand. A downside is that it excludes nurses from the planning process and reduces direct control of their shift plans, which creates work-life conflicts that negatively affect their well-being. The second approach gives full control of the shift plan to the nurses. This allows them to better integrate their work and private lives, but it can be inefficient and substantially increase workload for nurses, particularly in larger groups.

This thesis presents the design and evaluation of an approach to shift planning that attempts to combine the best of both worlds, but with a focus on the nurses' perspective. The research followed a nurse-centered design process, focusing specifically on subjective fairness and subjective well-being from the perspective of the nurses affected by shift planning. In addition, automatic processes were included if they did not interfere with the primary goal to create a shift planning system that promotes nurses' fairness and well-being.

The empirical section covers five studies. In Studies 1 and 2, we investigated nurses' subjective fairness experiences in the context of shift planning. Nurses understood fairness as equality ("everyone is treated equally") for the general distribution of resources, such as free weekends. But in concrete planning decisions about free shifts, they understood fairness based on individual needs ("the person with a greater need gets the day off"), which has fundamental implications for how fair conflict resolution should be designed. In addition, nurses experienced involvement in the decision-making process as a central facet of fairness (i.e., procedural fairness).

Study 3 covers the conceptual design of a nurse-centered shift planning system with the goal to promote subjective fairness and subjective well-being, based on interview studies with nurses and healthcare planners. Study 4 describes a nine-month appropriation study of a prototypical shift planning system that followed this conceptual design, in a ward of a retirement community. We found that some nurses used the system regularly for planning, but others did not. These differences were partially based on different lifestyles (e.g., planning months ahead vs. not planning the next week) and social considerations (e.g., preserving the reputation as a reliable and hard-working colleague). We also identified informal conflict negotiation practices (e.g., rescheduling private events, sharing shifts), informal functions of leadership (e.g., "pushing" colleagues to take time for themselves), and implications of the shift plan's release date on nurses' ability to plan for their private lives.

Finally, in Study 5 we compared the informal conflict negotiation practices identified in Study 4 with an alternative, fully automated conflict resolution process. The interactive version had positive effects on fairness, well-being, and team spirit.

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Introduction

Over the past few years, I talked with nurses from various healthcare institutions about their experiences with shift work. I was particularly interested in how shift work affected their lives, and which strategies they had developed to cope with it. One of these conversations turned out to be a sharp summary of what I see as the central problem of shift work in healthcare, and what I tried to address with my doctoral research.

I interviewed a nurse who worked in geriatric care and asked her how she balanced her private needs with the flexibility required by her shift work in her everyday life. She told me that she had been diagnosed with a serious illness, and that most of her personal appointments were related to its treatment. Every month she waited for her shift plan to be released, so that she could start organizing her medical appointments. Once she had her plan, she searched it for remaining free time slots and tried to fit her medical appointments in wherever possible. This was often difficult, because the release date of the shift plan was quite late. By the time she called her doctor, he only had few time slots left for her. Nevertheless, from her perspective, this seemed to be “the way things are done” in her healthcare institution.

Putting myself in her position, my first thought was to flip the process around: I would make my doctor’s appointments upfront and then ask my ward leader to plan my work around them. With my limited knowledge about nurses’ experiences of shift work at the time, I wondered why she did not plan this way. From an impartial perspective, it may seem like a technical nuance whether the nurse plans her private appointments first or waits for the shift plan to be released. But from my perspective today, her case is representative for how the nurse prioritized her own physical health, compared to her work. In her approach, work came first and personal concerns, even serious ones, second.

I mention this conversation here because it is exemplary for a paradoxical situation I found across various details in the daily work of nurses. The reason we have a healthcare system in the first place is to promote health in our society. However, when it comes to the nurses themselves who keep the healthcare system running, their health and well-being seem to play a subordinate role. Apparently, the low priority of nurses’ personal needs is so deeply rooted in the healthcare system that it affects both organizational and individual decision-making, including the personal beliefs and decisions of the nurse from my interview and how she accepts that “things are done”.

The goal of this thesis is to take a first step towards resolving this paradox by redesigning healthcare work organization. It is an attempt to empower nurses so that they are equipped with the tools that help them take better care of themselves. But this is a challenging transition. It requires a fundamental deviation from the trodden path in healthcare work organization, away from a mainly manager-centered efficiency paradigm that often overlooks the nurse perspective. My main focus lies on shift planning, the process of creating shift plans that define which nurse works at

which time on which day over a certain period of time (for example a month). Shift planning plays a key role in the healthcare work organization. This is where the important decisions from the nurse perspective are made: Who works on a Sunday morning? When can a nurse see her partner, and who takes care of her children while she is at work? What is a good way to deal with extraordinary events such as Christmas, where (almost) everyone wants to be with their families and hardly anyone wants to work? And finally, which values guide such planning decisions? In sum, my focus is on shift planning, because it fundamentally shapes both the private and work lives of nurses, and because it affects a number of concrete moments and experiences in their lives where we can make a change through design.

Such a profound transition towards nurse-centered shift planning offers new perspectives and opportunities for research. But it also comes with challenges. One is that the bulk of the existing shift planning literature mainly teaches us how to further increase economic efficiency, rather than integrating personal needs and wishes of nurses. It highlights an important, manager-centered perspective on shift planning. But it discounts other perspectives, including the concerns of individual nurses and of society as a whole. As a side effect, I argue that this narrow focus on managerial efficiency has led to certain inefficiencies on the other levels.

The primacy of manager-centered shift planning and efficiency has also set a corresponding, restricted framing of other central concepts in shift planning. For example, the ultimate goal of manager-centered shift planning is maximized efficiency, which is often associated with full automation to minimize the need for human intervention and the associated labor costs. As I will outline below, this narrow focus has restricted how further criteria such as fairness of shift planning decisions are handled, so that they fit with the full automation approach but not necessarily with the actual fairness experiences of nurses.

Contrasting the predominant efficiency paradigm, my research takes nurses' subjective experiences related to shift planning as a starting point. The first two studies described in this thesis investigate how nurses subjectively experience fairness in the context of shift planning. The third study then describes a design process of a prototypical, nurse-centered shift planning system. It builds on this understanding of subjective fairness and on positive shift planning experiences derived from interviews with different stakeholders of a healthcare institution. Study 4 reports the findings from a nine-month appropriation study of that prototypical system in a retirement community. During that study, the nurses developed several informal practices to handle planning conflicts. Study 5 further investigates these practices and confirms their positive effects on nurses' subjective well-being, subjective fairness, and long-term team spirit, compared with fully automated shift planning. Additionally, I have included two short, more focused reports of small studies we conducted on the side. They point to further aspects of shift planning that affect nurses' experiences but go beyond the scope of this thesis. Finally, I recapitulate the central findings, discuss how they extend our perspective on shift planning, and outline what is still left for future work as we turn from manager-centered towards nurse-centered work organization.

In the following, I first briefly recapitulate the historical context of shift planning research to ground the claim that it has so far mainly focused on manager-centered efficiency. Then I critically reflect on three central concepts in relation to shift planning. Specifically, I outline problems with the concepts of efficiency, automation, and fairness as they have been used in the past. Finally, I propose and justify an alternative set of primary goals for shift planning, namely subjective fairness and subjective well-being, both from the perspective of nurses.

The Historical Focus on Efficiency in Shift Planning

Systematic shift planning research began after World War II with two central goals. The first one was to increase planning safety. At the time, planners had difficulties predicting the demand for healthcare services and could not promise that enough staff would be available to meet it (Balintfy, 1959; Flagle, 1960; Wolfe & Young, 1965a, 1965b). Accordingly, one requirement for shift planning processes was to guarantee, with some statistical certainty, that the actual demand could be met at all times (Bailey, 1956; Wolfe & Young, 1965a). The second goal was efficiency (Bailey, 1956; Kaplan, 1975; Wolfe & Young, 1965a), that is, to minimize resource input (e.g., money) on the one hand, while maximizing health output (e.g., quality of care) on the other (Palmer & Torgerson, 1999). Both safety and efficiency are still dominant in shift planning research today, although other factors such as employee satisfaction have also found their way into shift planning research over time (Burke, De Causmaecker, Berghe, & van Landeghem, 2004; Van den Bergh, Beliën, Bruecker, Demeulemeester, & Boeck, 2012).

Safety and efficiency represent the central trade-off healthcare managers have to make during shift planning. They need to manage both the risks of understaffing and overstaffing (Erhard, Schoenfelder, Fügenger, & Brunner, 2017). Safety is related to the risks of understaffing, such as the risk that the assigned nurses cannot manage the workload during a shift or the risk that some nurses call in sick. When understaffed, the quality of care could be affected or patients could be endangered. Conversely, efficiency is related to the risks of overstaffing, which are mainly economic. Concerning efficiency, healthcare managers need to make a decision about the desired quality of care. Hiring and assigning more nurses means they can take over additional tasks or take more time for each patient. But they also make the care work more expensive. Efficient shift planning minimizes costs at a set quality of care (Burke et al., 2004).

The focus on these central manager concerns, safety and efficiency, has fundamentally influenced the further development of shift planning research. Most of the more recent work focuses on efficiency, which also aligns with policy changes and efforts to reduce costs in healthcare (Burke et al., 2004; Siferd & Benton, 1992; Van den Bergh et al., 2012). In addition, other factors were also integrated, such as fairness in dealing with nurses' requests for free shifts in the plan. But they usually play a subordinate role, which shows in the specific way the shift planning systems

are designed. One illustrative example is the shift planning process proposed in a seminal paper by Warner (1976). It consisted of two phases. In Phase I, the shift planner (a head nurse or supervisor) made decisions about coverage and general characteristics of the shift plan. The safety and efficiency trade-off was made here, marking out the general frame for possible solutions. Within that frame, Phase II covered nurses' requests for free shifts. If both the planner and the nurse considered them important enough, the requests could be included (Warner, 1976). This prioritization of the safety and efficiency trade-off over nurses' requests is reflected in how the different groups of employees reacted to the proposed system:

"The system has been received enthusiastically by nursing administration and especially by the head nurses. Members of the nursing staff perceive a slight increase in the quality of schedules provided by the system." (Warner, 1976, p. 856)

Later systems included more sophisticated technical processes, but with similar priorities. A certain economic efficiency and security were typically considered as "hard" or "absolute" constraints, that had to be satisfied at all costs, or they were part of a superordinate planning phase. Nurses' requests were considered as "soft" constraints that could sometimes be denied, or only included further downstream in the decision-making process (Kawanaka, Yamamoto, Yoshikawa, Shinogi, & Tsuruoka, 2001; Kostreva & Jennings, 1991; Li, Lim, & Rodrigues, 2003). Burke et al. (2004) presented a review of forty years of shift planning research, and summarized its central goals:

"In particular, it is very important to efficiently utilise time and effort, to evenly balance the workload among people and to attempt to satisfy personnel preferences. A high quality roster can lead to a more contented and thus more effective workforce." (Burke et al., 2004, p. 441)

In other words, efficiency is the established, central concern in shift planning research. Nurses' contentment is secondary and highlighted here specifically for its value in further increasing their effectiveness.

A Critical Perspective on Efficiency

The focus on efficiency is typically justified with two arguments: Financial pressure and the (global) shortage of nurses (Abdalkareem, Amir, Al-Betar, Ekhan, & Hammouri, 2021; Aluttis, Bishaw, & Frank, 2014; Butter, 1967; Liebman, Young, & Bellmore, 1972; H. E. Miller, 1976; Siferd & Benton, 1992). The efficiency-oriented perspective follows the conviction that healthcare institutions can minimize costs while maintaining quality of care if they optimize the nurses' shift work. The nurse shortage demands that the scarce human resources should be used as efficiently as

possible. These are valid and important considerations, but there are also problems with this particular focus on efficiency.

First, the argument of financial pressure implies that the appropriate reaction of healthcare systems to scarce financial resources is to cut costs in nursing staff (e.g., H. E. Miller, 1976; Sitompul & Randhawa, 1990). But this conclusion is not necessarily warranted. It is worth noting that scarce resources are not an invariable fact: Healthcare spending is quite different across the world and changes over time (Himmelstein et al., 2014; OECD, 2021). It is also part of a political process. Thus, one alternative to cutting costs would be to demand more funding for healthcare, although this discussion understandably takes place mostly in other venues than the shift planning literature (see e.g., Dieterich, Braun, Gerlinger, & Simon, 2019; Wiedemann, 2020, for critical perspectives on healthcare funding in the German context). Nevertheless, just accepting scarce financial resources as a given fact is not a neutral position either. The shift planning literature plays, to an extent, a normative role. If we implement tools to cope with underfunded healthcare systems, they may legitimate or further promote the status quo, instead of fixing the underlying problem of underfunding. Conversely, by presenting alternative approaches to shift planning, we may reveal problems in current funding schemes, which could influence policymaking by showing where more funding would make sense, for example to achieve a better quality of care or a more satisfied workforce.

A second problem with the argument of scarce financial resources is that healthcare spending does not directly convert into medical staff positions. The case of the United States is somewhat extreme here, but it is relevant because a lot of shift planning research comes from American research institutions. Healthcare spending is exceptionally high in the United States, but the rate of nurses per capita is lower than in comparable countries. Rather than costs for medical staff, the major “inefficiencies” in the US system are high prices for healthcare services and a high administrative overhead (Anderson, Hussey, & Petrosyan, 2019; Himmelstein et al., 2014):

“Today, for every doctor, only 6 of the 16 non-doctor workers have clinical roles, including registered nurses, allied health professionals, aides, care coordinators, and medical assistants. Surprisingly, 10 of the 16 non-doctor workers are purely administrative and management staff, receptionists and information clerks, and office clerks. The problem with all of the non-doctor labor is that most of it is not primarily associated with delivering better patient outcomes or lowering costs.” (Kocher, 2013, p. 1)

In the United States, but also in other countries, a substantial part of healthcare spending is used for work that is not directly related to healthcare services. This is a problem for the legitimacy of cutting costs for nursing staff and the proclaimed need for efficiency in that particular group of employees. Given that nurses provide core services for the healthcare system, optimizing the efficient organization of nursing jobs should arguably be among the last measures of a healthcare institution

to reduce costs, after minimizing administrative costs and working towards better healthcare funding. That said, shift planning does not only attempt to optimize how nurses are assigned to certain shifts, but the process itself can be understood as an administrative task. Thus, attempts to increase efficiency in terms of reducing the time spent on planning itself are of course not affected by this argument.

The second justification for efficiency is the ongoing nurse shortage which has been reported since at least the 1960s (Aluttis et al., 2014; Butter, 1967; Liebman et al., 1972; Siferd & Benton, 1992). One cause of the shortage is that only few young people start a nursing career, for different reasons. Many have no interest in healthcare, do not see themselves as capable to work with sick or wounded people, and see better pay in other fields (Hemsley-Brown & Foskett, 1999; Stevens & Walker, 1993). Of course, not everyone wants to or should work in healthcare if it is not the right job for them, as reflected by the first two reasons. But the fact that young people choose other jobs because of low pay expectations indicates that a focus on efficiency and cost saving alone may not solve the causes of the nurse shortage, and possibly comes with problematic long-term consequences for the size of the workforce.

Another cause of the nurse shortage is that many nurses leave the profession early. Major reasons to leave include low pay, low job satisfaction, health problems, personal conflicts at work, and conflicts between work and private life (among other reasons; Chan, Tam, Lung, Wong, & Chau, 2013; Hasselhorn, Tackenberg, Müller, & NEXT Study Group, 2005). Again, economic efficiency may be one way to deal with some of these problems, but also the cause for others (such as low pay). It can be counterproductive if efficiency concerns further reinforce the factors that already make nurses leave the profession early.

A third contributing factor to the nurse shortage is the relative increase in part-time contracts over the recent decades. For example, the total number of full-time nurses working in care homes in Germany has only increased by about six percent over the past 20 years. During the same period, the number of part-time nurses has more than doubled (Federal Statistical Office of Germany, 2001, 2019). In other words, the rising demand of healthcare services due to demographic changes in Germany is increasingly covered by part-time nurses.

The reasons to sign a part-time instead of a full-time contract differ from case to case. Some nurses may not be able to work longer, or they prefer a part-time contract for other reasons. On the societal level, a higher share of full-time contracts would be desirable, because it directly increases the available workforce to meet rising healthcare demands. But from the perspective of a healthcare manager, part-time contracts have several advantages for their local shift planning efficiency. Managers can intensify workloads if the nurses have more “free time” to recover, which can reduce the number of nurses needed per shift (Kelliher & Anderson, 2010). In addition, if managers hire for example eight nurses with a 75% position instead of six full-timers, they have more “heads” to call as replacements in case a nurse calls in sick. This allows them to reduce the safety buffers of the shift plan and to figure in more frequent replacements (Siferd & Benton, 1992). In addition, nurses may be more willing to stand in for a sick colleague and do overtime if they do not

work full-time already. Finally, in the United States many care workers are given “involuntary part-time” contracts, and one of the reasons is that the employer’s social security expenses are lower for part-timers than for full-timers (Even & Macpherson, 2015; Pech, Klainot-Hess, & Norris, 2021). Thus, increasing the share of part-time workers is a way for healthcare managers to improve local planning efficiency and to cut costs. But it adds to the nurse shortage on the societal level, which is in turn used as an argument to further increase efficiency (e.g., Abdalkareem et al., 2021; Liebman et al., 1972).

In sum, whether the different measures taken by healthcare managers actually increase “efficiency” depends on how we define it. In part, the efficiency improvements of a healthcare institution rely on externalizing costs and risks to the nurses, for example by intensifying workloads (Kelliher & Anderson, 2010), or by externalizing risks of understaffing to part-time employees (Siferd & Benton, 1992).

This critical review of the two central arguments for efficiency-oriented shift planning, the tense financial situation, and the ongoing global nurse shortage, hopefully indicated that they only represent part of a broader problem and mainly focus on a specific (i.e., manager-centered) perspective. Efficiency is certainly an important consideration in healthcare, including the efficiency of shift planning. But possible negative side effects also need to be taken seriously, and it may be worth considering alternative design goals beyond efficiency. I take these side effects as a prompt to critically reassess two further concepts that are central in current shift planning approaches: Automation and fairness. As outlined below, the way they are currently implemented is strongly influenced by the overarching focus on efficiency, and there are alternative approaches that can be useful to develop new perspectives on shift planning.

Automation under the Efficiency Paradigm

Automation can be defined as a process through which certain human activities are transformed and replaced with machine or computer activities (J. D. Lee & Seppelt, 2012; Parasuraman, Sheridan, & Wickens, 2000). In previous shift planning research, automation has been implemented more specifically as a top-down process that follows a typical pattern. First, the shift planning process is formulated as an abstract, mathematical problem. For example, constraint-based systems frame shift planning as a search for shift plans that satisfy certain constraints such as legal regulations, economic considerations, and nurses’ requests. These constraints are implemented as hard or soft “boundaries” in a machine-readable form. In a second step, the system searches for one or more shift plans that stay within these boundaries and that optimize for a certain goal, such as low costs. And third, it presents the solution(s) to a planner (e.g., Constantino, Tozzo, Pinheiro, Landa-Silva, & Romão, 2015; Kawanaka et al., 2001; H. E. Miller, Pierskalla, & Rath, 1976).

This abstract approach to automation has several advantages. The problem definition is transparent and precise. Mathematical methods exist to solve it, and they can be incrementally optimized over time. In addition, if the goals can be quantified, which is the case for financial costs, planners can compare different solutions with each other and select the best one.

But there are also problems with this approach to automation. Much of the criticism relates to oversimplifications that happen throughout the abstraction process (J. D. Lee & Seppelt, 2012). Selbst, Boyd, Friedler, Venkatasubramanian, and Vertesi (2019) have summarized five central problem categories in what they called “abstraction traps”.

The first is the “framing trap”, which describes differences between the representation of the world in the system and the actual world outside the system. For example, imagine a shift planning algorithm that is equipped with a safety mechanism in case someone calls in sick. It might be tuned to make sure there is always one nurse who had enough breaks before and after a shift, and relies on her to be ready to stand in. Internally, this mechanism could guarantee a certain safety. But in practice, this guarantee can break. The nurse could have other responsibilities at home or might not be willing to stand in for that particular sick colleague, because of a personal grudge. It is her free time, after all. Such misalignments can lead to false assumptions about the characteristics of a shift plan, if the social nuances of the real world are not considered appropriately.

Second, the “portability trap” highlights the assumption that a solution which works in one setting can easily be transferred to a different setting. A central goal of abstract automation is that the solution is general enough to be used in many settings. In fact, much of the shift planning literature is not only concerned with shift planning in healthcare or even in a specific type of healthcare institutions, but presented as portable across different industries as varied as transportation, military, manufacturing, and retail (Van den Bergh et al., 2012). Although some characteristics may apply in multiple domains, informal cultural aspects or local rules may be different across industries, locations, or cultural backgrounds (Akrich, 1992).

Third, the “formalism trap” describes inappropriate representations of relevant social constructs. Once a construct is translated into mathematical language, it may be different from the actual experience of that construct. I argue that in previous shift planning systems this was the case for fairness, as explained in detail in the following section.

Fourth, the “ripple effect trap” acknowledges that introducing a new technology into a social context changes the inner workings of that context. An example is the introduction of scoring mechanisms, which favor employee behavior that optimizes for high scores, but not for the actual intention behind the score (Deterding, 2014; Rieley, 2000; Schlicker et al., 2020). Employees adapt to the technologies and try to use them in ways that were not intended by the designers.

And fifth, the “solutionism trap” describes the tendency to search for technical solutions to problems that may better be solved differently (Morozov, 2013). Depend-

ing on the values that underlie the development, fully automated shift planning may not deliver the best possible solutions.

Despite all these potential “traps”, automation can of course have positive impacts on shift planning, if implemented carefully. But the design process should align with the values to be built into the system. This means that not every aspect of shift planning needs to be automated, just for the sake of automation. Instead, automation should only be used as a tool where it supports the design goals. One alternative approach to the abstract automation process has been coined “automation from below” (Klapperich & Hassenzahl, 2016; Klapperich, Uhde, & Hassenzahl, 2020). This is a bottom-up approach to automation that begins with the subjective experiences of system users and a normative take on how they should be influenced (e.g., with the goal to create positive experiences and increase well-being; Klapperich et al., 2020). The technical starting point can be a manual or “low tech” process, for example shift planning with pen and paper. During the development, automation is iteratively added where appropriate (i.e., where it supports the design goals), but not where inappropriate (i.e., where it interferes with the goals). A central advantage of this approach is that it keeps humans in the loop where it makes sense for them, as an essential part of the process. In addition, each automation step becomes a conscious design decision, and its effects can be tested against the design goals (e.g., the subjective experiences of the people involved).

In sum, automation has played an integral role in previous shift planning research, mainly in its abstract, top-down form. This can be consistent with efficiency-oriented shift planning, but it may be less appropriate for the design of shift planning systems with other goals. Full automation favors mathematical solutions with quantifiable outcomes, but is at risk of getting caught in the abstraction traps (Selbst et al., 2019). An alternative approach is “automation from below”, which only automates those parts of the system for which automation is actually desirable in terms of the design goals (e.g., positive experiences and well-being). With a focus on the nurse perspective, the design process of the shift planning system presented in Study 3 broadly follows this automation from below approach.

Fairness under the Efficiency Paradigm

The final concept reexamined here is fairness. Fairness has played an important role in shift planning research, to weigh up the nurses’ influence on the plan (Constantino, Landa-Silva, de Melo, & Romão, 2011; C.-C. Lin, Kang, Chiang, & Chen, 2015; H. E. Miller et al., 1976; Warner, 1976). Imagine you create a shift plan for a hospital ward with 10 nurses. Each of these nurses might have a few private appointments every month and might want some specific days off. As the planner, you can include these requests in many cases, but sometimes they lead to conflicts. For example, many nurses in Europe want to be with their families during Christmas and submit a request for a free day. In such cases, a solution must be found that resolves

the planning conflict. Typically, this means that some nurses will be assigned to work and have to cancel their private plans.

Within the abstract automation and efficiency paradigm, some shift planning systems have been developed with built-in fairness mechanisms to solve such conflicts. For example, the system presented by Warner (1976) allowed nurses to assign points to their requests for free shifts. These points were meant to represent how important the shifts were to them. The system then tried to find a “fair” solution by equalizing all nurses’ influences on the shift plan based on these points.

Such an automated approach to fairness is sometimes considered as superior to human planning for being more “objective” (e.g., Constantino et al., 2011; C.-C. Lin et al., 2015). But this claim of objectivity is fundamentally problematic. To include fairness in an automatic process, developers need a machine-readable definition of fairness so that they can represent it in code. One possible definition would be to distribute the influence among all nurses equally, which has been used in most shift planning systems presented so far (e.g., Constantino et al., 2015; Ramli, Hussin, Abas, & Ibrahim, 2016; Warner, 1976). An alternative would be to reward performance (e.g., Ball, 1997; C. K. Lin, 1999). The problem is that these different definitions of fairness lead to different shift planning decisions that are in principle incompatible with each other (Kleinberg, Mullainathan, & Raghavan, 2017). In other words, the choice of a fairness definition implies a subjective, normative decision made by the developers, because fairness can mean different things. As a consequence, this means that fairness cannot be “objective”. It always has a fundamentally subjective component. Thus, before starting to implement a specific fairness mechanism, developers should make a reasonable decision for a fairness definition, and it is not clear how that decision was made previously. I would suggest trying to understand the subjective perspective of nurses on fairness in shift planning, because they are the people whose personal lives are directly affected by planning decisions. This perspective has not been studied before, and is the focus of Studies 1 and 2.

Leaving the problem with subjectivity aside, some fairness definitions are easier to translate into a machine-readable form than others. Equal distribution is most straightforward. To achieve an easy form of equality, a system can simply count each nurse’s requests and grant the same number to everyone. Performance-based fairness is already more difficult to implement. It requires a measure for individual performance, introducing further problems. For example, if this measure is inaccurate or highlights certain indicators of good performance over others, nurses may start to use the system in unintended ways to optimize their own scores (Rieley, 2000; Schlicker et al., 2020).

Taken together, fairness in shift planning has been integrated as part of the abstract automation process as a way to improve the shift plan for the nurses. Previous, fully automated systems highlight an objective notion of fairness, which however relies on fundamentally subjective decisions. How the choice of fairness definitions was made in the past is unclear. Moreover, it is also unclear how nurses experience fairness in shift planning. Thus, we do not know if nurses actually experience the current fairness mechanisms as fair at all.

Towards Nurse-centered Shift Planning

The previous sections illustrated how the shift planning literature traditionally focuses on efficiency from a management perspective, and how this focus influences the definitions and uses of concepts such as automation, fairness, and even efficiency itself. The management perspective is important, but other perspectives on shift planning, such as how it affects the healthcare system on a societal level and how it affects individual nurses, have not played a pronounced role in the shift planning literature. This opens up a possibility to rethink shift planning from the ground up, through one of these other perspectives. The approach used in this thesis starts with the subjective experiences of nurses in shift planning. I adopt two guiding design goals and suggest them as alternatives to efficiency as the primary concern in shift planning: Subjective fairness and subjective well-being.

Subjective Fairness

Fairness has two important functions in shift planning. First, as outlined above, it provides guidance for dealing with planning conflicts. In some cases, not all requirements to a shift plan can be satisfied. For example, two nurses' requests may be in conflict with each other and there may be no other nurse available, so one of them needs to be assigned to work to assure patient safety. In such cases, fairness experiences from the perspective of the involved nurses can indicate how a good solution could look like. Thus, understanding fairness can directly improve shift planning decisions from the nurses' perspective. Second, fairness in decision-making has a pivotal function for several other constructs that relate to the broader work experience of nurses. Specifically, Colquitt and Zipay (2015) argue that fairness is informative for employees who try to deal with several uncertainties at the work place, because the fairness of a decision is relatively easy to observe. Thus, whether a decision is perceived as fair can inform nurses about other, less observable constructs. They distinguish between five such uncertainties with different theoretical groundings.

The first uncertainty relates to the trustworthiness of the planner. Colquitt and Zipay (2015) refer to social exchange theory, which claims that trust makes the difference between cautious economic relationships and more invested social relationships (Blau, 1964). Social relationships are more efficient than economic relationships, but in the case of healthcare work nurses put themselves at risk of exploitation. For example, if the planner is trustworthy, a nurse might be willing to stand in for a colleague, assuming that she will be returned the favor in some way some time in the future. However, if she feels that her trust is exploited and that she is treated unfairly in a concrete planning decision, she will become less cooperative (Lind, 2001).

The second uncertainty is about the nurse's social status. Fair decisions certify that a nurse has a certain standing in the group. In contrast, if her request for an important private appointment is not integrated in the shift plan, although it does

not conflict with other requests, the nurse can understand this subjectively unfair decision as a sign of low status in the group (Tyler & Lind, 1992).

Third, uncertainty about morality is concerned with an understanding of how a decision should generally be made, independent of a nurse's actual involvement. Fairness can be understood as a virtue on its own and unfair shift planning decisions can signal that a planner does not have that virtue (Folger, 2001; Folger, Cropanzano, & Goldman, 2005). For example, if a nurse witnesses that a colleague's request gets denied without a convincing justification, she can understand this as an indicator for the lack of morality of the planner.

The fourth uncertainty is about personal goal progress. A planning decision can hinder or support individual goals. If a nurse submits a request because she wants to go on a date, the decision whether she gets the free shift potentially influences her goal of starting a romantic relationship. This can have immediate emotional consequences, which can be influenced by fairness (Weiss & Cropanzano, 1996).

The fifth and final uncertainty is about: Potentially everything. The fact that the fairness of a specific decision is relatively observable makes it useful as an indicator for other, even unrelated uncertainties. Imagine an immigrant nurse who has already experienced several racist incidents outside of work. If she perceives a shift planning decision as unfair, she could reasonably interpret it as a sign of racist structures at the work place, even if the specific decision was made for different reasons.

These uncertainties indicate the importance of observably fair decision-making for a wide range of concerns nurses can have at work. Accordingly, fairness is especially relevant in the specific, observable interactions during shift planning.

Subjective Well-being

Although fairness is necessary to avoid problematic shift planning systems, it does not directly tell us how to build "good" alternatives. Even if a shift planning process is fair to everyone involved, it can still lack behind its potential to create positive experiences. At first, it may seem odd to create positive experiences through a formal work process such as shift planning. But in the concrete work contexts in everyday life, nurses may engage in various interactions with the shift plan and with each other that are not yet covered with the fairness perspective alone. For example, some shift planning systems allow nurses to submit requests for free shifts. Once the plan is released, each nurse checks at some point whether their requests were granted. Later on, nurses might want to make short-term changes if a colleague calls in sick, or even interact with past shift plans. A purely fairness-oriented definition of shift planning does not cover all experiential consequences of such interactions.

However, from the nurse perspective, these interactions represent the concrete touchpoints between shift planning and their everyday lives. This raises several questions for designers of interactive shift planning systems. When, where, and how exactly should nurses submit requests for free shifts (if at all)? They could enter them through their personal smartphones at home, on a piece of paper in the ward, or tell them to the ward leader. These alternatives have different implications: At

home, nurses may involve friends and family in the process, but they plan outside their regular work times. A piece of paper allows their colleagues to see the requests. When telling requests directly to the ward leader, nurses need to find a suitable moment during a shared shift.

Subjective well-being provides a guideline for such design decisions. The goal of designing for well-being is to shape the interactions so that they have a positive impact on the nurses' well-being (Desmet & Pohlmeier, 2013; Klapperich et al., 2019). Thus, well-being is included here as a crucial design goal on the way towards nurse-centered shift planning.

Summary and Central Research Goals

Shift planning research has made considerable progress over the past decades. The technical development makes it possible to create safe and efficient shift plans. But the efficiency paradigm has also shaped the field in a direction that primarily focuses on efficiency from the management perspective, and largely neglects the nurse perspective on shift planning. As a result, it frames central concepts such as efficiency, automation, and fairness in a particular, restricted way.

With this thesis, I set out to rethink shift planning by taking a fundamentally nurse-centered perspective, so that their needs and wishes can be integrated appropriately in shift planning. To that end, I first focus on nurses' fairness experiences. Study 1 presents a detailed account of realistic fairness and unfairness experiences nurses have in relation to shift planning. It sets these experiences in context with a broader framework of fairness in work settings. Study 2 validates the findings from Study 1 experimentally.

These two studies lay the foundation for the design process of an interactive shift planning system described in Study 3. Here, a new approach to shift planning is developed, that is based on a set of shift planning interactions with the intention to support subjective well-being of nurses. Study 4 reports the findings of a nine-month appropriation study of that shift planning system in a retirement community. During that study, we found that nurses developed informal practices to handle planning conflicts collaboratively. Study 5 validates the positive effects of these practices on nurses' subjective well-being, fairness, and team spirit.

The discussion integrates the central findings of the five studies and reflect on their impact on shift planning research and the Human-Computer Interaction (HCI) literature. The inclusion of the nurse perspective as a top priority in shift planning has several implications that are deeply tied to a change in methodology and a different approach to shift planning, that more openly admits and explicitly addresses its normative character. It allows for a new perspective on shift planning and hopefully motivates a new direction of future research.

Background and Related Work

The introduction laid out the general motivation of this thesis on a broad level, and accordingly I have used central terms such as shift planning, fairness, and subjective well-being relatively broadly. This section provides more precise definitions of the central concepts used in the rest of the thesis and presents previous findings about how they relate to nurse-centered shift planning. In addition, it covers previous research and design of technical interventions to improve the situation for nurses in shift work.

The Shift Planning Process

Shift planning (sometimes also called “shift scheduling” or “rostering”) is a work organization process through which individual workers (e.g., nurses) are assigned to work in certain time slots (i.e., “shifts”) during a time period (e.g., one month; H. E. Miller et al., 1976). The result of the shift planning process is the shift plan, which provides an overview for the healthcare organization about how many nurses are assigned to each shift, and for the individual nurses about when they work and when they have time off.

Shift planning is part of an interrelated set of work organization processes that have to do with staff management. These include (Burke et al., 2004; Warner, 1976):

1. *Staffing decisions* about how many nurses should be hired and the extents of their contracts (e.g., full-time, part-time)
2. *Scheduling decisions* about who works when during a certain time period (shift planning happens here)
3. *Allocation decisions* in larger healthcare institutions about which nurse works on which ward (e.g., to react to local peak demands with nurses who “float” across wards)
4. *Task assignment decisions* about what each nurse works on

There are two general approaches to shift planning (Burke et al., 2004). The “fixed” or cyclical shift planning approach is based on stable shift patterns that repeat after a certain time period. For example, a nurse could work only morning shifts in even calendar weeks and only afternoon shifts in odd calendar weeks, with no other variation. The “flexible” or non-cyclical shift planning approach is not based on such repeating patterns. Instead, planners dynamically create new shift plans for every planning period.

Both fixed and flexible shift planning have their advantages (Burke et al., 2004; Warner, 1976). With fixed shift planning, nurses know their shift plans early on, theoretically months or years in advance. Thus, they can also plan their private lives

around them in advance. Fixed shift plans are also more straightforward to create, and the planner can more easily implement shift rotation patterns that take nurses' circadian rhythms into account. In contrast, flexible shift planning allows nurses to include personal requests in the shift plan, such as taking a specific day off. Many nurses regularly work on weekends, which makes it more difficult for them to plan for their free times. Such requests are a way to compensate for that. In addition, flexible shift planning makes it easier to include individualized work agreements. For example, a single parent may only be able to work shorter morning shifts than their colleagues, because they have to bring their children to the kindergarten or pick them up at a certain time. Such individualized patterns can affect the shift lengths of other nurses and disturb a fixed plan. Finally, flexible shift planning makes it easier to react to changes down the line. Someone may call in sick, nurses might need to attend further training, people might quit or be hired, and the demand for healthcare services in the region could change over time. Thus, the dynamics of realistic healthcare settings often make fixed shift planning difficult in practice (Burke et al., 2004).

Both the fixed and flexible shift planning processes need a "planner", someone who creates the shift plan. In some larger healthcare institutions, the planners are administrative staff in a central office, who create plans for the entire institution (e.g., Silvestro & Silvestro, 2000). A more decentralized alternative is that members of each ward (e.g., the head nurse; Rönnerberg & Larsson, 2010) create their ward's plan. Finally, in "self-scheduling" approaches, nurses create their own shift plans (M. L. Miller, 1984). Of course, combinations are possible, and in contemporary computer-supported shift planning systems several planning tasks are handled automatically (Burke et al., 2004; Van den Bergh et al., 2012).

Planners need to consider several criteria during shift planning (see e.g., Van den Bergh et al., 2012). The central groups of criteria are summarized below, but given the large variety of different healthcare contexts around the world, further criteria may be relevant in specific healthcare contexts.

The first group of criteria that is especially important from the management perspective are economic considerations. These include the trade-off between risks of understaffing (e.g., lack of patient security) and risks of overstaffing (e.g., lack of efficiency; Erhard et al., 2017). This trade-off implies a decision for a certain quality of care that sets boundaries for under- and overstaffing (Palmer & Torgerson, 1999; Wolfe & Young, 1965b), and an approach to deal with uncertainty. Planners need to be able to react if a nurse calls in sick, for example by drawing from a pool of "floating" nurses (Easton, Rossin, & Borders, 1992) or by factoring in overtime work (e.g., Burke, Cowling, De Causmaecker, & Berghe, 2001).

The second group of criteria can be summarized as legal constraints. These include legal regulations such as minimum breaks for each nurse within and between shifts, union agreements, and minimal required staffing levels for the number of patients (e.g., German Federal Ministry of Health, 2021). These regulations vary between different countries or regions.

The third group are personnel characteristics, such as individual skills, professional degrees, and each nurse's contractual agreements (e.g., full-time or part-time contract; Van den Bergh et al., 2012). This group can also include less formal criteria in relation to staff members, such as individual requests for free shifts, how the shift plan affects each nurse's free times and how they feel about that, personal relationships among nurses and between nurses and patients, fairness, team spirit, and effects on health and well-being (e.g., Constantino et al., 2015; M. L. Miller, 1984; Petrovic, Parkin, & Wrigley, 2020).

Depending on the specific approach to shift planning, for example whether a central planner creates a fixed plan for an entire hospital or whether self-scheduling nurses create their own flexible plans, these criteria may be prioritized differently. Central managers do not necessarily know about the personal relationships between nurses on each ward, so they cannot consider them during planning. In contrast, nurses typically have no detailed understanding of all economic pressures the management has to deal with, and may neglect criteria such as efficiency. In some healthcare contexts (e.g., outpatient care), nurses may not know their colleagues personally, which can affect the relationships among them (Fletcher, 2001) and how they are factored in during planning. Finally, the specific domain of care work can influence how flexible the shift plan can be. If a nurse primarily works in surgeries that last for several hours, they may have less flexibility in shift timings than a nurse who works on shorter tasks.

The bottom line of this long list of criteria to be considered is that shift planning is a complex process, and that there is usually no "one best solution" to it. A shift planning process that focuses on economic efficiency is different from one that focuses on nurse satisfaction. This is important, because it also implies that all shift planning processes necessarily have a normative character, depending on which criteria they prioritize over others.

Shift Work and Planning from the Nurse Perspective

Before looking into specific effects of different shift planning processes on nurses, it seems necessary to briefly summarize how shift work in general affects nurses. Shift work is the cause of several health problems. The constantly changing work times affect physical health, psychological well-being, and social life (Barton et al., 1995; Perrucci et al., 2007). Some of the problems arise because shift work disturbs circadian rhythms, for example through light exposure at night and sleep deprivation. The consequences include higher risks for a disturbed metabolism, cardiovascular diseases, and cancer (Behrens et al., 2017; Costa, 2016; Puttonen, Härmä, & Hublin, 2010; Tucker, Marquí, Folkard, Ansiau, & Esquirol, 2012). In addition, shift work is associated with psychological problems, such as burnout and lower subjective well-being (Hulsege, van Mechelen, Proper, Paagman, & Anema, 2020; Oates, 2018; Oates, Jones, & Drey, 2017; Y.-Y. Zhang et al., 2018). Finally, shift work also affects

the social life and work-life balance of nurses, because the work times are out of sync with typical societal rhythms (Arlinghaus et al., 2019; Pisarski & Barbour, 2014; Pisarski, Lawrence, Bohle, & Brook, 2008). These physical, psychological, and social problems are also interconnected. For example, nurses who are less satisfied with their social life also have higher rates of burnout and stress (Hulsegge et al., 2020). Of course, in addition to the problems caused by shift work, nurses have to deal with several other work-related stressors, such as frequent exposure to suffering and death (Sharma & Dhar, 2016).

Despite these generally negative impacts of shift work on nurses' health and well-being, the specific design of the shift planning process can make a difference. For example, giving nurses some control about their own work schedule is associated with higher well-being and lower work-life conflict, which are in turn associated with fewer health problems (Arlinghaus et al., 2019; Fenwick & Tausig, 2001; Garde et al., 2012; Kubo et al., 2013; Pisarski & Barbour, 2014; Pisarski et al., 2008).

Accordingly, nurses tend to value the flexibility of shift planning processes that give them more control, as opposed to fixed processes (Ejebu, Dall'Ora, & Griffiths, 2021). In addition, the decision about who creates the plans (the planner) also affects control. For example, centralized planning gives more control to the administrative staff (Silvestro & Silvestro, 2000) and self-scheduling gives more control to the nurses (M. L. Miller, 1984). That said, independent of the choice of fixed versus flexible planning, and independent of the choice of a certain planner, the shift plan still needs to comply at a minimum with legal regulations, such as minimal shift coverage. Thus, if one nurse gets "full control" of her shift plan in a self-scheduling system and decides not to work on certain days, this implies that her colleagues need to cover these days. At this point, group level processes come into play and particularly fairness becomes important.

Fairness in Shift Planning

Fairness in work contexts has been studied extensively in the organizational psychology literature (here, the terms “fairness” and “justice” are used interchangeably; Colquitt, 2001; Colquitt & Zipay, 2015). The central framework of organizational fairness includes four dimensions that determine whether decision-making is perceived as fair (Colquitt, 2001):

- *Interpersonal fairness* refers to respectful interactions among the people involved
- *Informational fairness* is given if relevant information about the decision-making process are communicated appropriately
- *Procedural fairness* is the perceived appropriateness of the decision-making process
- *Distributive fairness* refers to the perceived appropriateness of the result

Accordingly, in the specific case of shift planning, a nurse may think that a) the shift planning process is based on respectful conduct (interpersonal fairness), b) she understands why shifts are distributed the way they are (informational fairness), c) the planning process is fair (procedural fairness), and d) the resulting shift plan is fair (distributive fairness). In other words, the framework not only takes the final decision into account, but includes other aspects of the decision-making process as well. In an extreme case, this could mean that a nurse may get a free shift she asked for, but still perceive the decision as unfair, because she thinks that her co-worker should have gotten it.

This may seem counter-intuitive, but it can be explained with the “allocation norms” that guide the decision-making process. Allocation norms can be understood as subjective, underlying definitions of fairness. Deutsch (1975) distinguished between three such norms for contexts where humans need to cooperate. Which norm applies in a certain context depends on the goal of the cooperation. If the goal is economic productivity, the performance-based “equity norm” is most common. If personal welfare is the goal, individual needs are most important (“need norm”). And if the cooperation is mainly about maintaining positive social relationships, the “equality norm” is guiding. In addition, different norms can become relevant in the same social group at different times (Deutsch, 1975).

The norms and their impact on fairness may become clearer in an example. Imagine a nurse who works in a hospital ward and who has often stood in for colleagues in the past. To the planner, this could be an indicator of good performance. The nurse submits a request for a free day, because she wants to watch a football game with her friends. But this request is in conflict with a colleague’s request, who wants the same day off to go to a friend’s wedding. The planner could follow the equity norm and give the free shift to the good performer as a reward. If both nurses

care most about economic productivity, they would probably both think that this is fair (Deutsch, 1975). But the nurses could also prioritize personal welfare above economic productivity in the shift planning context, which makes the need norm more relevant. In that case, if they consider the wedding as more important than the football game, the same decision would be seen as unfair. A third option would be that maintaining positive relationships is the central goal, so the equality norm becomes most important. Accordingly, the planner could grant the free shift to the nurse who had fewer requests granted in the past, independent of her performance and her reason for taking time off.

Although fairness mechanisms are already part of several shift planning systems, the norms that guide nurses' fairness experiences in shift planning have not been studied before. Most existing systems implicitly apply the equality norm (Constantino et al., 2011, 2015; C.-C. Lin et al., 2015; Warner, 1976). For example, the automatic decisions made by the computer in Rönnerberg and Larsson (2010) were tuned to distribute weekends and unpopular shifts evenly among the nurses. The equity norm is less common. One exception is the system presented by Ball (1997), who let nurses volunteer for unpopular shifts to earn points which helped them avoid other unpopular shifts. No shift planning systems built on the need norm have been presented yet.

In addition, the main focus of fairness in previous shift planning systems was the final shift distribution. How the algorithms work internally and how this can be communicated to nurses has not yet been studied in shift planning. In automated decision-making systems more generally, this problem of communicating process information to users has been investigated under the term "explainability" (Adadi & Berrada, 2018; Dodge, Liao, Zhang, Bellamy, & Dugan, 2019). In the context of automated shift planning systems, explainability could be necessary for nurses to understand why a certain decision was made (e.g., based on which fairness norms), to make up their minds about whether they think it is fair, and to possibly raise their voices against it (Hirsch, Merced, Narayanan, Imel, & Atkins, 2017; M. K. Lee, Jain, Cha, Ojha, & Kusbit, 2019; Woodruff, 2019).

Fair shift planning can have positive effects on nurses. It can reduce several uncertainties, for example about social status and the perceived trustworthiness of the planner (Colquitt & Zipay, 2015). In addition, fairness is associated with job satisfaction (Sušanjan & Jakopec, 2012). In shift planning more specifically, fairness is related to satisfaction with the shift plan, and to subjective work-life balance (Nelson & Tarpey, 2010).

Taken together, fair decision-making in shift planning has to do not only with the outcome (i.e., the shift plan), but also with process characteristics. The communication of information, interpersonal conduct, and other process factors are important to determine whether nurses perceive shift planning as fair. In addition, the planning decisions can be based on the equality, equity, or need norm, which should align with the group goals and nurses' subjective experiences in a shift planning context to increase subjective fairness.

Although fairness already provides some guidance about how shift planning decisions should be made to improve nurses' experiences, nurse-centered shift planning can go beyond fairness alone. The shift plan fundamentally shapes nurses' lives, the social interactions they can have at work and at home, and how they can balance their lives between the two. Thus, it fundamentally affects nurses' subjective well-being (Oates, 2018). The next section introduces subjective well-being as the second central design goal that can pave the way out of shift planning as a "zero-sum game" between different nurses' needs. Instead, a focus on subjective well-being reveals opportunities inherent in shift planning to create positive experiences.

Subjective Well-being

On a broad level, subjective well-being "refers to how people evaluate and experience their lives in positive (vs. negative) ways" (Busseri, 2018, p. 68). It is the central concept in positive psychology and was introduced as a positive counterweight to psychology's traditional focus on illnesses and problems. Most fundamentally, subjective well-being as a goal helps to extend the research focus from merely reducing or removing problems, to also entail research about where positive experiences come from or how people can fully express their virtues (Seligman & Csikszentmihalyi, 2000).

In the context of shift planning, traditional problem-centered research typically focuses on reducing negative effects of shift work. For example, we can ask how to reduce the health problems caused by shift work outlined above. This research focus has created valuable knowledge about how to make shift rotation patterns less detrimental to health, about suitable shift lengths, and well-placed breaks (Ferri et al., 2016; Harrington, 2001). However, not much research has been presented about how shift planning, a seemingly "dull" work organization process, can actually create positive experiences for nurses, or how it can positively contribute to their subjective well-being. These are different types of questions that broaden the perspective and confront designers to think about new challenges and possibilities of what shift planning can be about (e.g., Desmet & Hassenzahl, 2012; Desmet & Pohlmeier, 2013). For example, we can ask how we can make shift planning "fun", or what makes nurses satisfied with their shift plan. What are some concrete positive experiences nurses have when interacting with their shift plans? This does not mean that we should add jokes or smileys to the interface, but rather that it may be worth looking at what we can find as inherent to shift planning that has the potential to create positive experiences (see e.g., Klapperich, Laschke, & Hassenzahl, 2018; Klapperich et al., 2020, for examples from other domains).

Research with such a focus on positive experiences and well-being is still rare in the context of healthcare shift work (Tahghighi, Rees, Brown, Breen, & Hegney, 2017). One exception is the study by Clendon and Walker (2013), who surveyed experienced nurses about their opinions on shift work. Besides the admittedly

mostly negative impact of shift work, some nurses also reported positive aspects. For example, the flexible working hours helped them run their errands during regular working hours without taking time off, which would not easily be possible with a regular work schedule. In addition, some nurses reported that their unusual working hours match their personal lifestyle. A different study reported that shift work can support fathers in some cases to take a more active and personally satisfying role in childcare (Barnett & Hall, 2007).

On a more detailed level, subjective well-being has been defined as the result of frequent experiences of positive affect, seldom experiences of negative affect, and a high overall “life satisfaction” (Busseri, 2018; Diener, Emmons, Larsen, & Griffin, 1985; Martela & Sheldon, 2019). Positive and negative affect can result from everyday experiences, and are related to psychological need fulfillment (more need fulfillment leads to more positive experiences; Hassenzuhl, Diefenbach, & Göritz, 2010; Ryan & Deci, 2000; Sheldon, Elliot, Kim, & Kasser, 2001). The most common needs in experiences that involve technology interactions are autonomy, competence, relatedness, stimulation, security, and popularity (Hassenzuhl et al., 2010; Hassenzuhl, Wiklund-Engblom, Bengs, Hägglund, & Diefenbach, 2015). For example, a nurse who submits a request for a free shift and later finds out that it was accepted might experience autonomy, because this implies that she can live a bit of her life just the way she wants to. Frequent autonomy experiences can in turn increase her subjective well-being over time. The other component, life satisfaction, is an evaluative, subjective assessment about how content someone is with their life, overall (Diener et al., 1985).

Design for Well-being and Fairness

Although well-being can be clearly defined on a theoretical level, the process of implementing it into a product such as a shift planning system is less straightforward. One approach is the “design for well-being” process (Klapperich et al., 2019). It is based on the insight that positive experiences result from successful need fulfillment, and that this need fulfillment results from concrete, everyday activities in context (Hassenzuhl et al., 2010). To describe these activities precisely, design for well-being draws from social practice theories (e.g., Reckwitz, 2002; Shove, Pantzar, & Watson, 2012).

Shove et al. (2012) have defined social practices as a twofold concept. On the one hand, a practice is a specific performance of an activity that requires certain material, meaning, and competences. For example, manual shift planning requires a digital or analog shift plan, the motivation to create a plan, and certain competences including knowledge of the legal requirements. Besides these performances or “instances” of practices, they also become an established and meaningful “entity” over time. Healthcare planners have a certain idea of what “shift planning” is that transcends the individual instances of shift planning. Shove and colleagues argue that practices as instances and practices as entities shape each other reciprocally. Each time someone creates a shift plan in a healthcare institution, that specific planning

practice is shaped by the material, meaning, and competences that have become associated with shift planning over time. The practices evolve, for example through new material. Imagine the first time someone, somewhere, created a shift plan. There was no specialized material such as templates or computer-based shift planning programs. Over time, along with the proliferation of shift planning practices, such new material was introduced and at some point became an integral component of the shift planning practice.

Designers can analyze these practices and their components to restructure them in a desired way. They can envision arrangements of material and competences that transport a certain meaning, such as psychological need fulfillment (Klapperich et al., 2018). For example, the positive effect of nurses' control of their shift plan suggest that they could have a need for autonomy in shift planning. Accordingly, a shift planning system that explicitly addresses the need for autonomy could include certain interactions that allow nurses to make autonomous decisions throughout the process. Thus, the specific design of the shift planning system plays an essential role in shaping practices and thereby experiences. The technology can facilitate well-being by allowing for these practices of autonomy, or it can hinder well-being if it does not.

Design for well-being is part of the larger field of practice-based design (e.g., Diefenbach & Hassenzahl, 2017; Kuutti & Bannon, 2014; Wulf, 2009). The practice-based design approaches have in common that they focus on rearranging the material and competences of a practice to charge it with a certain meaning. Several studies have focused on sustainability as the central meaning. For example, Kuijter, de Jong, and van Eijk (2013) have developed a practice called "splashing" as a water saving alternative to taking a shower. They have designed around an envisioned practice, adapted the material in an iterative process, and finally created a prototype that serves the splashing practice and helps save water. Lawo, Engelbutzeder, Esau, and Stevens (2020) have analyzed a network of food procurement and disposal practices. Specifically, they looked at how the practices are connected with each other through their material, competence, and meaning components. This helped them identify certain gaps as design opportunities, such as linking the procurement competence of "sensory examination" with disposal practices, which currently often only rely on checking the "best before" date.

Fairness as part of the meaning component has not yet been a central focus of practice-based design. But the organizational fairness model offers several opportunities to integrate subjective fairness with a practice-based design approach, for example by studying practices that relate to informational or interpersonal fairness. In addition to supporting well-being, a shift planning system can be designed to foster respectful conduct, appropriate communication of information, and an overall fair decision-making process.

Nurse-Centered Technologies

This final section covers previous work aimed at improving some aspects of nurses' experiences with shift work and shift planning, summarized particularly with a focus on how they consider subjective fairness and well-being.

Coping With Problems of Shift Work

Several studies have presented technical interventions that can help nurses cope with problems in relation to shift work. Given the mainly problem-oriented focus, most of these studies did not explicitly design for positive experiences. They are also mainly concerned with individual nurses, so fairness of decisions that concern multiple nurses has not played a major role.

One focus of research has been to provide tools that help nurses cope with sleep problems and disturbed circadian rhythms. Some tools are concerned with sleep problems more broadly, for example by tracking sleep patterns (Liang & Ploderer, 2016), by suggesting more healthy sleep habits (Bauer et al., 2012), or by supporting personal activity planning in line with chronobiological rhythms (Janböcke, Gawlitta, Dörrenbächer, & Hassenzahl, 2020). Another approach to address sleep problems is to regulate light exposure through specifically designed lamps. For example, such lamps have been tested as part of the technical infrastructure of a healthcare institution (Schledermann, Bjørner, & Hansen, 2021) or integrated into a wearable device (Profita, Roseway, & Czerwinski, 2015). Nunes, Ribeiro, Braga, and Lopes (2018) presented an integrative approach, specifically tailored to the needs of shift workers and based on a network of devices including a wearable light sensor and a daylight therapy lamp to monitor sleep, activity levels, and light exposure. As part of that technical network, they developed a smartphone app that recommended healthy practices such as when to drink coffee or when to take naps.

Shift work also affects social relationships, which was addressed in further studies. Chien, Diefenbach, and Hassenzahl (2013) presented the "Whisper Pillow", an interactive pillow that allows couples to leave voice messages when going to sleep that their partner with a different daily rhythm can listen to when they go to sleep and vice versa. Thus, the Whisper Pillow imitates a familiar communication pattern for couples and makes it available to shift workers. Another tool is the "Picture Box" (Lenz et al., 2016), designed to improve the connection between working parents and their children. The Picture Box presents a one-way, icon-based interface for the children to leave messages that the parents can see at work (but not reply). In the shift work context, this design allows nurses to occasionally stay in touch with their families without the risk of disturbing them at home (e.g., during a night shift). These two designs indicate how the problem of communicating with closely related people despite time and location differences can provide opportunities to create positive relatedness experiences and thus contribute to nurses' subjective well-being.

Redesigning the Shift Planning Process Itself

Besides these technologies that can help nurses cope with negative effects of shift work, some systems have been presented that redesign the shift planning process itself, with the focus on increasing nurses' control. Such efforts have a long but somewhat marginal tradition in shift planning research, and they are typically inspired by M. L. Miller (1984)'s "self-scheduling" concept. She let nurses in a hospital ward plan their entire shift plan by themselves. This included vacation planning and conflict resolution around unpopular shifts. The head nurse played a supportive role as an advocate for the self-scheduling approach and during the transition from the previous system. Overall, this fundamental shift in control reportedly led to lower turnover rates, an improved team spirit, and more cooperative behavior between nurses and management.

To an extent, these findings were confirmed in later work. In a large-scale study, Silvestro and Silvestro compared healthcare institutions with different shift planning processes. In some cases, nurses prepared their shift plans autonomously. Other institutions had the head nurses plan separately for each ward or relied on a central office to plan for multiple wards. They found that nurses who created their shift plans themselves felt more empowered, managed to resolve their planning conflicts autonomously, and had lower turnover rates. But they also identified certain limitations with self-scheduling in larger groups. With a growing number of staff, the entire shift plan becomes more complex. The legal regulations, individual contract details, and economic considerations become a challenge for distributed self-planners to handle appropriately. They recommended self-scheduling for small teams, but more centralized approaches in larger teams because of these complexities.

As an alternative to centralized planning, computers can assist with handling these complexities and legal regulations. Such partial computer-support has been integrated in self-scheduling approaches before (Koning, 2014; Nabe-Nielsen, Garde, Aust, & Diderichsen, 2012; Rönnerberg & Larsson, 2010). For example, Rönnerberg and Larsson (2010) have implemented a computer-supported system based on self-scheduling. It allowed nurses to create their individual shift plans first and automatically integrated them later on. Remaining conflicts were resolved by the head nurse. The computer made the integration process more efficient and reliable. In addition, the responsibility for a functional shift plan was clearly assigned to the head nurse. But this was also the central problem from the nurses' perspective. In this approach, nurses lost their direct control to the head nurse and the computer, which was also their main concern with the system.

In Nabe-Nielsen and colleagues' (2012) study, the conflict resolution design was slightly different. Nurses submitted individual shift plans, from which the computer program first generated a preliminary group plan. Then the nurses could adapt it where needed. Thus, they had more direct control about the final shift plan than nurses in the system by Rönnerberg and Larsson. In this study, nurses reported more subjective flexibility and fewer short-term changes to the shift plans.

Bailyn, Collins, and Song (2007) presented a case in which a self-scheduling implementation failed. They used a system in which nurses signed up for shifts and were asked to follow specific guidelines, for example about how the unpopular Friday night shifts should be distributed. Initial results were positive: The nurses reported higher control of the shift plan and better quality of patient care. It also led to fewer short-term changes. But after a while, nurses signed up for fewer shifts and did not fill in their full shift plans anymore. They also did not resolve critical planning conflicts among themselves. Because of this lack of long-term engagement, the head nurse made final decisions again, which led to complaints and eventually to a cancellation of the project. Similarly, Wynendaele, Gemmel, Peeters, Myny, and Trybou (2021) analyzed self-scheduling in six nursing homes and found that it can negatively affect procedural fairness, despite the increased nurse control. They explain their findings with negative interaction effects between self-scheduling and the leader-nurse relationship, and possibly a lack of negotiation skills on the side of the nurses. Bailyn et al. concluded that such fundamental changes in shift planning require intense preparation and communication with all nurses.

Taken together, efforts to increase nurse control through self-scheduling have been successful to an extent in the past, although the additional planning tasks have led to significant workload for nurses in some cases. Problems can arise in larger wards due to the complexity of the planning process, but also in cases where nurses do not fully engage in self-scheduling or conflict negotiation. As Wynendaele and colleagues (2021) point out, nurse control does not necessarily lead to more fairness, and it can even have negative effects. Some of the problems with self-scheduling can be addressed with computer-support, but it seems essential that the design is based on a thorough understanding of nurses' experiences in relation to shift planning, and the social dynamics in the team.

In other words, self-scheduling can have positive effects on nurses, but the specific details of its implementation need to be considered to avoid negative consequences. It has been the most prominent approach to nurse-centered shift planning in the past, and the different case studies provide a broad and somewhat ambiguous image of its potentials and risks for nurses.

Going forward, we took a slightly different approach that was not primarily focused on implementing self-scheduling as such. Instead, we tried to first develop a thorough understanding of what makes shift planning fair from the perspective of nurses, and at what points they had positive experiences in relation to shift planning that could contribute to their well-being. This understanding of subjective fairness and well-being laid the foundation of our design process.

Study 1: Understanding Subjective Fairness in Shift Planning

The presentation of Study 1 was slightly adapted to fit with the overall format of the thesis (e.g., wording, structure, figures). The original version was published in:

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Research Questions

The goal of Study 1 was to understand the subjective fairness experiences of nurses in shift planning. Our research questions were guided by Deutsch (1975)'s allocation norms and the framework of organizational fairness (Colquitt, 2001). Specifically, the two research questions were:

RQ1: Which allocation norms (equity, equality, need) apply within the context of shift planning?

RQ2: How do nurses experience the four facets of organizational fairness?

Method

The design and analysis of Study 1 were based on Interpretative Phenomenological Analysis (IPA; Smith, Flowers, & Larkin, 2009). IPA is a qualitative method for small sample studies, with typically three to six participants. Its central focus are the subjective sense-making processes of people who share certain experiences. The topic is usually narrowly defined. In this case, we set the focus on nurses' subjective experiences of fairness and unfairness in the context of shift planning.

Participants

Three female registered nurses participated in our study (age: 24, 29, 57). All three had more than 6 years of work experience. We recruited the three participants from different wards within the same retirement community. The interviews took place in September 2017 during a morning shift and lasted around 35 minutes on average. The participants received no further compensation apart from the working time. In the organizational system of the retirement community, nurses received their shift plan from their ward leader. One of the participants had an additional role as the deputy planner, which means that she occasionally helped her ward leader with planning.

Procedure

The interviews were semi-structured and based on an interview guide covering questions about fairness and unfairness. We started with general questions and then narrowed the focus to more detailed descriptions of specific experiences. Three different interviewers accompanied their respective interviewee for two hours during their normal shift before the interviews to establish mutual trust and familiarize themselves with the environment. We then ran the interviews in separate rooms in the residence, allowing for a calm, undisturbed atmosphere. All interviews were voice recorded. Given the open nature of the interviews, we sometimes deviated from the interview guide in order to gain a deeper understanding of the participants' perceptions and concerns. Afterwards, we debriefed them and thanked them for their time.

Analysis

Following the IPA guidelines (Smith et al., 2009), we first transcribed all interviews in the native idiom of the interviewees as well as in standard German. The analysis was then conducted independently by two of the interviewers. We started by simultaneously listening to and reading the transcript, while writing down first impressions. In the next step, we annotated everything considered noteworthy for answering the research questions regarding content, intonation, and expressed feelings. Then we summarized relations among concepts and common themes.

Finally, we compared and discussed the results of both analyses and consolidated or restructured themes accordingly, depending on agreement and disagreement. The following section focuses on shared themes between at least two of the three interviews.

Results

The results are structured by the four facets of organizational fairness (Colquitt, 2001), starting with distributive fairness and the associated allocation norms, and followed by procedural, interpersonal, and informational fairness.

Distributive Fairness and Allocation Norms

Across all three interviews, we found a similar pattern of allocation norms. With no further context given, all interviewees preferred shift planning based on equality. For one participant, fairness meant *“that everyone is treated the same way, no matter where they come from and what they do. Just equal rights”* [P3:19–20]. The general preference for equality in shift planning was even expressed unsolicited: *“there are also situations [regarding the shift plan] where employees get upset, when they see, for example... someone has only... one weekend off and someone else has three. That’s a*

no-go, and then they really get upset” [P3:235–239]. Here, equality was the guiding allocation norm.

However, when more context was provided by talking through particular critical shift planning situations, the applied allocation norm changed. One interviewee had initially complained about a co-worker with a special agreement (an “inequality”) to only work in the morning to be able to take care of their children. When we asked how these special agreements should be dealt with, she replied: “*Well, actually it’s fair, because they [employees with special contract conditions] also need their work...*” [P3:189–190]. Furthermore, she stated that in the case of conflicts among two nurses the planner “*needs to talk to the two parties. Maybe one only has an appointment with, let’s say, the hairdresser and the other one has an important appointment with the doctor. In this case, I would say that the appointment with the doctor is more important*” [P3:47–50]. Both statements are clear references to the need norm. If equality were the norm, the nurse might have referred to an equal amount of granted requests. Instead, she used the involved nurses’ needs as her criterion. We found a similar pattern in the other interviews.

One problem that arises with need-based fairness is that employees who do not have any obvious obligations beside their job, such as a family member to take care of, may experience a stronger pressure to be always available (Perrigino, Dunford, & Wilson, 2018; Young, 1999). We found this phenomenon, called *work-family backlash*, among the interviewees as well. For instance, after we asked her about a particularly unfair experience with planning, one participant commented: “*Simply casual statements where someone said: ‘well, you are still young’ and ‘You’re still an apprentice with no other obligations’ and ‘you could easily work 12 or 13 days in a row’ [...] although I’m young, I still want my freedom and free time somehow. [...] Ok, so basically, for you I’m just a robot that needs to function, and apparently I’m not allowed to have a private life [...] that was very stifling*” [P2:62–94]. In this excerpt, the nurse was especially upset about the assumption that she has no private obligations. She did not complain about the actual distribution of shifts, but about the fact that her availability was taken for granted, simply because she had no children or apparent health problems. Furthermore, it shows that she wants to have a say when it comes to decisions made about her shift plan. Her description of feeling like a “robot” is on point: A robot has no needs or private life and can always work. It is a tool that gets told what to do and mindlessly executes its tasks. We understand this statement as a complaint that the nurse’s personal needs are not appropriately taken into account.

For the sake of completeness, note that we found no statements supporting the equity norm in any of the interviews. All in all, while nurses referred to equality as the overall relevant norm on an abstract level, they judged specific situations exclusively with reference to the need norm.

Procedural Fairness

A predominant theme for the nurses regarding the fairness of planning procedures was their involvement in decision-making. For instance, when talking about the

distribution of shifts during public holidays, such as Christmas, one interviewee stated that *“an optimal solution would be to discuss it within the team: ‘Who wants to work on which holiday?’ ”* [P1:118–119]. Another interviewee appreciated that *“he [the ward leader] has always involved the employees while creating the work schedule: ‘Look at this, does it fit? Is it ok for you?’ ”* [P2:151–153]. Yet another positive experience was: *“[the ward leader] says at an early stage ‘Well, there are two shifts or two holidays and I cannot give everyone the day off’. You know, it became addressed as soon as possible, and it can now be discussed within the team”* [P1:87–91]. From the deputy planner’s perspective, it was mentioned that *“when the work schedule is finished, it’s fixed, and then we need to talk about it within the team and see whether there is a solution that is fine for everybody somehow”* [P3:246–248]. Notably, in these examples the nurses are already more involved than just through the mere submission of requests. However, this was not an explicit part of their current planning system, but a downstream informal practice based on an individual planner’s personal initiative. In fact, in the previous excerpt, the interviewee explained that after the shift plan was “fixed”, nurses engaged in informal activities to cooperatively adapt it to everyone’s needs, thereby actually circumventing the planning system and questioning the supposedly “fixed” shift plan. Given that the nurses mentioned the involvement as important for experiencing fairness, the active negotiation of the shift plan should be considered to be made explicit within planning systems.

Not being involved leads to experiences of unfairness. This became evident in statements such as: *“Most of the employees are not even asked. They simply get their shifts assigned and only see it when the schedule is released”* [P2:478–480]. One participant explicitly complained about non-involvement: *“But you need to ask me! You cannot just decide over my head”* [P2:410–411]. This experience can lead to negative emotions: *“It happens very often that shifts are distributed without informing the employees. [...] And... well... I think it’s sad”* [P2:166–168]. Both, the positive experience of involvement and the negative experience of non-involvement, support a more participatory planning process, not only focused on the shift plan as an outcome, but also on the way it is created.

Informational Fairness

The central topic concerning informational fairness was the transparency of procedures. One participant described the positive effect of transparency: *“I think it would be very important to have transparency here, because everyone could understand or accept why it [a request] didn’t work out this time. [...] And I think if the problems were openly addressed by the planner there wouldn’t be so much resentment. Perhaps there would be more understanding”* [P1:340–355]. Accordingly, another participant pointed out the negative effect of a lack of transparency: *“Everybody wonders why the shifts are distributed and decided over our heads. [...] Why it is handled this way? Well, we don’t know”* [P2:170–175]. Transparency is thus desirable insofar that it helps the nurses understand the reasons behind subjectively important decisions.

Conversely, however, the requirement of providing and justifying a request publicly was seen as problematic as well: *“I don’t want to reveal to everybody why I want to swap”* [P1:402–403], and *“Honestly, I believe nobody needs to justify why they need someone to replace them or why they are absent”* [P2:314–316]. If individual needs are the reason why a certain free shift cannot be granted, one nurse’s need for transparency is inherently in conflict with another nurse’s need for privacy.

Interpersonal Fairness

Concerning interpersonal fairness, we found that the practice of asking a colleague to swap shifts requires an already existing, good and trusting relationship. The willingness of the person to cooperate is higher, the more they like the person who is asking: *“A lot of it is handled by sympathy [...] if you know somebody privately [...] it’s easier to ask or the willingness to swap is higher”* [P1:395–400]. In a shift planning system based on cooperation and negotiation, positive interpersonal relationships and a positive overall team spirit are particularly important prerequisites.

In general, the respectful treatment of each other was crucial for experienced fairness and well-being. One interviewee described a hypothetical shift swap with a colleague: *“If I had swapped shifts with a colleague in the past, and now I want to swap one of my shifts [...] and he would reply: ‘No sorry, I don’t feel like doing that.’ [...] Well I mean, if he could give me a good reason or at least a reason at all, it’s a different thing. But if it was like ‘No, forget it’ directly... well then I would think it’s unfair. And that would have been the last time for me to swap with him”* [P1:50–67]. This shows that the interaction of the co-workers is based on more than a mere quid pro quo social exchange. An overall cooperative attitude is crucial to successfully negotiate shifts. In this process, again, individual needs play an important role.

Summary and Discussion

All in all, the interviews provided a detailed understanding of the prevailing concept of fairness in shift planning among nurses. They cast doubt on a simple, equality-based distribution of shifts and suggest a stronger focus on the need norm. We found distributive fairness to be a two-stage process, where equality is an underlying, rather abstract meta-norm. But when specific situations and conflicts are concerned, all interviewees applied the need norm. Therefore, we assume that in the case of real conflicts or problems, an equality-based shift allocation may not be the most desirable choice. Instead, need-based conflict resolution seems more appropriate. Equity played no role in the interviews.

The nurses clearly preferred shift planning processes that involved them. They saw non-involvement as unjust, independent of whether the resulting distribution was perceived as fair.

Regarding informational fairness, the nurses expressed two conflicting requirements of transparency and privacy. On the one hand, transparency is crucial to

understand the decision-making procedure and the outcome. On the other hand, privacy is a requirement given that reasons for requesting time off can be sensitive. Mutual sympathy and trust are important facilitators that can help to resolve this contradiction and a positive team spirit makes even personally difficult decisions easier to accept. But a good solution for work places with a negative team spirit is still needed.

Study 2: Experimental Validation of the Subjective Fairness Concepts

The presentation of Study 2 was slightly adapted to fit with the overall format of the thesis (e.g., wording, structure, figures). The original version was published in:

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Study 1 was based on a small sample of three nurses. While the in-depth interviews provided us with a detailed understanding of their subjective fairness concepts, we ran an additional experimental study to validate the central results with a larger population of nurses and to test whether differences in subjective fairness can be causally attributed to the different fairness norms.

Hypotheses

We tested the following hypotheses concerning procedural and distributive fairness in shift planning in healthcare:

- H1:** On an abstract level, equality is more prevalent than the need (a) and equity (b) norms.
- H2:** Specific conflict resolutions are perceived as fairer when based on individual needs rather than on equality (a) or equity (b).
- H3:** Specific conflict resolutions are perceived as fairer when based on equality rather than on equity.
- H4:** Specific conflict resolutions are perceived as fairer if nurses become involved in the decision-making process, compared with resolutions made by a computer only.

We excluded aspects of interpersonal and informational fairness in the experimental design. Both seem to depend to a great extent on the specific inter-individual relationships, which are difficult to address meaningfully in an experimental online study.

Method

Participants

We recruited participants in August 2018 through social media, snowball sampling, and from other retirement communities of the same organization of the participants in Study 1. We only included nurses who worked in shifts, were fluent in German, and who had no prior contact with us through our previous research. The participants could sign up for a raffle to win one out of five 30 € vouchers for Amazon Germany or Austria. Fifty-one nurses participated in the study (13 male, 36 female, and 2 participants with undisclosed gender), with a median age of 35 years ($min = 21$, $max = 60$). Thirty-nine were registered nurses in general, geriatric, or childcare. Eleven were nursing assistants and one participant did not disclose his or her specialization. They were employed in hospitals (25), retirement homes (24), and a home for people with disabilities (1), with one undisclosed institution type. Twenty participants had already been responsible for shift planning to some extent. The majority lived in Germany (48) and three participants lived in Austria.

Procedure

The entire study took approximately 15 minutes to complete. After accessing the introduction page through a link, the participants were first informed that the topic was shift planning, data were anonymized before analysis, and that they could quit at any time. Next, the participants filled in demographic questions about their specialization, age, gender, and country of residence. Here, we filtered out participants not working shifts and/or not working in healthcare. Following the demographics, we asked each participant to formulate in two open questions what fairness meant to them in general and with regard to shift planning specifically. We chose this open format to avoid directing the answers towards a specific norm.

We then assigned participants randomly to a set of 18 *vignettes*. Each vignette represented a brief textual description of particular shift planning situations. Systematically varied vignettes are at the heart of the *Experimental Vignette Methodology* (EVM; Aguinis & Bradley, 2014), a method frequently used in Social Psychology and its applied fields (e.g., Aguinis & Bradley, 2014; Tversky & Kahneman, 1981). Typically, participants are asked to immerse into the presented situations and to make explicit decisions, judgments, or to express behavioral preferences within these situations. This method allows for experimental rigidity in realistic, contextualized scenarios.

In the present study, the vignettes described a conflict between two nurses. Both wanted a day off – the participant and a fictional co-worker to whom they had a neutral relationship. An example vignette was: *“It’s you or your co-worker – one of you has to work. You want your day off because **you have an important appointment with your doctor** [need norm salient]. On the other hand, it’s your co-worker’s turn, because **he got almost none of his wishes granted recently** [equality norm salient].*

The system decides [locus of decision] *in favor of your co-worker* [winner], *in order to assure that the free time is distributed equally among all employees.* [reason]”.

We varied the *norms* that the participant and co-worker used to justify their respective claims for the free shift. Furthermore, we varied the *locus of decision* (nurses vs. system) and the *winner* (who gets the free shift?). The vignettes ended with one sentence explaining why the decision was made, to clarify the applied allocation norm. Thus, the fixed context factors we provided were the neutral relationship with the co-worker (1), the need to decide for one of the two shifts because of staff shortage (2), and a moderate level of transparency (3). The provided reason stated the allocation norm of the winner, but provided no further details. See Appendix A for all variations used.

These variations resulted in a total of 36 vignettes (3x3x2x2). We chose a set size of 18 vignettes for each participant, which allowed us to test our hypotheses without confounding factors at a reasonable study duration (Atzmüller & Steiner, 2010; Steiner & Atzmüller, 2006). We varied the factor *locus of decision* between individuals, and all other factors in a repeated design. This means that, for example, an individual participant only answered vignettes in which the computer made decisions, and did not see those where the co-workers decided together (and vice versa). However, each participant saw several scenarios with different argumentations based on needs, equality, and equity, in which sometimes the participant won and sometimes the fictional co-worker. In addition, we used two different operationalizations for each argument norm in order to increase variation and to allow for more natural comparisons when both nurses in the vignette justified their claim with the same norm (e.g., need vs. need). Then, we created two sets of 18 vignettes each, separately for both factor levels of *locus of decision* (nurses, system), with randomized operationalizations and orders of the vignettes. Thus, we had a total of four sets covering all possible combinations. For each vignette, the participants rated the fairness of the result (distributive fairness) and the fairness of the process (procedural fairness) on a 7-point scale ranging from “unfair” to “fair”. Together, these formed a comprehensive measure of the tested subjective fairness facets. In addition, we asked participants how well they could immerse into that situation (7-point from “not well” to “well”). The study concluded with an open comment field and the possibility to leave a contact address for the raffle.

Results

First, we analyzed the open-ended questions, where participants described what fairness means to them, both in general and in relation to shift planning. Two independent coders categorized each answer with respect to the implied allocation norms: need, equality, and equity. Multiple categorization was allowed. If a clear categorization was impossible, the statement was coded as *no association*. For example, one participant wrote: “*Justice for all*”, which could not clearly be attributed to

any category. On the other hand, “*Considering the needs of every human being*” was assigned to the “need” category and “*That everyone is treated in the same way and nobody receives preferential treatment*” was assigned to “equality”. The inter-rater reliability across both questions was very high (Krippendorff’s $\alpha = .86$; Hayes & Krippendorff, 2007) and remaining disagreements were resolved in a follow-up discussion. The absolute frequencies of mentioned norms and their combinations are shown in Figure 1.

When asked about fairness in general, 26 of the 51 participants referred only to the equality norm (41%; Confidence Interval: $CI_{95\%} = [28\%, 56\%]$), followed by 9 referring only to the need norm (18%; $CI_{95\%} = [9\%, 31\%]$). Moreover, 5 comments referred to both equality and need (10%; $CI_{95\%} = [4\%, 22\%]$). No participant referred to equity and 16 comments could not be categorized. When asked about fairness in the context of shift planning, 25 participants (49%; $CI_{95\%} = [35\%, 63\%]$) referred to the equality norm, 11 (22%; $CI_{95\%} = [12\%, 36\%]$) to needs, and 11 to both equality and needs (22%; $CI_{95\%} = [12\%, 36\%]$). Again, nobody referred to the equity norm and four comments could not be categorized. Besides these three categories, a few participants also mentioned aspects relating to interpersonal and informational fairness. For example, one participant mentioned “*friendly cooperation*” among other aspects and another one wrote: “*Honest, open, transparent, just*”.

As expected (H1), equality was the most common fairness norm in general (41% exclusively and 18% together with needs, thus 59% in total), and when we specifically, but abstractly asked about shift planning (49% exclusively and 22% combined with needs, 71% in total).

Vignettes

To analyze the vignettes, we first transformed the data to remove redundant coding. Given that the factor levels of both nurses’ norms were equivalent, we analyzed our model in a combined $2 \times 3 \times 2 \times 2$ model. The within-subject factors were *argument role* (winning vs. losing *argument*), *argument norm* (need, equality, and equity), and *winner* (participant vs. co-worker), and the between-subjects factor was *locus of decision* (nurses vs. system). For example, when the participant won with a need argument against an equity argument by the co-worker, we coded the winning argument as need-based, the losing argument as equity-based, and the participant as the winner. Our dependent variable was a combination of the two *fairness facets* (distributive fairness and procedural fairness) in a single, compound measure. We had no specific hypotheses for the individual facets.

The scenarios were immersive with a high average of 5.57 points ($SD = 1.37$) on a scale from 1 to 7. Thus, they represented realistic situations the participants could relate to.

We ran a $2 \times 3 \times 2 \times 2$ -MANOVA that revealed a significant interaction effect for *argument role* \times *argument norm* using Wilks’ statistic ($\Lambda = .63$, $F(4, 194) = 12.75$, $p < .01$, $\eta_p^2 = .21$). Moreover, we found a main effect of *locus of decision* on fairness ($F(1, 49) = 3.31$, $p < .05$, $\eta_p^2 = .06$).

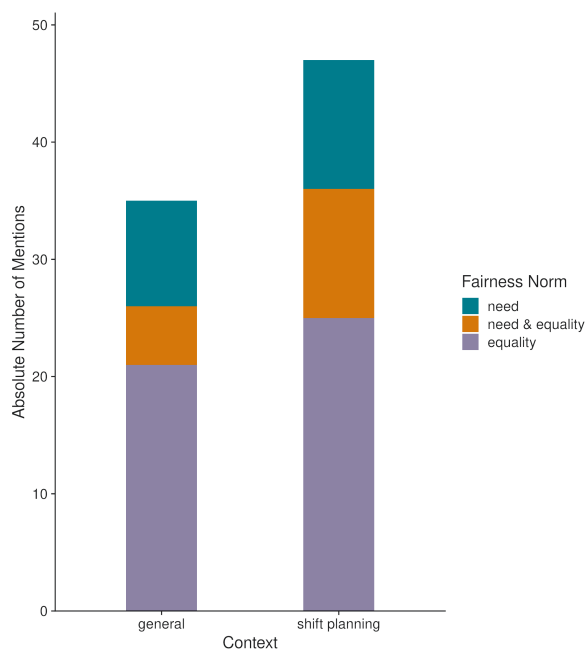


Figure 1: Absolute frequencies of allocation norms the nurses mentioned when asked about fairness in general (left) and in shift planning (right). Equity was not mentioned. (n=51)

The interaction effect relates to our hypotheses H2 and H3 (see Figure 2). As expected, decisions based on a need argument ($M = 5.06, SE = 0.18$) were perceived as fairer than those based on an equality argument ($M = 4.57, SE = 0.17, t(50) = 3.00, p < .01, d = 0.42$) and fairer than decisions based on an equity argument ($M = 4.11, SE = 0.18, t(50) = 5.07, p < .01, d = 0.71$). Moreover, when a decision was based on an equality argument, it was perceived as fairer than one based on an equity argument ($t(50) = 3.08, p < .01, d = 0.43$).

Conversely, when a need argument was ignored, that is, a decision was made *against* it ($M = 4.07, SE = 0.18$), the decision was perceived as less fair than when an equality argument was ignored ($M = 4.68, SE = 0.16, t(50) = 4.14, p < .01, d = 0.58$) or when an equity argument was ignored ($M = 4.99, SE = 0.17, t(50) = 4.95, p < .01, d = 0.69$). Decisions ignoring equality arguments were perceived as less fair than those ignoring equity arguments ($t(50) = 2.30, p < .05, d = 0.32$). In sum, decisions based on the need norm were perceived as fairest and those ignoring the nurses' needs were perceived as least fair, confirming H2. Moreover, decisions based on the equality norm were perceived as fairer than those based on the equity norm and decisions against the equality norm were less fair than those against the equity norm, confirming H3.

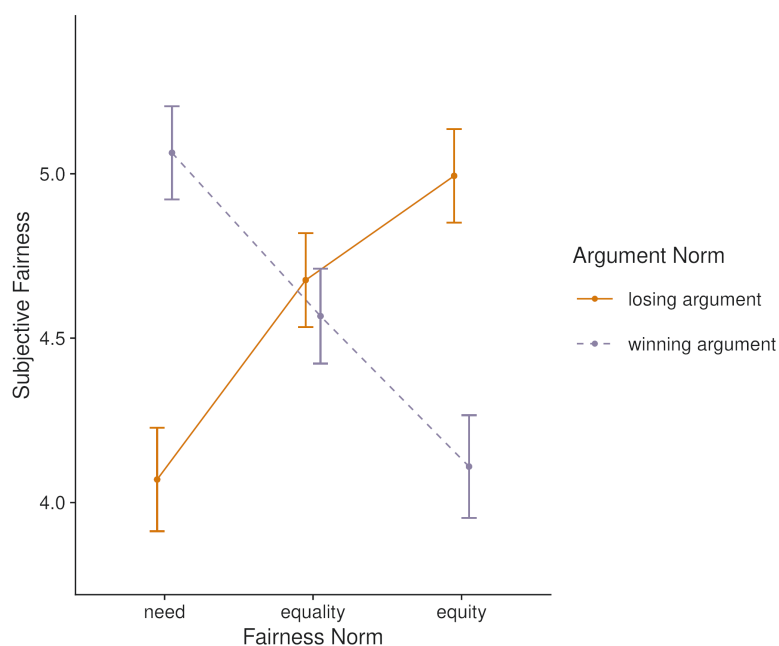


Figure 2: The interaction effect *argument role x norm* from the vignette study. Y-Values represent the combined fairness facets. Error bars represent the 95% confidence interval. (n=51)

The main effect of *locus of decision* supports our hypothesis H4. Scenarios in which the nurses made a collaborative decision led to higher subjective fairness ($M = 4.84$, $SE = 0.20$) than those in which the system made a decision autonomously ($M = 4.33$, $SE = 0.20$).

Open comments

Finally, we analyzed the open comments to see whether they further qualify our results. In line with H4, two participants wrote that they see mutual decision-making between two employees as preferable to computer decisions. One participant stressed the fairness of mutual agreements: *“If the system asks us to find a decision together and we do that, then the decision who gets the time off is based on mutual agreement. So, logically, it is fair”*. Another one focused on problems with computer decisions: *“I don’t like the idea to have an algorithm decide about my free time”*.

Two more comments provide suggestions on how to act if no mutually acceptable decision can be found based on the need norm. One person commented: *“If you have a co-worker who always insists on his free time, no matter how important your appointment is, I would draw lots. Thank god that hasn’t happened yet”*; and the other one: *“I would accept generally unique reasons like a wedding for a day off, as long as it’s not the wedding of a person the employee hardly even knows. [...] Everyone has*

the right to have some days off, but also has to accept if it doesn't work out sometimes. However, if it turns out that someone is not reliable or 'often sick', maybe an employee who is more reliable should be preferred". In both cases, the need norm has the highest priority. But if it is not sufficient or misused, one nurse suggested a random decision (equality-based) while the other one suggested a performance-based process (equity).

Subjective Fairness in Case of Conflicts

In sum, when looking at fairness in general, the equality norm was most common, confirming our hypothesis H1. However, specific conflict resolutions based on the need norm were perceived as fairest, followed by the equality norm and confirming H2 and H3. Finally, decision-making that was guided by the computer but made by the nurses was fairer than autonomous decision-making by the computer, confirming H4.

Summary and Discussion

The experimental vignette study confirmed the overall picture of subjective fairness in shift planning derived from Study 1. Oversimplified concepts of fairness as equality of outcomes underlying the majority of previous shift planning systems (e.g., Constantino et al., 2015; C.-C. Lin et al., 2015), do not resonate with nurses' understanding of fairness. While equality was the most common norm on an abstract level, it is not appropriate for resolving concrete planning conflicts. Instead, conflict resolution should be need-based. Equity, that is, fairness based on prior performance, did not play a pronounced role. It was also considered as the subjectively unfairest norm in our experimental study. The need norm was the fairest. Moreover, our exploratory comparison between decisions made by nurses and decisions made by a computer (H4) shows that previous systems that were designed to make autonomous decisions about personally relevant conflicts may profit from integrating the nurses in the process. The shift planning algorithm should ideally support the participants in their decision-making, but not decide on their behalf. Notably, we found this effect despite the fact that both the algorithm-based and collaborative decisions were briefly justified to the nurses in each vignette, thus providing higher explainability than some existing systems (Adadi & Berrada, 2018; Constantino et al., 2015; Dodge et al., 2019).

Why do current solutions tend to apply the equality norm? As indicated above, one explanation is the vision of a fully automated planning process that solves the social conflicts autonomously. This requires an exhaustive mathematical model of fairness. When creating such a model based on needs, a developer needs a vast range of (partially sensitive) information about each nurse in each situation. For instance, assume a conflict where one participant "takes care of the own child" which could be considered an important reason, while the other one "goes to a concert", which might be less important. However, the urgencies depend on whether

a nurse has, for example, a spouse to help out with childcare, compared to being a single parent. In contrast, the concert may be subjectively more important if it is part of a romantic date and as such possibly a step on the way to build a family. A fully automated system needs these sensitive data to make meaningful decisions, which are necessarily normative. In contrast, equality as used in previous work (e.g., Constantino et al., 2015) is less (but still) complicated to implement. Moreover, the qualitative data from Study 1 indicate that shift planning may be a case of “particularized fairness” (Binns, 2020), meaning that it may be inherently important to treat each conflict on a case-by-case basis, and not as another iteration of learned, seemingly appropriate decisions. This implies fundamental issues when treating conflict resolution as a purely mathematical decision-making problem (Binns, 2020; Selbst et al., 2019). Instead of aiming for full automation, we thus advocate a meaningful integration of the affected nurses, not as an intermediate step, but as a design goal. Involving nurses in the decision-making then seems to be a logical and straightforward solution that can be supported by technology. We showed that such a mutual decision-making process is perceived as fairer by nurses, compared with a fully autonomous process.

Design Implications: A Sketch of Fair Shift Planning

Based on the findings from Studies 1 and 2, we can outline a tentative shift planning system designed to increase subjective fairness (see Figure 3).

Equality in General Shift Planning Decisions

On an abstract level, all nurses should be treated equally. This includes that they should have similar amounts of requests and free weekends, and similar abilities to include their preferences in the shift plan. Algorithms are potentially good at asserting this equality.

Need-based Conflict Resolution

However, in case of a specific conflict due to overlapping requests, nurses should have the chance to justify their claims by stating why they need the time off. These needs should form the basis for conflict resolution.

Inclusive Decision-making

The conflict resolution process should not be done by the system itself, because this leads to lower procedural fairness than mutual decision-making. Instead, the system should support conflict resolution, for example by fostering a sensible, step-wise procedure of disclosing the claims to each other, with a focus on building mutual trust and not invading privacy. Computer-support could be included in the form of

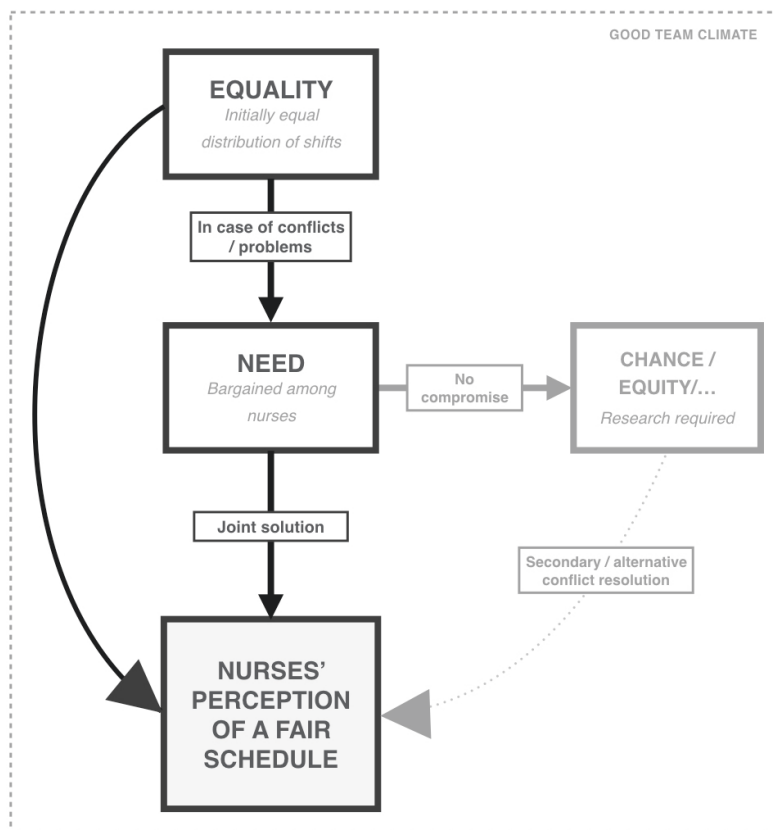


Figure 3: A sketch of a fair shift planning system. On a general level, equality should be the goal. However, when conflicts arise, they should be solved on a need basis. If this doesn't lead to a solution, other processes may be used. Generally, a good team climate facilitates the negotiation process. Graph license: CC BY 4.0

identifying planning conflicts, presenting all legal solutions (e.g., who would have to withdraw a request), and indicating how and when the nurses could resolve the conflict in advance, for example the next time they work together. Such a system would turn a currently informal practice heavily relying on a committed planner to a more formal practice open to all nurses in an organization.

Two Options for Difficult Conflicts: Randomness or Equity

Probably not every conflict can be resolved with mutual agreement. In such cases, either an equality-based mechanism, such as granting a similar number of "wins" to each nurse, or an equity-based solution, such as rewarding flexibility, may be used. However, while these mechanisms seem straightforward at first, on closer inspection a number of issues arise. For instance, a planner could use the overall number of granted requests for each nurse as a baseline (with and without conflict) or focus

on the number of “wins” and “losses” only of the nurses involved in the conflict at hand. Moreover, the time span has to be taken into account: how much does a “loss” from three months ago count in comparison to one from five years ago? In addition, a nurse with a part-time position may be more flexible to help out than a full-time nurse who is at work anyway. When applying an equity-based system, how do we compare the demonstrated flexibility these two nurses show? While equity and equality seem to imply a certain objectivity, there is no natural “true” standard for all these decisions. Needs can be expressed and negotiated, and in case the nurses find no agreement, a random selection (e.g., flipping a coin) is a simple solution that avoids further complexities. Alternatively, the specific team could agree on the exact conditions of how equality and equity are valued or even attempt to avoid a forced decision altogether by promoting consensus-oriented decision-making (see e.g., Krawinkler, 2018; Laloux, 2014). Finally, if financial resources and the specific healthcare setting allow it, additional float nurses could be assigned from other wards or externally to resolve such bottleneck situations (Easton et al., 1992).

Cultivating a Positive Team Spirit

Respectful conduct is an important prerequisite for successful shift planning. In Study 1, we found that mutual respect and empathy for the co-worker increased the willingness to swap shifts and to engage in constructive conflict resolution. Such a collaborative process was also perceived as fairer in Study 2. A shift planning system should therefore foster this positive team spirit, for example by explicitly designing for positive interactions among the nurses through the system. This could be achieved through the design for different levels of informal communication.

Data Sovereignty and Transparency

To successfully resolve conflicts, shift planning systems need to balance privacy and transparency. On the one hand, some nurses do not want to share private, sensitive information publicly. On the other hand, knowing the reason why a free shift is granted to a co-worker helps accept the decision (if the reason is deemed valid). Shift planning systems should support the negotiation by initiating it and by facilitating the stepwise, voluntary disclosure of private information until a solution is found. The disclosure can also happen offline, for example in a private conversation at work.

In sum, despite the concerns about fully automated decision-making, algorithmic shift planning systems can be of help if designed appropriately. They can create legal shift plans and detect planning conflicts among nurses. Not all conflicts are avoidable, but the resolution can be made easier by fostering need-based negotiations. The system can jump-start constructive discussions among involved nurses and, for instance, inform them when they share a shift to talk solutions through, face-to-face. It can also suggest possible solutions so that nurses can be sure that their replanning (e.g., of a doctor’s appointment) actually solves the problem. This facilitates pro-social behavior and can be beneficial for the team spirit, fueling a virtuous circle of

growing together as a team. Finally, by indicating and explaining legal issues, an inclusive shift planning system allows nurses without further training in planning to take back control of their time.

Limitations

While we believe that our suggested approach to shift planning would have a positive impact on nurses' fairness experiences, there are a number of possible negative consequences to be considered. First, a need-based system risks to further consolidate the so-called "work-family backlash" (Perrigino et al., 2018; Young, 1999) by implicitly giving an advantage to nurses who often have higher needs due to family obligations. However, this risk might be less problematic than it appears at first glance. Study 1 showed that nurses already maintain practices of adapting presumably "fixed" shift plans to their needs. The suggested system would support a better match between the "official" and the emerging "real" shift plan. A possible bias in favor of workers with children could therefore be more accurately represented, providing explicit data that may help to develop appropriate coping mechanisms within the team. In addition, even the young apprentice nurse from Study 1, who had no own children, found need-based shift planning to be fair in principle. When introducing an explicitly need-based conflict resolution process, needs in general may become more visible, because it becomes official practice to base decisions on individual needs and negotiations. This may in turn even reduce the bias. However, without an implemented system, this remains speculation.

Second, a more involving system assigns additional tasks to the nurses, namely conflict resolution and deeper involvement in planning. This contributes to their already high workload. While we cannot rule out the possibility that some nurses will find this problematic, the interviewees in Study 1 mentioned a few situations where they would have preferred to be more involved. In fact, there were no complaints about too much involvement in either study. This is consistent with previous insights into organizational fairness, where more involvement is typically perceived as positive (Colquitt & Rodell, 2015; Nelson & Tarpey, 2010) despite the added work. Moreover, as we found in Study 1, nurses already involve themselves into shift planning to varying degrees, currently as an informal practice. Through the suggested need-based negotiations, these practices would become an official part of the everyday job responsibilities, which may actually make already existing efforts more visible.

Third, results in Study 1 were based on a small sample. We replicated the central findings in Study 2, but more confirmatory research is needed, for example for interpersonal and informational fairness. The existing data indicated that both team spirit and a balance between privacy and transparency are important.

Addendum 1: Work-Family Backlash

In a qualitative follow-up study (unpublished), we further investigated the work-family backlash in nurse shift planning more specifically. We conducted five individual interviews with nurses and a focus group with six nurses in June 2019, all from the same retirement community.

Although tentative, this follow-up study indicated how the dynamics between nurses with and without children can produce tensions in practice. However, it is important to highlight that both groups acknowledged the other perspective. Some of the parents felt guilty for the additional stress they offloaded onto other nurses and wanted to “give something back”. Childless nurses complained that their own needs were often treated with a low priority, while also realizing the difficult situation for the colleagues with children. The nurses reported that a good team spirit with an understanding of both sides helps to ease conflicts between nurses with and without children, and mentioned that the situation is especially tense for single parent nurses.

One participant justified preferential treatment of nurses with children with an informal inter-generation compact: She argued that the younger colleagues would one day have children on their own and could then rely on other colleagues in return. But this compact was seen critically by others. Specifically, one participant argued on behalf of nurses with a desire to have children, but who could not or not yet have any. A related argument was that the perceived demand to be constantly ready for work interferes with efforts to start building a relationship and potentially a family in the future. For example, “I want to go on a date” could be considered as less important than “I have to take care of my children”. Moreover, some nurses do not want to have children and are also disregarded in such a compact.

In addition, the parent nurses found themselves in a time conflict between work and childcare that was unresolvable for some under “normal” shift work conditions. As a result, two participants had threatened the management that they would quit their jobs, which helped them negotiate a special agreement to only work a short morning shift that allowed them to drop off and pick up their children at the kindergarten. As a consequence, the time conflict caused by the mismatch between business hours of the kindergarten and the shift plan was directly passed on to the colleagues without children, who had to be more flexible (e.g., work longer shifts). An alternative reported solution was for parents to only work night shifts, but this is not always possible.

In conclusion, the work-family backlash in nurse shift planning becomes tangible through some tensions on both sides (nurses with and without children). Solutions on the parent side included short morning shifts and agreements to work night shifts only. More flexibility was demanded from childless colleagues, irrespective of their own plans to start a family. More research or structural changes might help resolve the tensions between nurses with and without children in the future, who overall seemed empathic for each other’s perspective.

Study 3: Designing a Nurse-oriented Shift Planning System

The presentation of Study 3 was slightly adapted to fit with the overall format of the thesis (e.g., wording, structure, figures). The original version was published in:

Uhde, A., Laschke, M., & Hassenzahl, M. (2021). Design and Appropriation of Computer-supported Self-scheduling Practices in Healthcare Shift Work. In *Proceedings of the ACM on Human-Computer Interaction (CSCWI)*, 5, 26 pages. New York, NY, USA: ACM. doi: 10.1145/3449219

Recapitulation

Studies 1 and 2 provided a detailed picture of nurses' subjective fairness experiences in shift work. They indicated that, on an abstract level, resources such as free weekends should generally be distributed equally among nurses. However, specific conflicts should be resolved based on the need norm. Concerning the planning process itself, nurses experienced an inclusive, collaborative process as fairer than fully automated shift planning. In addition, transparency and privacy created a tension if conflicts were resolved based on private needs. Finally, a positive team spirit supports cooperative behavior and successful conflict resolution.

Objectives

Study 3 covers the design process of a nurse-centered shift planning system, in which we transferred these findings into a concrete design. We had two central objectives:

Objective 1: Develop interactive practices that align with the fairness experiences and support subjective well-being

Objective 2: Validate that the practices address nurses' needs and adapt them where necessary

Setting

The design case was set in a medium-size retirement community in Germany, with around 45 nurses and 120 residents. In this retirement community, shift plans were separately created by the leaders of five different wards on a monthly basis. They collected requests for days off from their team members (including themselves) in a paper notebook. Besides their planning responsibility, the ward leaders also worked in care, together with their team members. Once a draft for a shift plan was finished, the ward leader handed it to a central planner who made a legal and economic check,

possibly adapted some shifts, and returned it to the wards. Unlike the ward leaders, the central planner was part of the management and did not work in care. He was located in a separate office area in the same building. In line with previous findings (e.g., Rönnberg & Larsson, 2010), two central issues and expectations were reported in a preliminary meeting with the different stakeholders. On the one hand, nurses hoped for the system to give them more control of their shift assignments. On the other hand, the ward leaders as well as the central planner hoped that the new system would save them time.

Design Process

We began the design process in May 2017 following the “Design for Well-being” (DfW) approach (Klapperich et al., 2019).

The first step was to identify existing positive shift planning practices and their associated psychological needs. Thus, we started with interviews about specific planning activities that nurses and planners experienced as positive in the centralized setting. In the second step, we used these positive practices as the basis for the design of new technologically mediated planning practices. This involved a creative transfer process from centralized to decentralized planning, because future planning practices performed by nurses are by definition different from more centralized practices performed by ward leaders and central planners. Nevertheless, they may borrow from already existing practices. The third step was the implementation of the planning practices as an interactive tablet app.

Step 1: Identifying Positive Practices in Current Centralized Planning

In order to identify positive formal and informal practices of shift planning, we conducted five initial interviews using the Positive Practice Canvas (PPC; Klapperich et al., 2018). The PPC is a tool specifically designed to gather positive practices from domain experts. First, we asked participants for positive practices they performed in relation to shift planning, and to sort them from “most enjoyable” to “least enjoyable”. Second, starting with the most enjoyable practice, the interviewees further decomposed the practices into the material and skills required, as well as the psychological needs that are fulfilled through the interplay of material and skills. We employed a laddering process (Reynolds & Gutman, 1988) to relate elements of a shift planning practice to underlying needs (e.g., “creating (skill) an early overview of planned vacations (material) gives security (need)”).

The participants in our PPC interviews were staff members from all three roles involved in shift planning (i.e., nurses, ward leaders, central planner). Because there was only one central planner who had started his job a few months prior to the interviews, we interviewed another employee who had worked as central planner for several years in the same retirement community before, but had switched to a different position in the meantime. In addition, we included two ward leaders who,

as reported by the general manager, particularly enjoyed planning and were thus suitable interviewees. Given that both worked as registered nurses themselves, we included questions about their role as planner and as nurse, so that they doubled in their roles, assuring the appropriate representation of the nurse perspective in our data collection. This procedure allowed us to overcome the problem of interviewing nurses with shift planning experience in a setting that did not designate any planning activities to nurses, besides submitting requests for free time. In addition, we interviewed one nurse with no planning responsibilities besides submitting his requests, although the interview turned out to be difficult because of the nurse's limited experience with shift planning. All interviews took approximately one hour and were led by the same interviewer. Two participants denied video or voice recording, but we took extensive notes on the PPC itself. The other three interviews were recorded and transcribed in German for further analysis.

The PPC interviews resulted in a total of fifteen positive practices of centralized planning. In the next step, we matched practices that had a similar function in the centralized planning system, resulting in ten distinct centralized shift planning practices (see Table 1). For example, both central planners had a practice of integrating the printed shift plan of the previous month, which included several short-term changes, with a digital system to see who had worked how many hours. We included all needs in the integrated practice that were fulfilled for at least one participant. In this case, for example, only one planner described an experience of competence when integrating the shift plan, so we included the need. The central need fulfillment for this practice was the security experienced when each nurse's hours were correctly counted and the feeling to be able to help them (popularity) if otherwise forgotten working hours could be included.

To verify our correct understanding of both the practices and their underlying needs, we then wrote a short story of about 100 words for each of the ten centralized shift planning practices, including their specific links to psychological need fulfillment. We described each practice in an idealized way, that is, assuming that everything worked out perfectly. Each of these stories was then reviewed in an informal interview with one of the previous interviewees who had mentioned that practice during the PPC interviews. Although the interviewees generally considered the stories as accurate, we corrected small misunderstandings based on their feedback.

Table 1: The ten centralized planning practices identified in the PPC interviews. The roles are CP = “Central Planner”, N = “Nurse”, and WL = “Ward Leader”. The needs are Aut = “Autonomy”, Com = “Competence”, Pop = “Popularity”, Sec = “Security” and Sti = “Stimulation”.

Practice	Role	Primary Needs	Secondary Needs	Description
Strategically relieving employees	CP	Pop	Com, Sec, Sti	When planning for special events (e.g., a company barbecue), making sure that nurses who had shown extraordinary commitment can participate
Creating an overview of the year	CP	Sec	Pop	Entering all vacation requests and larger events of the next year in the calendar to anticipate staff shortages
Distributing the new (paper) shift plans	CP	Pop	Sec, Com	Walking to all wards to distribute the shift plans for the next month
Closing revision of the previous month	CP	Pop, Sec	Com, Sti	Including swapped shifts and other changes to assert that everyone’s working hours are correctly counted
Collectively create the night shift plan	WL	Sec	Com, Pop	Get together with all WLs to plan the night shifts for the following month
Granting a wish	WL	Pop	Sec	Including a submitted wish in the shift plan
Improving the shift plan	WL	Com, Sec	Pop	Smoothing out the shift plan to make it more comfortable for the nurses (e.g., swapping an early and a late shift based on one’s knowledge of their preferences)
Making changes on short notice	WL	Pop		E.g., finding a replacement if someone calls in sick
Correcting the working hours	WL	Com, Sec	Aut, Pop	Including the changed working hours of the nurses (e.g., due to swapped shifts) in the shift plan so the central planner sees them
Submitting a wish for a free shift	N	Aut	Com, Pop	Writing a wish for the next month in the notebook

An example idealized practice (“Making changes on short notice” in Table 1) addressing the need for popularity was:

“One of the colleagues called in sick in the evening for the next day (the afternoon shift). Apparently she feels really bad, so the ward leader assures her that he takes care of finding a replacement. He knows that two co-workers would agree to stand in, so he first tries to reach one of them to ask if she could do it. The co-worker directly signals empathy for the sick colleague and asserts that she can jump in. Thankful that the co-worker is so cooperative, he marks the change in the schedule. Finally, he sends a text message to the colleague – everything is fine, she can take her rest, the co-worker takes over.”

Notably, this idealized description strongly connects to the emotional experience from the planner’s point of view. We used this to validate the associated need fulfillment with the interviewees during the reviews. After the validation of all stories, four major and one minor needs emerged as sources of positive emotions during shift planning:

- *Autonomy* was experienced when a nurse wrote a request for a free day in the notebook as an act of prioritizing private life
- *Popularity/helping others* was prominent in pro-social practices. For instance, the ward leaders had a practice of making small improvements to an otherwise finished shift plan, such as swapping the morning and afternoon shift between two nurses based on their knowledge of each individual's preferences.
- *Security* was the primary need concerning predictability of the shift plan. For example, one of the central planners mentioned that he created an overview of vacation times of each employee early on to be able to anticipate staff shortages.
- *Competence* was experienced by both ward leaders during the combinatorial challenge of fitting the initial shift plan together.
- Finally, the minor need was *stimulation*, which was experienced by the central planner who was new on the job and explored the new tools. However, we considered this stimulation not to be derived directly from shift planning itself and excluded it from the further process.

Step 2: Designing a Nurse-Centered Shift Planning Concept Based on the Identified Practices

The ten centralized shift planning practices and four needs extracted from centralized planning served as the foundation of the conceptual design of the planning process (see Figure 4). Of course, given the fundamental change in work organization, not all of them could be used directly. For example, the practices "granting a wish" and "distributing the new (paper) shift plans" only make sense in a centralized system. Thus, in some cases we had to replace the functions of the ward leader in the current system with a collaborative process among nurses. Moreover, competence played less of a role, because it was tied to the combinatorial challenge of a human planner to assemble a shift plan. Given that we focused on nurses' planning practices and gave the primary control to the nurses directly, we prioritized their autonomy above a planner's need for competence. Therefore, we used a computer-based mechanism to identify shift planning conflicts and to mediate the interaction on a group level. The combinatorial challenge was thus delegated to an algorithm.

The resulting shift planning process was based on eight planning practices for nurses divided into three phases. Phase 1 starts before the shift plan sets in. It contains four preparation practices. Phase 2 starts after the initial shift plan is completed and accounts for changes on short notice while the shift plan is already running. Phase 3 is set after the shift plan was worked through and contains a retrospective practice. The next planning cycle starts prior to the next month, overlapping with the previous cycle. We presented the new process with a video prototype in two workshops, one with the ward leaders and one with non-planning

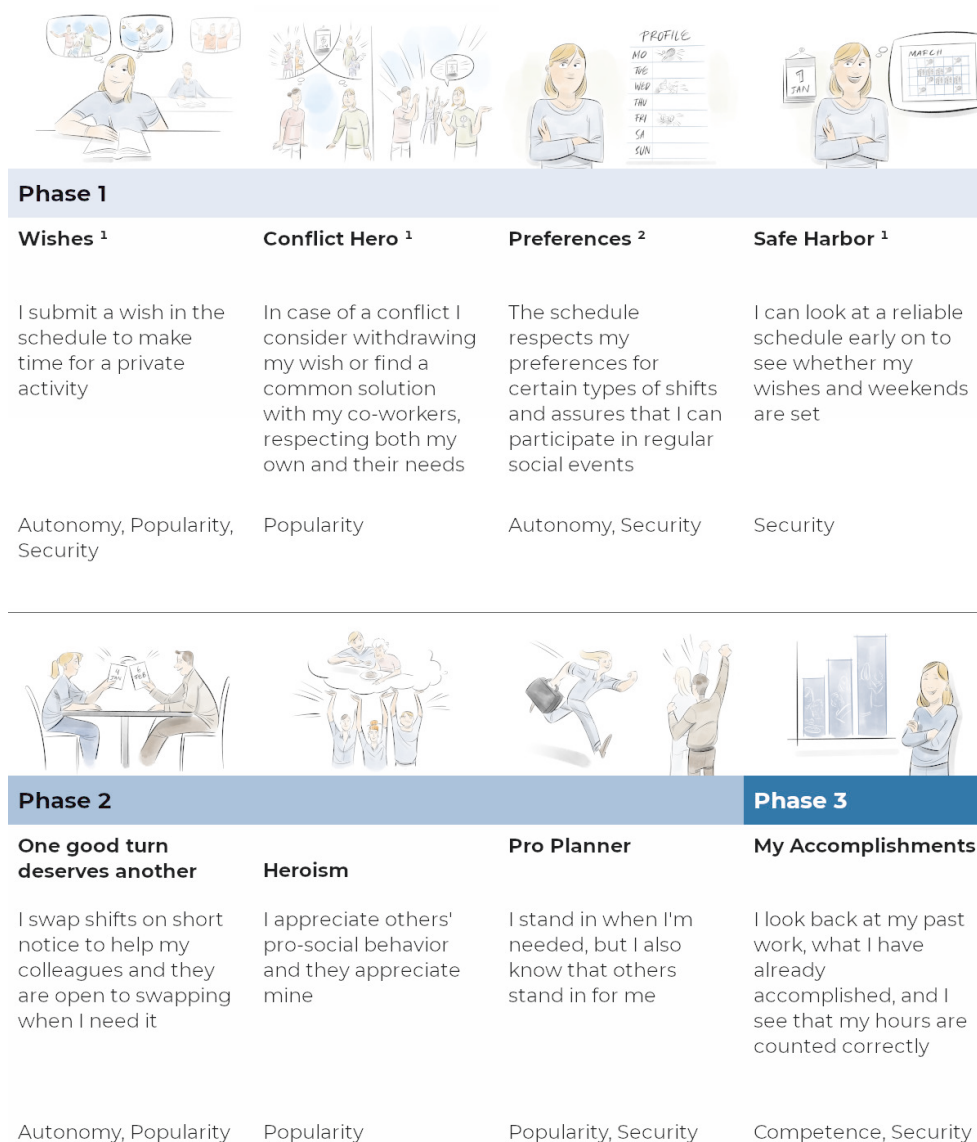


Figure 4: The eight positive practices forming our nurse-centered shift planning concept including the psychological needs they address. Practices marked with a (1) were directly integrated in the app, while the “Preferences” practice (2) was indirectly and manually integrated by the ward leaders.

nurses. In addition, we ran three individual interviews with non-planning nurses. Feedback was generally positive, and the new process was perceived as realistic and resonating with the nurses' experiences. One critical remark from all three individual interviews was that the appreciation for the co-workers who stand in (see the "pro planner" practice in Figure 4) was somewhat exaggerated in the video, where we had emphasized it with an audible applause. Nevertheless, they saw appreciation itself as desirable.

Step 3: Building an Interactive Research Prototype

The eight planning practices served as the conceptual frame for the interactive prototype. Together with our project partners, we implemented a minimal planning process, including three of the four practices from Phase 1, with an android tablet app. The user interface is depicted in Figure 5. "Wishes", or particular requests for specific free shifts, were implemented. "Preferences", or a more long-term individual pattern (e.g., "I generally prefer morning shifts") was not, because it required a non-trivial amount of development work while we expected only minimal interaction when submitting the preferences once. Instead, we relied on the ward leader to manually take care of long-term preferences in the background. "Conflict hero" and "safe harbor" were also implemented. The app was iteratively developed in a user-centered process, with several smaller prototypes to test the usability of the specific functions. Conflicts were calculated on an external back-end server, because the calculations were computationally intense.

Nurses could submit "wishes" (Figure 5b) for a free morning shift, afternoon shift, or the whole day, and they could assign a "priority" to the most important wish in the month. This was meant to facilitate discussions about other, "non-priority" wishes, while providing predictability of the most important ones. On weekends, only wishes for a morning or an afternoon shift could be submitted and only on a nurse's work weekends. We included this restriction because free weekends were distributed in the retirement community beforehand (normally every second weekend is free). Each nurse had three wishes per month, which they considered an acceptable amount, and which prevented overly egoistic planning. We decided to provide no means to give a justification for a wish, at least not in the system itself. This contrasted the paper notebook used in the previous system. In doing so, we followed the recommendations from Study 1 to support face-to-face interactions during conflict resolution, which allows for a need-based process and helps overcome the dilemma of privacy and transparency (Colquitt, 2001; Colquitt & Zipay, 2015; Uhde, Schlicker, et al., 2020). Face-to-face interactions give nurses full control of which details they disclose to whom, while promoting fairness of the decision-making process during conflict resolution.

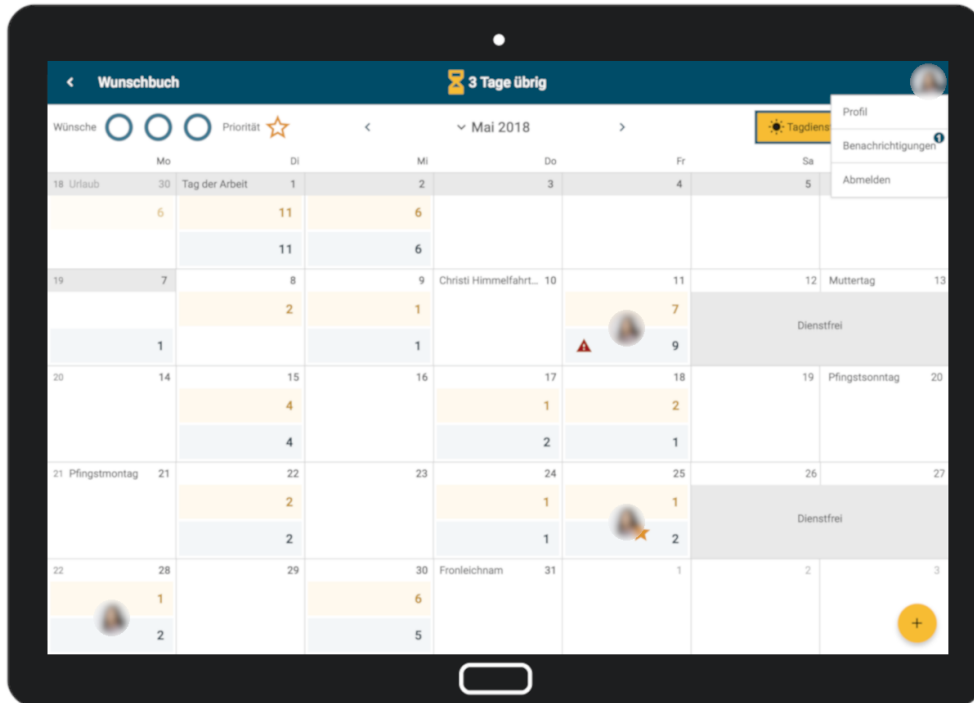
"Safe harbor" was represented through the calendar view (Figure 5a). Ideally, the plan should be published several weeks in advance, but due to management decisions of the retirement community and economic pressure, the planners endeavored to publish the plan two weeks ahead. As described above, weekends were planned

earlier. Similarly, nurses could submit wishes early on, and they could follow the planning activities of their co-workers including their names, because they needed this information in case of a conflict.

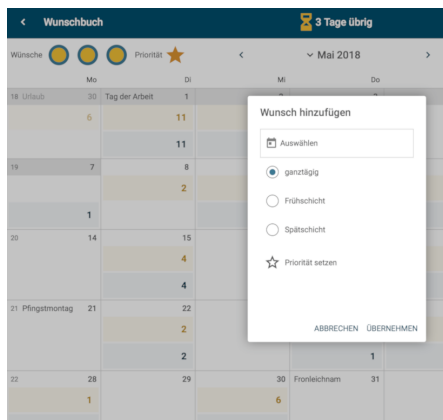
For the “conflict hero” practice (Figure 5c), (only) the involved nurses were notified about their conflicts after logging in. They could see who was involved and withdraw their wish through the interface, or else approach the colleagues personally. If more than one co-worker was involved, all possible solutions were shown, in case, for example, more than one nurse would need to withdraw the wish.

In this prototypical version, the ward leader had an additional, separate interface to finalize the shift plan, that is, to include preferences for morning or afternoon shifts after wishes and conflicts had been integrated.

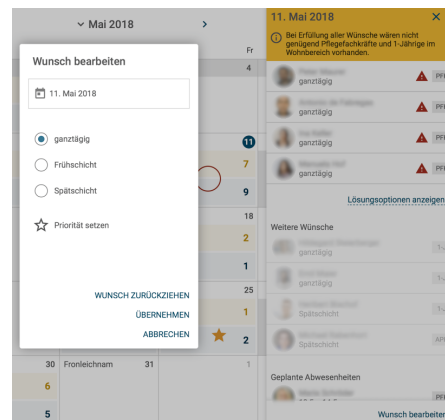
Taken together, the prototype of the nurse-centered shift planning system comprised all necessary functions to prepare a functional shift plan. These included individual planning practices (e.g., making a wish) and group-level practices (e.g., conflict resolution). Some more complex activities that seemed to be less relevant for the nurses’ subjective experiences were carried out by the ward leader, which created a realistic scenario of partially automated shift planning.



(a) Calendar overview representing the “safe harbor” practice and showing how many wishes have been submitted on which day. The own wishes are marked with the profile picture and remaining conflicts are indicated with a red triangular warning sign.



(b) The “wishes” practice in the user interface. The dialog allowed nurses to enter wishes with the options to select a date and to indicate whether it is for a morning shift, an afternoon shift, or the whole day. The “priority” button was removed after the first evaluation.



(c) The “conflict hero” practice in the user interface. It contains a dialog on the left for conflict resolution, allowing the user to change or withdraw the wish. The menu on the right contains information about involved colleagues and a button to show possible solutions.

Figure 5: The user interface of the tablet app prototype.

Addendum 2: Pro-Social Practices Beyond Shift Planning

The shift plan lays the foundation for a functioning work environment. But nurses are also busy with many other work practices in their everyday lives. Although these practices are not directly related to shift planning, they may have an effect on the team spirit, which can in turn influence conflict resolution practices as indicated in Study 1. Thus, we were interested in how further pro-social practices that nurses perform at work may have positive indirect effects by improving the team spirit. To that end, we ran an exploratory study that was published as part of a doctoral consortium (Uhde, Mesenhöller, & Hassenzahl, 2020). In this side project, we interviewed three Japanese nurses in July 2019, who worked in three different healthcare contexts (outpatient care, day care, and residential care). These different contexts imply different modes of collaboration in terms of spatial and temporal distribution of the work (Rodden, 1991). We were interested in the opportunities for pro-social behavior in these different contexts.

Settings. P1 worked in outpatient care and had switched to that setting because it gave her more control of her shift patterns. She refused to work anything but morning shifts that started not too early, and had strong opinions about the flexibility that is usually demanded from nurses. She hardly had any contact with her colleagues and did not know all of them personally. P2 was the group leader in a residential care home and worked all shifts (morning, afternoon, night). In contrast to P1, she had switched to this work place despite the shift rotations, because she valued the interpersonal communication. Finally, P3 worked in day care with two slightly different but overlapping shifts, and all employees worked together at the same place.

Communication patterns. These different care contexts had strong impacts on the nurses' communication patterns with their colleagues. P1 communicated mostly indirectly with her colleagues (e.g., through a messenger app, mediated by a central office and through a notebook in the clients' homes). Direct communication only happened in rare, urgent cases (e.g., for question about a client's medication intake in the previous shift). P2 saw communication among colleagues as an essential part of her job. They mostly communicated directly in face-to-face conversations and through a messenger and phone calls, also during her free time. In addition, the team had monthly drinking parties ("Nomikai") and shared free time activities that also involved residents and their families and included conversations about private and work topics.

P3 separated private and work life more clearly than P2. At work, she had stand-up meetings every morning, where they talked about the clients and work of the day. They also documented their work in a notebook for future stand-up meetings. Communication mainly happened at work.

Pro-social practices. P1 reported several pro-social practices mediated by artifacts in the clients' homes. She wrote in large, readable letters in the notebook, because she knew that some colleagues could not see well. She also used smileys and stamps in the messenger, and when she had some time left, she cleaned the clients' homes or the company car to make them more comfortable for the colleagues. Some of her co-workers were also friends in private and occasionally left presents for each other at a client's place (e.g., alcohol in the fridge), if they knew the colleague would work there later. One time she accidentally met a colleague she had not met in person before, and they had a fun conversation about a common client's parrot. P2 reported intense, open and direct communication, within and outside of the work times about "everything". She saw caring for her colleagues as part of her job requirements. For P3, actively pro-social practices were difficult at work, because everyone was very busy. In addition, the specific work tasks were not clearly assigned to one nurse, and everyone was responsible for everything, which made it difficult to explicitly "help" a colleague with their job. However, she also prepared small favors beyond her duties. For example, she prepared material in the evening for the next stand-up meeting, so it could run smoothly.

Summary. This short study illustrated how diverse shift work contexts can be, and how that creates different opportunities for pro-social practices. First, nurses have different priorities. P1 felt exploited by common demands of shift work and found a setting where she could control her work times. The limited personal contact to her colleagues additionally reduced the social pressure she felt to accept undesirable shifts to "help her colleagues". For P2, the team was more important than control of her work times or separation between work and private life. These findings indicate a fundamental conflict between self-concern and other-concern that should be further investigated in the future (see also Grant, 2008). Second, the outpatient care setting suggested more mediated communication patterns that open up new design opportunities. Third, the specific work organization and distribution of responsibilities can influence how easily nurses can show pro-social "extra miles", and whether co-workers can recognize them as such.

Study 4: Appropriation of the Nurse-oriented Shift Planning System

The presentation of Study 4 was slightly adapted to fit with the overall format of the thesis (e.g., wording, structure, figures). The original version was published in:

Uhde, A., Laschke, M., & Hassenzahl, M. (2021). Design and Appropriation of Computer-supported Self-scheduling Practices in Healthcare Shift Work. In *Proceedings of the ACM on Human-Computer Interaction (CSCWI)*, 5, 26 pages. New York, NY, USA: ACM. doi: 10.1145/3449219

Research Questions

In Study 4, we introduced the prototype from Study 3 in a realistic healthcare setting with the goal to understand how nurses use and experience it. The central research questions were:

RQ1: How do nurses use individual planning practices?

RQ2: How do nurses use group planning practices?

RQ3: How does the system affect the nurses and the team?

Study Setting and Method

We introduced the prototype mid-February 2019 in one of the five wards of the same retirement community as in Study 3 that was selected because of its good team spirit (i.e., no major interpersonal conflicts according to management), with a workshop explaining its functionality. In the beginning, fifteen people worked in the ward, one of whom left during the study period. Moreover, the ward leader was reassigned to a different house of the same employer in October 2019, because of an organizational restructuring, and a different ward leader took over. The relationship of the nurses with the new leader was also generally described as positive. The app was installed on an android tablet which was placed in the ward.

Given the early stage of development, we had to make several design decisions. First, to assert a functional shift plan and integrate it with the other shift plans in the retirement community, the previous shift planning system was still running in parallel for the central planner and ward leader to use. While this may have created a tension between the two planning processes, it allowed us to collect real shift planning experiences of the nurses and prompted a direct comparison of the two systems, facilitating reflection. The ward leader and researchers asked the nurses to use the tablet app for planning and to consider the previous process to submit wishes in the notebook only as a fallback. Second, the central planner was legally

responsible for shift planning in the retirement community, and he was therefore allowed to make changes to the shift plan. But he agreed to keep this to a legally required minimum. Third, we only installed the software on the tablet that was placed in the ward, rather than having the employees use their private devices for planning. This assured that planning took place only at work, which simplified the separation between work and free time as well as the integration of employees who have no smart devices. Furthermore, it reduced development effort significantly. Given that we focused on shift plan creation (Phase 1), this decision did not interfere with planning practices, because calling people at home was not necessary in that Phase.

The nurses could submit their first wishes for March 2019. Early in April, after the first two monthly planning cycles, we organized an early evaluation session including one focus group with the ward leader and the central planner ("FG1") (both male, 35 and 43 years old), as well as one with the nurses without the ward leader ("FG2"; 10 participants, 1 male and 9 female; 21 to 55 years old, *median* = 44). Both sessions lasted for around one hour. The interview guide contained questions about technical problems and experiential outcomes, for example, how they used the "wishes" and "conflict hero" function. Based on feedback from these focus groups, we increased the amount of "wishes" per nurse to five per month and removed the "priority" function because the nurses said that usually all wishes are of high priority. After the two focus group sessions, we remained in contact with the ward leader(s) during the study phase, sent reminders for them to motivate the team to use the system, collected feedback on technical or usability problems, and fixed them timely.

We conducted a second evaluation session in November 2019 with seven individual interviews, including one with the new ward leader. The participants were between 21 and 55 years old (*median* = 30) and had between 3 and 37 years of experience working in healthcare (*median* = 8). All participants were female. The interview guidelines were created following the "Interpretative Phenomenological Analysis" (IPA) guidelines (Smith et al., 2009). Similar to Study 1, we chose this method because our primary interest was the appropriation of the system from the nurses' point of view, and we probed experiences relating to our intervention that were perceived as meaningful, those that were not, and why. The interviews lasted around 35 minutes on average. The two focus groups from April and the seven individual interviews from November served as the central data corpus for this study, which included subjective experiences of both ward leaders and most of the nurses. They were audio recorded after taking informed consent and transcribed in German.

Our analysis followed the IPA process (Smith et al., 2009) as well. In a first step, two independent coders read the transcripts and listened to the audio files of the two focus groups as well as the seven individual interviews while taking notes on linguistic and conceptual patterns. They inductively identified themes for each interview and focus group. Second, they merged the themes across the interviews and focus groups when patterns were similar in more than one case. Third, the two coders compared their two theme sets, identified common patterns between both analyses, and established consensus about the interpretation.

Complementing the subjective account of the nurses, we first briefly present basic, quantitative usage data that were collected just before the second interview sessions early in November. These serve as an objective reference point for our main, qualitative analysis, which is organized around the central themes of the interviews, focuses on the nurses' subjective experiences with our system, and how our intended practices unfolded in the field.

Nurse-Centered Shift Planning in Practice

Usage Data

In total, 11 nurses submitted 105 wishes for free shifts to the system (see Figure 6). Five nurses did not use the system and the ward leaders only used it until/from October. Nurses submitted 19 wishes for free morning shifts, 24 for afternoon shifts, and 62 for the whole day. During our analysis, we noticed that a lot more wishes were submitted for November and December, compared with the other months. Upon request, the new ward leader explained to us that she had used a different planning procedure for November, just after she had joined the group. She had asked some nurses to directly enter their wishes through the planner's separate interface, together with her. This interface was intended only for the ward leader and central planner. It allowed them to adjust the preferences and individual shifts after all wishes had been entered, to account for the legal responsibility of the central planner. Therefore, one user had ten wishes in November, which was usually not possible. Excluding November, 74 wishes (6 morning shifts, 20 afternoon shifts, 48 whole days) were submitted. The peak in December is due to Christmas and New Year's Eve, which summed up to eleven wishes.

There was a distinctive disparity between different individuals and their system use. Five out of sixteen team members submitted more than one wish per month on average. The most active user alone accounted for more wishes than ten of her co-workers taken together. The reasons for this disparity are detailed below.

Data collection was also activated for conflict resolution, but the feature had not been used at the time of our study, despite our explanation in the introductory workshop. The reasons for this will also be clarified below.

Appropriation of Individual Planning Practices: What is 'Worth a Wish'?

We intended the "wishes" practice to allow for a higher quality in the nurses' private lives and increased autonomy, for example, by allowing them to plan for enjoyable leisure activities. This was only partially what we found. In the ward, opinions differed among the nurses about what kind of wishes they would submit, resulting in the large disparity in the number of submitted wishes. There did not seem to be a general agreement on what is "worth a wish" and what is not. A clear case

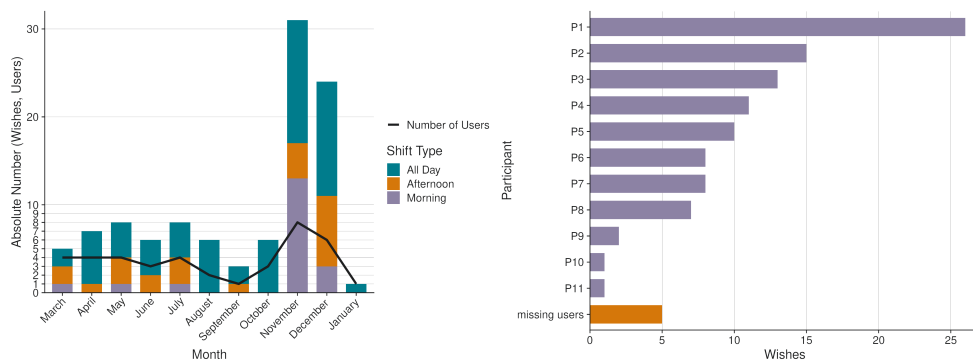


Figure 6: Distribution of wishes by month and nurse during our study. The left graph depicts the wishes submitted per month, with the peak in November. The horizontal line represents the number of users who submitted wishes in each month. The right graph depicts the number of wishes submitted per nurse. Five nurses did not submit any wishes, the most active nurse submitted 26.

were doctor’s appointments and weddings. However, less institutionalized activities varied in subjective importance and whether a nurse would submit them. When asked about the reasons for their wishes, one participant said: *“For example ‘birthday of my boyfriend’, I have submitted that in the app and in the notebook”* [I3; 32]. Another one who told us that she only sees her partner every second weekend, submitted only one wish during the entire period (to both systems). The subjective importance of the weekends spent together became clear throughout the interview, so we asked why she did not plan for them.

Participant: *“That’s always difficult because, like I said, the distance. And, well, in order to go to the Christmas market or so I wouldn’t submit a wish.”*

Interviewer: *“Okay. How do you think your co-workers would react if you submitted such a wish?”*

Participant: *“I think that wouldn’t be a problem.”*

Interviewer: *“But you still wouldn’t do it?”*

Participant: *“No... I think I’m too proud for that (laughs)”* [I1; 194–198]

Thus, although she had only very limited time to spend with her partner, and although she expected that her wish would not be seen as problematic, she did not consider their plans important enough to ask for free time in the group beforehand (even without having to submit a reason). This contrasts the typical assumption that nurses try to maximize their individual “utility” by requesting and competing for free time (e.g., Constantino et al., 2015; C.-C. Lin et al., 2015). Instead, this nurse prioritized her reputation within the team.

A further important prerequisite for submitting wishes was that the nurses were willing and able to plan for them, both in terms of their individual lifestyle and the

nature of the wish. One participant said: *“Actually I don’t use so many [wishes]. Because in the end I’m fine with it... I usually only use a wish if I know specifically: ‘I want to go there’, you know, because I need free time, I don’t know. I want that birthday, I want to go to a wedding, to a concert. Then I know it. But normally, when I have, let’s say, no appointments in a month, I don’t make a wish. Then I just wait and see what’s coming”* [I2; 202]. In contrast, another team member said: *“Usually I check it when I’m home, which appointments I have during the next two months... and then at some point I look at what’s happening in January. Before December comes, then January, February, and then I submit it for the next two months”* [I7; 322]. This was positively referred to by one of her co-workers: *“Well, she is someone who has regular wishes. Because... she is just a person that... she can already plan a lot for the future. I can’t manage that yet. I don’t even know what I should eat next week. I always have to go grocery shopping day after day, and she just has it all structured. Then she knows: ‘Okay, I have appointments then and then. Here is where we want to go on a trip’. And then she plans it in advance. So that’s nice for her with the app, because she can sort of make an overview for the year”* [I3; 92]. There was no grudge involved about the colleague submitting more wishes, but rather a mild form of admiration.

Taken together, submitting wishes requires courage to demand free time if the wish itself provides no obvious justification (such as a wedding). Moreover, people differ in how much they plan ahead, which resulted in the different amount of wishes between different nurses that we found in the usage data.

The fact that no justifications could be provided in the app sparked some discussion. Some participants assumed it was a still missing feature that was going to be added later on. Thus, some used the paper notebook additionally, in order to give a reason for their wish, but reflected on it:

Participant: *“Strangely enough, I do [submit a reason in the paper notebook]. Although I don’t need to. I mean, it’s of nobody else’s concern why I want that day off. But somehow I still do.”*

Interviewer: *“Why?”*

Participant: *“So that it’s clear that it’s important. And that it should be taken into consideration. Because maybe I write: ‘I want to go to a concert’, but the other one has an appointment with the doctor. So he says: ‘the doctor is more important than your free time’... and, well.”*

Interviewer: *“But in that case it’s not good to write that you want to go to a concert, is it?”*

Participant: *“Yes, not in that case. But if it’s a birthday or so, if I really want to have the time off, then I do write it.”*

Interviewer: *“Okay, but that would mean that the concert is somehow less important...”*

Participant: *“For others, certainly. For me? No”* [I2; 206–214]

Another participant indicated a certain peer pressure: “Yes, I’ve seen, others write it. Well, then I also write it there. And then maybe... it [the wish] will be noticed, you know?” [I6; 232]. These two statements symbolize the problem of justifications from the perspective of the nurses. Both try to emphasize that their appointment is important, but are aware that a simple comment in the notebook may not convey that message as clearly as it should. If they want to emphasize the importance, they feel an urge to justify it. But if they do, it may not be understood as important. We understand this as an indication that our envisioned face-to-face conflict resolution could help nurses resolve that problem in a better way, although it was not adopted by all, yet.

Although we designed the system with peer-to-peer conflict resolution in mind, the above statements also imply that the nurses still assumed a “central judge” to make critical decisions. We have asked the new leader about it: “Nobody needs to tell me why they want time off. For me, that’s... a wish is a wish. That has to be given. That’s what I think about it. They don’t want the time off without a reason. And if they don’t get it, well, you know, some folks, they just don’t show up. And that’s what one wants to avoid” [I4; 178–184]. And the previous one: “If I had a colleague who runs to the doctor twenty times a month, then I would be wondering: ‘Is that right? And others have to swap their shifts for that?’... It is interesting... but actually it’s not of my concern” [FG1; 481–484].

While both leaders described themselves as very open about wishes, nurses reflected on having to tell them about their plans in the previous system: “Well, I think... because if you always have to go to the ward leader... that is... it’s very difficult. I’d have scruples, honestly... to bother him every time” [FG2; 341–344], and: “Yes, well, we just thought... well, maybe some don’t dare [submitting wishes]. We just... had this case that you don’t want to put this burden on the ward leader to make the decision and so on. And it would be nice if you could also... submit some half important appointments, if that doesn’t bother anyone” [FG2; 750–756]. These statements are in clear support of the distributed planning process, reducing feelings of guilt that can prevent nurses from submitting wishes.

Finally, although justifications were mostly used to signal that a wish is important, one participant also suggested the opposite: “In my case it’s usually about the kids or appointments with the doctor or so. But well, if I actually have some... uhm... private party or so, I could write it down. So that the other one sees that it’s not that important, that we can talk about it” [I5; 96].

Taken together, nurses had the freedom to use more wishes, but some did not do so for several reasons. First, submitting many wishes may be seen as a risk to their reputation in the group, although from the perspective of a colleague it was seen rather positively. Second, different lifestyles allow for different amounts of wishes. And third, the justifications are used as a signal of importance and thus imply that wishes should only be used in exceptional cases. Our “wishes” function, which provided no means to leave a justification, has been used to that end successfully and sparked reflections about the role of justifications.

Conflict Prevention Behind the Scenes

At first glance, conflicts did not seem to exist. The (lack of) usage data showed that the conflict resolution process was not used as intended, despite our introductory session explaining the feature. We inquired several times and during both feedback sessions, with similar replies: “No, I didn’t... we didn’t have that yet” [I5; 102], “No, there was nothing” [I6; 72], “And, actually, there haven’t been any conflicts” [I7; 66].

However, we noticed that several informal strategies were used to manage and avoid conflicts before they arise. For example, some participants checked if someone else had submitted a wish before planning a private appointment: “Then you can also, if you see: ‘Ah, someone else has already submitted something’, and then you can pick another date or so. It gives a better overview” [I5; 80–82]. In another case, a nurse who had submitted wishes was aware of her cooperative colleagues: “Everyone knows: There are the small children. So they are so friendly to pick another date” [I5; 108]. Thus, in a first step, the nurses avoided conflicts by rescheduling their private appointments, if possible.

If that did not work, they did submit a wish on the same day as a colleague, but that was often unproblematic. In everyday life, there is enough staff in the ward so that even two registered nurses can take the same day off. Sometimes, however, the situation becomes more difficult, for example during weekends or if one of the registered nurses is on vacation. Nevertheless, these cases can often be resolved without a “real” conflict by activating further resources, for example from the other wards: “Yes, if they are four people [in another ward], then maybe someone can come down and help us a little or so” [I4; 248], or else: “The nurses with a one-year apprenticeship can also take over a shift lead, if there is a registered nurse on a different ward as a supervisor” [I3; 207]. Moreover, they would try to minimize the impact of their wish: “If I don’t get it, that would be inconvenient. In that case I could do only a [irregularly] short morning shift. That is the alternative” [I6; 66]. The second informal practice was to activate further resources, outside the restricted shift planning system. However, these resources are only meant for exceptional cases and not to be used regularly.

Sometimes, despite all precautions, a shift planning conflict cannot be avoided. This is common around traditional holidays, in our case for example Christmas and New Year’s Eve, which were planned in November. Fortunately, these are predictable, and the ward has established special precautions in the form of informal rules: “Yes, well... but we have the rule: Those who work on Christmas get the New Year’s shifts off and vice versa” [I4; 86]. This rule serves as a general frame of reference for everyone. The ward leader had put a list in the office early on so that everyone can indicate which holiday shifts they prefer. On top of that, some have submitted wishes in our app. We found proactive, pro-social strategies that eased the tension: “We’re lucky here to have a Muslim team member, and she has directly said: ‘I’ll do the late shift on Christmas, because I don’t celebrate it’. And then another one has volunteered with no children, no family. So it was directly clear who was going to work” [I4; 128–130]. This doesn’t always work, however: “New Year’s Eve was more difficult this time. [...]

So I mentioned it in the team meeting, I said: 'I need a registered nurse in the morning between New Year's Eve and on the 1st of January. [...] And then somebody volunteered. And she said: 'Okay, I'll do it.', but she has asked to get the 2nd of January off'" [I4; 110]. Notably, the ward leader played a central role in solving this conflict by initiating the resolution process. However, she did not make the decision herself and instead worked towards a decision coming from the team.

These rules were of immense importance during conflict resolution. In fact, they surpassed a planning logic of efficiency or sufficiency. For example, one participant insisted on her late shift on 1st of January, even if she were not needed:

Participant: *"But now we are three, all of whom want to work. And nobody wants to leave the afternoon shift, because we want to sleep off after the party and then go to work. And there is one person to spare."*

Interviewer: *"Okay, but if the early shift is already taken..."*

Participant: *"Yes, then we have to see if one person gets the day off. But that wouldn't be right, because that one already has Christmas off. It's either the one or the other... If you're free on Christmas, you work on New Year's Eve and the other way round. And that person cannot get both days off. So he/she needs to go somewhere else" [I2; 128–130].*

Finally, sometimes there are planning conflicts that are less predictable and no simple solution can be found. One such case was a staff outing to the Oktoberfest in Munich. Several ward members wanted to participate. Unfortunately, the trip overlapped with the school holidays, so one team member had taken vacation already. The (previous) ward leader and two more registered nurses wanted to go, but because people from the other wards also participated, the situation became difficult. The wish could not be moved to a different date, external resources were depleted, and no rules had been established beforehand for that specific case. In the end, the general manager of the retirement community made a decision. She assigned the ward leader for the trip, because he was in the transition to another house at that time, and it was understood as an informal opportunity to get to know the new team. Then she drew lots between the other two. The one who lost said: *"Well, that's how it was. I have accepted it quickly. I also thought: 'Okay... [...] well, only [the colleague] or me. And then I thought, well, without her, I don't want to go anyway. [...] Maybe it's better this way, because you don't have your friends and family with you. And it would have felt weird, if she [...] had stayed home" [I3; 146].* In the end, the "winner" called in sick that day and did not go either. Instead, an apprentice nurse "stood in" for the trip.

In sum, the pro-social conflict prevention process worked mostly independent of our technical function, but followed the same fundamental principle: If conflicts cannot be avoided altogether, they are resolved face-to-face, based on individual needs first. If that provided no satisfactory solution, it was followed by an equality-based mitigation process. Only in one case where this process had also failed and which involved the entire retirement community, a top-down decision was made. The

several levels of escalation illustrate that the nurses try to find acceptable solutions for everyone and use all available options, even some that may be outside the scope of a typical shift planning system. Regarding our interactive system, the information about the time and date of everyone's wishes proved useful.

Early Planning of Important Appointments

Most nurses waited impatiently for the plan to be released: *“Well, first everyone rushes directly to the new schedule, because you want to know how you work the next month. So that you can directly start planning”* [I3; 162]. It is important for both preparing private activities and work: *“I usually look at the weekends first, if they are correct. And the second thing is if I see: ‘Okay, there is a big block!’ And then I count how many days in a row I work. So that I can prepare for that”* [I3; 173].

Some reported that other healthcare institutions release the shift plan earlier: *“When I was in the hospital with my daughter, she [the hospital nurse] told me: ‘What do you mean, you don’t know it yet? We always get it in advance!’ ”*, *“That’s why I say, at least more than a month so that you can plan a little bit. Because, as I said, on April 15 I theoretically don’t know how I work on the 1st of May.. because it’s not released.”*, *“That makes the doctor’s appointments and everything so difficult”* [FG2; 183–193]. Some nurses start planning even important private activities only after the shift plan is released, which should thus happen as early as possible. We are aware that the ability and willingness of the management to plan earlier depends on several external factors. In our case, the retirement community receives financial support for each resident. But when a resident passes away or leaves the community for other reasons, financial support stops on that day, while the company has to pay for the scheduled staff until another resident moves in. So the management needs to consider the risk of overplanning. The short planning cycles are a direct result of this economic pressure, which is different for example in hospitals where the number of patients has to be estimated differently during planning. However, we think that a more fine-grained system that reduces economic risks for the management on the one hand, and allows nurses to plan for punctuated, important appointments on the other, is possible.

Taken together, for subjectively important appointments, early release of the shift plan facilitates planning, but puts the company at a higher risk of overstaffing. A compromise between flexibility and the option to plan for individual appointments would help provide security for both the nurses and the company. The simple calendar overview our system provided fulfilled the nurses' need to check their appointments. But the release date turned out to be the most important factor.

Leadership

Shift planning as envisioned by our process assumes no designated leader and each team member has equal power over the shift plan. Nevertheless, we found several important functions of a leader, beyond being the decision-guide during conflicts, that need to be accounted for. In our case study, the nurses did not plan in an exceedingly selfish way, but rather stood back with their individual wishes more than needed. Both ward leaders urged their team members to submit wishes, and motivated them to think about occasions when they could take a day off for some leisure activity: *“Yeah, well... because they don’t have so many wishes I had to push them a little. ‘Come on, submit a wish! Look!’. And then they accepted that”* [FG1; 184–186]. The newer ward leader also reported to have established a new, nurse-oriented rule: *“I had an afternoon shift with her on a Sunday and I already felt that something was wrong. And a few days later she told me that Sunday had been her birthday. So I said: ‘What do you mean, we **worked** together!’, ‘Yes, but I didn’t dare saying it’, because she had already swapped that [another] weekend. [...] And I was very shocked. And since then we have a birthday calendar [...] I felt really sorry, also because she has two small children and, well... [...] And it’s really important for me that nobody needs to come to work on their birthday”* [I4; 274–290].

Both leaders also made several adjustments to the shift plan that are not obvious for an outsider. Some were based on individual considerations: *“Well, you know your team. One only wants to work up to four days in a row. Others say: ‘I’d prefer a block of seven days’ ”* [I4; 210], or team composition: *“This one doesn’t like to work with that one, that other one not with him. But I also have to see that the combinations are good. That I have a strong one here, and a strong one there. Not that all the strong ones are in one weekend. That doesn’t work. Because then the other weekend will go down”* [I4; 446].

Moreover, group-level fairness played a role in these adjustments. One team member had a part-time position with only few hours to work every week. So in the past she had not been assigned to weekends, but instead stood in for sick team members more often. The new ward leader changed that: *“That’s where I say: ‘I don’t do that’. Because it’s also unfair for the others. Because she had some months where she had not worked a single weekend. And there were others who said: ‘Well, why doesn’t she work now, yet again?’. And I don’t think that’s right. In that case you need to plan everyone. And also: I prefer to plan all employees I have for the weekend. And if someone is sick, you can still use the ones that are available. I can say: ‘Hey, look. We have six men in the morning shift. We can give some away’ ”* [I4; 406–412]. This adjustment to assign everyone equally was not necessarily better from an efficiency perspective. But it was important for the subjective experience of fairness.

As a team member, the ward leader was accepted to have a say on the shift plan. This was not always the case for the central planner, who was often complained about. Being an “external” person, his decisions were considered somewhat careless. For example, the ward leader once had submitted a wish that had been replanned: *“And then I went to see him. And asked what that was for. So he said ‘Well, it would be*

better like that'. And I said 'But I submitted a wish there!' But he can't know that. So I said 'And that's exactly the problem. Ask before you change something, otherwise it doesn't work' " [I4; 308].

In sum, the role of a ward leader was still valuable, despite the reduced responsibility in planning. First, they motivated the colleagues to submit wishes. Second, they facilitated conflict resolution. And third, through smaller, informal practices of team composition and by having an eye on the private lives of the nurses, they adjusted the shift plan, making it more agreeable and fair for the team. In a leaderless shift planning system, these functions need to be accounted for differently. We offer some possibilities below.

Central Findings and Discussion

Study 4 presented a case study about the design and appropriation of a computer-supported collaborative shift planning system. Over the course of nine months, we found complex, sociotechnical interactions between informal social contracts, individual values, and socially aware shift planning practices that shaped how nurses engaged in planning. We will first discuss our central findings about the planning practices and how our app could support them, based on the themes of the previous analysis. For each theme, we also add a note on how it relates to psychological need fulfillment and thus to subjective well-being. Then we discuss our findings in the broader context of related literature. And finally, we present design guidelines based on our insights for computer-supported, nurse-centered planning.

Central Findings

Individual Planning Practices in Context

Concerning individual planning, we found evidence that is inconsistent with a simplistic view on individual shift planning as a means for the nurses to maximize individual “utility”. When using the “wishes” practice to plan for individual free time, nurses were aware of their team as a social group and their standing within it, and they used their freedom to plan responsibly. Differences in lifestyle, that is, whether a nurse plans private appointments in advance or lives more spontaneously, led to a disparity in the usage of wishes, but not to grudge. A central insight is that, rather than problems relating to overuse of this individual freedom, some nurses may be too careful to claim specific free shifts on a regular basis. Moreover, we illustrated the dilemma of justifying wishes in written form, which failed to convey their subjective importance. This supports our notion to foster face-to-face interaction. Overall, individual planning practices were successfully supported by our shift planning app.

Regarding psychological need fulfillment, the “wishes” practice was primarily designed to address autonomy, which has worked relatively well by allowing nurses to engage in planning. Two hurdles we found related to reputation and different

lifestyles. We think that reputation can be a threat to autonomy for some nurses and should be addressed in the design. The differences in lifestyle are not, and in fact they can rather be understood as the expression of autonomous decision-making in private, which results in these different lifestyles. In our app, the general functionality to plan more autonomously was provided. Design guidelines that could help overcome the reputation problems are presented below.

Pro-social Conflict Prevention

Conflict prevention and resolution were similarly embedded in context. The participants performed several pro-social informal practices, resulting in a step-wise, escalating conflict resolution process. First, nurses tried to avoid a conflict altogether by rearranging their private plans. Second, they searched for external resources to find an acceptable solution for everyone involved, based on personal needs. Third, for predictable conflicts, they relied on established, equality-based rules to find a solution. In one case, all precautions failed, and the conflict was escalated to the general manager, who made a workable but unsatisfying decision. The focus of our app on conflict resolution did not appropriately support these informal, pro-social conflict prevention practices.

In terms of subjective well-being, the “conflict hero” practice was designed to support the need for popularity (e.g., Hassenzahl et al., 2010). The central idea was that participants respect each other’s needs and work together to find a common solution, thus fostering a positive team spirit. This corresponds to our findings of a pro-social conflict prevention process.

Private Planning on Hold

Early release of the shift plan proved to be essential for some nurses to plan private appointments. Some of the participants tended to wait until the shift plan was released before they made private plans, for example with the doctor. Thus, private life was on hold until the shift plan was set. Our app was limited in its support for early planning, given the economic considerations of the management. An important takeaway of our study is that the release date can be seen as a means of “negotiation of flexibility”, with respect to other societal actors such as clinics, kindergartens, the friends and partners with their work times, or cultural events. A late release means that the nurses have to reschedule and possibly solve private planning conflicts with their co-workers on short notice, which might be avoided if they knew the shift plan earlier. Taking this into account, we understand work and private life not as fundamental opposites, but rather as co-emerging processes. While it may be counterintuitive to advocate a “less flexible” (i.e., decided early on) shift plan to support private life, the high pressure of the shift plan on private life is independent of its release date. Early (partial) release facilitates informed private planning.

Accordingly, the associated “safe harbor” practice could only fulfill the need for security to a limited extent. Once the plan was released and nurses saw their

individual shift plans, they did not only verify whether their private appointments could be met, but also anticipated phases of high workload to plan for them ahead of time. Taken together, the need for security was central to planning, but directly affected by external decisions.

Leadership

The ambiguous role of the ward leader in our study highlighted several implicit leadership functions they have in centralized shift planning. These need to be accounted for in nurse-centered, distributed shift planning systems, which by definition have no leader. The leaders motivated their colleagues to occasionally prioritize their private lives above work. They also initiated conflict resolution. Moreover, they had an eye on team composition, group-level fairness, and implemented small pro-social rules to make the shift plan more agreeable. However, there are also several drawbacks of a leader role in shift planning. We found that the mere practice to submit a wish for free time to a leader, thereby creating additional workload for them, was seen as a hurdle. Moreover, as was found previously (Rönnerberg & Larsson, 2010), a leader could be seen as a gatekeeper and reduce nurses' subjective control of their shift plan. In terms of subjective well-being, we can only tentatively interpret the role of leadership as a moderating factor that shapes whether and how nurses engage in planning, when and how conflicts are resolved, and that makes adjustments on a group level.

Design Guidelines

For future implementations of nurse-centered shift planning systems, we conclude with some central design guidelines based on our findings.

Scaffolding of Individual Planning Practices

Practices of individual planning need to be understood within the social context (Ackerman, 2000; Selbst et al., 2019). While the focus of dealing with nurse influence on the shift plan typically lies on resolving conflicts (Constantino et al., 2011, 2015), designers should consider social hurdles that complicate individual planning for nurses, such as an expected negative impact of submitting “unimportant” wishes on their reputation. A technical successor of our “wishes” practice could include mechanisms to counter this negative impact. One possibility would be to provide examples of acceptable wishes in the interface, such as visiting a Christmas market or a concert. Based on this, nurses' might change their beliefs about what is “worth a wish”. Other possibilities include the support to share stories about “unimportant” wishes within the group. However, based on our findings, we recommend not to include a possibility to provide detailed justifications, because they can misrepresent the subjective importance of a wish. Abstract, vague markers (e.g., “time for myself” or “I need a change of scene”) could be used alternatively and optionally for cases that

are less important. In order to further support nurses with spontaneous lifestyles, reminders to submit wishes or suggestions for possible wishes could be included.

Dealing With Conflicts

Conflict resolution already worked fine without technical support in most cases and, as in our system, the necessary information about others' wishes should be provided early on. But the outlined process can be augmented in several ways. First, additional resources in the specific context could be presented more readily. For example, tacit indicators, such as color codes in the calendar that indicate days with many wishes in other wards could further help anticipate and facilitate conflicts and possibly even promote proactive collaboration across wards. Second, the equality-based rules for predictable conflicts could be better integrated. For example, in our case, the rule for Christmas and New Year's Eve could be picked up, become represented directly in the system, and actively addressed as a dedicated event. This could reduce the need of a leader to initiate conflict resolution. Third, technical support may have helped avoid the collision between the staff outing and school holidays by helping the planner of the outing to anticipate the staff shortage. However, the case in our study involved actors beyond the ward, which have to be considered. Moreover, given that only a single case was found that was not satisfactorily resolved, better social mediation processes may be needed, independent of their efficiency.

Co-emergence of Private and Work Lives

Providing a way for the nurses to plan for important private appointments early on could help rebalance the organizations' risk of overplanning while allowing nurses to better plan for their private lives. The fixed weekends have helped in our study, but they could not cover appointments during the week (e.g., with the doctor). One compromise would be to decide for one or two working days per week and nurse, where they know their shift plans further in advance or where they should try to make their appointments if possible. This could help distribute these appointments and increase stability, and additionally free the wishes for less important ones. Alternatively, nurses could be supported to conclude informal contracts within the team early on for specific shifts, for example asserting that they would be available during the colleague's appointment. This could be designed as a pro-social practice and provide security even if the shift plan is not fixed yet.

Self-Leadership

Our study revealed positive impacts of a dedicated leader. In possibly leaderless planning, this needs to be replaced by other means. One function of the leaders can be summarized as "saving nurses from themselves" by regulating their workload and motivating them to take time off. First technological solutions have been presented already that could support self-care practices of shift workers, for example to regulate their caffeine intake and sleep patterns (Nunes et al., 2018). In addition, Hassenzahl,

Buzzo, and Neuhaus (2016) proposed a “benevolent” calendar to support well-being by actively balancing work and private life. Janböcke et al. (2020) presented a calendar to help people with planning daily tasks more in line with their “inner clock” (i.e., circadian rhythms). In all three cases, available knowledge about healthy usage of time became implemented in a technology to productively challenge their users to think more about their own well-being. Besides practices of self-care in shift planning, practices of other-care that are not necessarily related to shift planning, but to the work context itself, could also help to cope with shift work (as described in Addendum 2). A second function of the leaders was “informed group composition”. The ward leader argued that nurses prefer to work with colleagues they like, rather than distributing “strong” nurses across shifts. In a previous study, Langfred and colleagues (2007) found some evidence that group performance in self-organized work can suffer from personal conflicts, so sympathy should not generally be condemned as a bad heuristic. Physically exhausting tasks may be supported by robotic assistance (Riek, 2017), which could further reduce this problem. Nevertheless, including and working with information about which nurses are strong and reliable and which are not can lead to further ethical and privacy issues. Other, less problematic information (e.g., nurses who have been in the ward for a long time vs. those who have just joined), can be used by a shift planning system to improve group composition and highlight shifts where problems may arise. Where a dedicated leader cannot be replaced easily, other group-based mechanisms could be considered, including rotating leadership, consensus-based mechanisms, or no-veto-agreements (see e.g., Laloux, 2014, for some practical examples). Finally, it might also be a good choice to simply keep the leader in place.

Limitations and Further Research

Although Study 4 was set in a real-world healthcare environment, our findings are taken from a ward where the team spirit was generally positive. This allowed us to provide a positive reference scenario, but, of course, insights into how such a system would be appropriated in a less harmonic setting are missing. Moreover, given the relatively small sample, we did not collect quantitative data about the system’s impact on well-being, which would add further insights about the effectiveness of our nurse-oriented approach. Other challenges with long-term use, including the integration of new nurses in the team, are also left for future research. In addition, we have not focused on the efficiency of our system, in terms of time and effort needed to create a shift plan. A comparative study would help to estimate a possible management overhead of nurse-centered planning, or even indicate that they can be more efficient because conflicts are avoided or handled quickly and more directly (Laloux, 2014). Finally, using the planning system in a setting where no fallback system is available, as well as a more complete implementation that includes all practices from all three phases could provide insights about a more complete appropriation.

Study 5: Fairness and Well-being in Interactive Conflict Resolution

The presentation of Study 5 was slightly adapted to fit with the overall format of the thesis (e.g., wording, structure, figures). The original version was published in:

Uhde, A., Laschke, M., & Hassenzahl, M. (2022). Experiential Benefits of Interactive Conflict Negotiation Practices in Computer-Supported Shift Planning. In *Proceedings of the 2022 Australian Conference on Computer-Human Interaction*, 13 pages. New York, NY, USA: ACM. doi: 10.1145/3572921.3572927

The previous studies have provided a detailed understanding of nurses' experiences of fairness, as well as insights about the design and appropriation of nurse-centered shift planning in practice. In this final study, we focused on the informal conflict negotiation practices found in Study 4 and tested their effect on fairness and well-being. We also tested for effects on team spirit, because this was indicated in Study 1 as an important factor in shift planning. We compared this interactive approach with fully automated shift planning, which is the current state of the art in the shift planning literature.

Hypotheses

Our specific hypotheses were:

- H1:** Interactive conflict negotiation practices lead to a more positive emotional experience for nurses (i.e., affect balance) than fully automated conflict resolution.
- H2:** Interactive conflict negotiation practices lead to more need fulfillment than fully automated conflict resolution.
- H3:** Interactive conflict negotiation practices are perceived as fairer than fully automated conflict resolution.
- H4:** Interactive conflict negotiation practices lead to a better long-term team spirit than fully automated conflict resolution.

Method

Similar to Study 2, we used the experimental vignette methodology (EVM; Aguinis & Bradley, 2014) to test our hypotheses in an online study. Specifically, we chose EVM because it allowed us to experimentally test the effect of interactive conflict negotiation practices, independent of their outcome in practice (i.e., whether a nurse's wish was granted or not). Thus, EVM allowed us to provide enough context

to create and compare realistic scenarios while removing other factors that may influence the participants' experiences in field studies.

Participants

In total, 94 German-speaking nurses completed our online study. We recruited participants through snowball sampling, social media channels, and indirectly by asking the healthcare managers of around fifty healthcare institutions to forward our call. As compensation, participants could opt in to a raffle for a 30 € voucher, and we additionally donated 50 Cents for each complete questionnaire to a non-profit organization to increase motivation to participate.

The sample included 13 participants who identified as male and 81 who identified as female. The average age was 39 years ($sd = 11.20$; $min = 21$; $max = 63$). Participants had 16 years of work experience on average ($sd = 12.10$; $min = 0.5$; $max = 46$). 62 participants worked as registered nurses, and another 17 had an additional role as ward leader. 6 participants worked as childcare nurses, 3 as nurse assistants, 3 had other healthcare-related occupations (intern, midwife, healthcare specialist), and 3 did not disclose their specific occupation.

Procedure

The participants accessed the study through a link or a QR code provided during the advertisement for the study. They landed on a welcome page that informed them about the overall process of the study, the expected length (15 minutes), and anonymous data analysis. On the next screen, participants were introduced to the general scenario, which was based on the hybrid shift planning model inspired by Studies 3 and 4. We asked them to imagine that a new shift planning system was introduced in their team. They could access this new system through an app on a tablet in their office. The shift planning system allowed each nurse to submit long-term preferences for early shifts, late shifts, or specific times in a week (e.g., Wednesday from 16:00 to 18:00, so they could join their sports club). We said that these preferences only needed to be entered once and were valid until changed. In addition, the shift planning system allowed nurses to enter wishes for specific free days or shifts.

On the following pages, we presented four vignettes of planning scenarios in relation to such wishes (see Appendix B for an English translation of the full text of all vignettes). In the "conflict negotiation" condition, we used the four interactive conflict negotiation practices from Study 4. Nurses could try to find a solution using these practices, and used a fully automated process as a fallback. In the "automatic" condition, the process consisted only of the fully automated processes, as is common in many shift planning systems (e.g., Burke et al., 2004; Constantino et al., 2011; C.-C. Lin et al., 2015). Participants were randomly assigned to either condition (between-participants variation). 53 participants finished the conflict negotiation condition and 41 finished the automatic condition. The vignettes in both conditions

focused on the process of handling possible planning conflicts, but left the result open. Thus, we left open whether a participant's wish was granted in the final shift plan or not. We left the final decision out, because we were primarily interested in the experience of the process, not the result.

The "conflict negotiation" condition resembled the four interactive conflict negotiation practices reported in Study 4. In the first vignette ("rescheduling"), participants had wished a day off, but they were later informed that a co-worker has also wished the same day off. They reacted by attempting to reschedule their private appointment to a different day, where no other nurse has wished a day off, to increase the chance that it could be granted. In the second vignette ("external resources"), participants had wished a shift off for a private appointment they could not easily reschedule. A co-worker wished the same shift off. They discussed this with their co-worker and tried to activate external resources so that both wishes could be granted (e.g., by asking nurses from other groups to stand in or by splitting the shift). The third vignette ("informal rules") described an expectable group conflict: Shift planning on Christmas. Many nurses wanted to get Christmas Eve off, but not all wishes could be granted. Here, the group leader initiated an open discussion during a team meeting, based on an informal rule (i.e., "whoever works on Christmas gets New Year's Day off and vice versa"), again with an unknown result. Finally, the fourth vignette ("unavoidable conflict") described a conflict that could not easily be resolved, and for which no informal rules existed. The employer planned a company outing and healthcare nurses from all wards of the institution wanted to join. In addition, the outing overlapped with the holiday season. Thus, the event could not be rescheduled, external resources were scarce (e.g., nurses from other groups), and there were no established, informal rules. The nurses searched for a solution together with a colleague who also wanted to go, but it was unlikely that they found a solution that allowed both of them to participate. In all four vignettes, the participants were told that the algorithm made a decision if the nurses could not find an alternative by themselves.

Participants in the "automatic" condition faced the same problems, but the process did not involve the interactive conflict negotiation practices. Instead, the decision was made by the system, which attempted to automatically find a good solution (the result was not described in the vignettes). This is state of the art in many automatic shift planning systems (Burke et al., 2004; Constantino et al., 2011; C.-C. Lin et al., 2015) and served as our control condition.

Following each vignette, we included several items to measure the dependent variables. Subjective well-being was measured based on affect balance and need fulfillment¹. In addition, we measured procedural fairness and nurses' expected impact on team spirit. After the fourth vignette was finished, we asked participants for their age, gender, job title, and work experience as a nurse. Finally, at the end of

¹We did not include the third measure of subjective well-being, life satisfaction (Diener et al., 1985), because it is relatively stable over time, and we considered effects of the few scenarios unlikely.

the questionnaire, we included an open field for comments about the study, and a field to enter contact information for the raffle.

Measures

Summary statistics of all measures can be found in Table 2.

Immersiveness

As is common practice in EVM (Aguinis & Bradley, 2014; Atzmüller & Steiner, 2010), we measured how well participants could immerse into the scenario with one 7-point scale item ranging from 1 (“not at all”) to 7 (“very well”). Immersiveness of all four vignettes was high across both conditions (means ranged between 5.29 and 6.36).

Affect Balance

We measured affect balance with two 7-point scales (positive and negative affect) by asking how positive/negative participants felt during the described situation. Both scales ranged from 1 (“not at all”) to 7 (“extremely”). We calculated the affect balance as the difference between positive and negative affect. Higher values represent a more positive affect balance.

Psychological Need Fulfillment

To measure psychological need fulfillment, we used the need scales from Sheldon and colleagues (Sheldon et al., 2001) in a German translation (Diefenbach & Hasenzahl, 2010). We included the four needs that we had identified as relevant in shift planning in Study 3: Autonomy, competence, popularity, and security. Each need was measured as the average of three items and overall need fulfillment was measured as the average of the four needs. An example item for autonomy was “I felt free to do things my own way”. All items were measured with a 5-point scale from 1 (“not at all”) to 5 (“extremely”). Internal consistencies of all needs in all four scenarios were good (all between Cronbach’s $\alpha = .76$ and $\alpha = .93$).

Fairness

As reported above, our study focused on fairness of the decision-making process, not on the result. Accordingly, we measured procedural fairness with the 7-point procedural fairness item adopted from Study 2. The scale ranged from 1 (“unfair”) to 7 (“fair”).

Expected Team Spirit

Finally, we asked participants to estimate the long-term effect of the described decision-making process on team spirit on a 7-point scale from 1 (“negative”) to 7 (“positive”).

Table 2: Summary statistics for all measures of the four vignettes and two resolution processes (n = 94). m = mean, sd = standard deviation.

measure	scenario	process			
		negotiation		automatic	
		m	sd	m	sd
immersiveness	rescheduling	6.36	1.03	5.98	1.39
	resources	6.08	1.33	6.07	1.26
	informal rules	6.36	1.20	6.02	1.43
	unavoidable	5.32	1.89	5.29	1.99
	<i>overall</i>	6.03	1.46	5.84	1.57
affect balance	rescheduling	-0.62	2.93	-1.17	2.67
	resources	-0.47	3.21	-2.59	2.17
	informal rules	0.43	3.00	-0.02	3.36
	unavoidable	-1.60	3.03	-0.02	3.40
	<i>overall</i>	-0.57	3.13	-1.00	3.11
need fulfillment	rescheduling	3.01	1.02	2.97	0.96
	resources	2.98	1.01	2.62	0.92
	informal rules	2.99	1.07	2.75	0.94
	unavoidable	2.51	1.03	2.74	1.00
	<i>overall</i>	2.87	1.05	2.77	0.96
fairness	rescheduling	4.85	1.66	4.10	1.70
	resources	4.85	1.84	3.59	1.55
	informal rules	5.51	1.59	4.15	1.63
	unavoidable	4.49	2.22	4.44	1.83
	<i>overall</i>	4.92	1.88	4.07	1.70
team spirit	rescheduling	4.42	2.10	4.10	1.81
	resources	4.75	2.08	3.34	1.59
	informal rules	5.13	1.72	3.78	1.90
	unavoidable	4.11	1.95	3.80	1.73
	<i>overall</i>	4.60	2.00	3.76	1.78

Results

Plots for all measures can be found in Figure 7.

Well-being

Affect Balance

Our first hypothesis was that interactive conflict negotiation practices lead to a more positive affect balance, compared with a fully automated process. We tested this by running a 2 (resolution process) x 4 (scenario) ANOVA with affect balance as measure. We did not find a main effect of experimental condition ($F(1, 92) = 0.98, p = .33$), but a significant interaction effect ($F(3, 276) = 7.53, p < .01, \eta_p^2 = .08$). A post-hoc analysis with Holm-adjusted α values revealed a positive effect of the interactive “external resources” practice on affect balance, compared with the automated process ($t(92) = 3.36, p < .01, d = .70$). No other pairwise comparison was significant.

We further explored whether the effect of the “external resources” practice was based on more positive affect or less negative affect, compared with the automatic process. Both differences, for positive ($t(91.83) = 3.63, p < .001, d = .74$) and negative affect ($t(88.74) = 3.29, p < .001, d = .66$), were significant. Thus, the external resources practice led to more positive and less negative affect, compared with the automatic process.

In sum, we could not confirm an overall positive effect for all interactive conflict negotiation practices on the emotional experience of nurses (i.e., affect balance). However, we found a more specific positive effect of the “external resources” practice on the nurses’ emotional experience, compared with an automated decision-making process. This effect was based both on more positive affect and less negative affect.

Need Fulfillment

Our second hypothesis was that interactive conflict negotiation practices lead to more need fulfillment, compared with the automatic process. We ran a 2 (resolution process) x 4 (scenario) ANOVA with overall need fulfillment as measure. Again, we found no main effect of the resolution process ($F(1, 92) = 0.85, p = .36$), but a significant interaction effect ($F(3, 276) = 7.02, p < .01, \eta_p^2 = .07$). A post-hoc analysis with Holm-adjusted α values revealed a positive effect of the interactive “external resources” practice, compared with the automatic process ($t(92) = 2.33, p < .05$). No other pairwise comparison was significant.

We further explored the need fulfillment of the “external resources” practice for the four needs separately, and found a significant difference in autonomy ($t(92) = 2.95, p < .01, d = 0.61$) and competence ($t(92) = 2.48, p_{crit} = .025, p = .015, d = 0.52$). The differences in security and popularity were not significant.

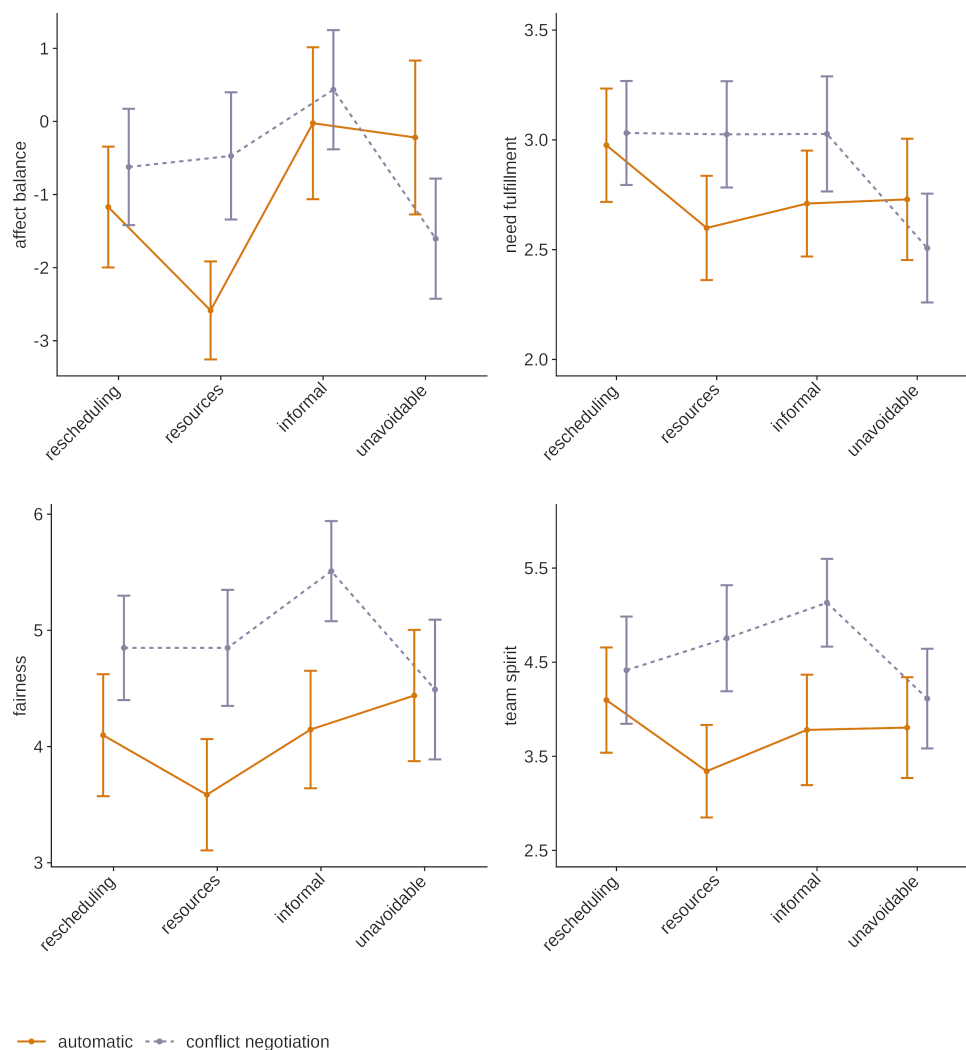


Figure 7: Results for the four measures by resolution process and scenario. The error bars mark the 95% confidence intervals.

Taken together, we could not confirm an overall effect of all interactive conflict negotiation practices on need fulfillment. However, we found a more specific effect of the “external resources” practice on need fulfillment, which was based on higher fulfillment of the autonomy and competence needs.

Fairness

Our third hypothesis was that interactive conflict negotiation practices are perceived as fairer than a fully automated process. We ran a 2 (resolution process) x 4 (scenario) ANOVA with fairness as measure and found a significant main effect of the resolution

process ($F(1, 92) = 10.31, p < .01, \eta_p^2 = .10$). We also found a significant interaction effect ($F(3, 276) = 4.04, p < .01, \eta_p^2 = .04$). A post-hoc analysis with Holm-adjusted α values revealed a positive effect of the interactive “informal rules” practice ($t(92) = 3.67, p < .01$) and the “external resources” practice ($t(92) = 3.40, p_{crit} = .025, p < .01$), compared with their automated alternatives. The differences between the interactive and automatic resolution processes in the “rescheduling” and “unavoidable conflict” scenarios did not reach significance after Holm-adjustment.

In sum, we could confirm a positive overall effect of the interactive conflict negotiation practices on procedural fairness from the nurse perspective, compared with automatic shift planning. This effect was particularly based on positive effects of the “external resources” and “informal rules” practices.

Team Spirit

Our fourth hypothesis was that interactive conflict negotiation practices lead to a more positive team spirit than a fully automated process. We ran a 2 (resolution process) x 4 (scenario) ANOVA with team spirit as measure and found a significant main effect of the resolution process ($F(1, 92) = 7.11, p < .01, \eta_p^2 = .07$). We also found a significant interaction effect ($F(3, 276) = 5.24, p < .01, \eta_p^2 = .05$). A post-hoc analysis with Holm-adjusted α values revealed a positive effect of the interactive “external resources” practice ($t(92) = 3.58, p < .01$) and the “informal rules” practice ($t(92) = 3.43, p_{crit} = .025, p < .01$), compared with their automated alternatives. The effects of the resolution process in the “rescheduling” and “unavoidable conflict” scenarios did not reach significance after Holm-adjustment.

Taken together, we could confirm a positive overall effect of the interactive conflict negotiation practices on team spirit, compared with automatic shift planning. This effect was specifically based on positive effects of the “external resources” and “informal rules” practices.

Open Comments

In addition to the quantitative measures, 21 participants left a comment at the end of our questionnaire (12 in the conflict negotiation condition, 9 in the automatic condition). In this section, we present the comments that were relevant to our research, organized by the different topics they addressed.

Overall Evaluation of the Shift Planning Process

The evaluation of the shift planning process seemed more positive in the interactive conflict negotiation condition, compared with the automatic condition. We received four positive comments on the process in the conflict negotiation condition. One participant found it “*very interesting, sounds good.*”, another one simply commented “*tip-top.*” The other two participants especially appreciated the long-term preferences feature adopted from Study 3 (e.g., general preferences for morning shifts) that we

mentioned in the introduction of this study. Notably, this feature was part of both experimental conditions and did not play a direct role in the four scenarios.

In the automatic condition, one participant generally appreciated the interest of academic researchers in shift planning. However, there were no other positive comments on the shift planning process in this condition. One participant expressed a negative opinion: “*The case-based questions can only be answered in a negative way, because a system makes the decisions. Communication among each other and conflict resolutions are missing.*” The other comments were not related to the automatic shift planning process.

Conflict Negotiations

Three further comments (two from the automatic condition) were related to conflict negotiations more generally. One participant expressed that “*It is difficult, because you cannot please everyone.*” Another one also commented that “*It is difficult, especially with very emotional decisions such as Christmas [our scenario 3] which simply weighs more than a company outing [our scenario 4].*” The third comment highlighted the importance of a positive team spirit and interpersonal relations: “*Depending on the colleague you work with, swapping a shift or so is easier, or you are more considerate. Unfortunately.*”

Structural Problems in Healthcare Shift Work

Finally, three further comments (one from the automatic condition) were a bit longer and described systemic problems in healthcare from the nurse perspective. These were not directly related to our research questions, but relevant to shift planning more generally. One participant complained that changes in the shift plan are not always transparent. This causes problems especially for nurses who only work a few hours each week, and who rely on the good will of their colleagues to notify them about important changes to their shift plans. Another participant described general problems that result from shift work, such as health problems and difficulties to maintain a social life. They suggested allowing shift workers to retire earlier, because of these problems. Finally, the third participant argued that many difficulties in shift planning result from a general staff shortage, as well as outdated, rigid structures in the daily work organization.

Discussion

Study 5 presented an experimental online study in which we compared two different processes of handling conflicts between nurses’ wishes in computer-supported shift planning. The “conflict negotiation” process was based on the four, informal conflict negotiation practices identified in Study 4 and directly involved nurses in the decision-making process. First, nurses tried to *reschedule* their own wish to avoid a conflict

with a colleague's wish. Second, they looked for *external resources* (e.g., nurses from other wards, more flexible shift timings) to integrate both wishes. Third, nurses used *informal rules* to handle difficult but expectable conflicts, for example around public holidays with many wishes. Fourth, nurses attempted to find a good solution for all colleagues, even if the conflict turns out to be *unavoidable*. The other, "automatic" process was based on fully automated conflict resolution of the same four problem scenarios, as is currently state of the art in computer-supported shift planning systems (e.g., Abdalkareem et al., 2021; Van den Bergh et al., 2012).

Overall, we found that involving nurses through interactive conflict negotiation practices had positive effects on subjective fairness and team spirit, compared with the fully automated shift planning process. These effects were particularly based on the "external resources" and "informal rules" practices. We also found a more specific positive effect of the "external resources" practice on nurses' subjective well-being, specifically on the emotional experience/affect balance and psychological need fulfillment. In addition, our analysis of the (qualitative) open comments confirmed that nurses tended to appreciate the interactive process. In contrast, a participant in the automatic condition complained that the system makes decisions on their behalf, which takes away an opportunity to communicate and resolve conflicts among colleagues. Notably, they framed automatic conflict resolution as a problem, not as a desirable feature.

Design Implications

Optimize for Meaningful Involvement of Nurses in the Shift Planning Process

Our study confirmed specific, positive effects of nurse involvement on subjective well-being, fairness, and team spirit. Notably, earlier work has also found negative effects of other ways to involve nurses in computer-supported shift planning, for example on subjective control (Rönnerberg & Larsson, 2010) and workload or long-term commitment (Bailyn et al., 2007). From our perspective, it becomes increasingly clear that the specific way this involvement is designed is essential for successful, interactive shift planning. Simply reassigning planning tasks to the nurses for example by having them create full shift plans seems problematic, because it primarily increases their workload. In addition, these tasks do not seem to improve the nurses' experiences, as long as they do not lead to meaningful involvement in the actual decision-making processes, or if these processes do not consider the social dynamics in the team (Bailyn et al., 2007; Rönnerberg & Larsson, 2010). Instead, shifting targeted control to the nurses about the specific work and free times they care about seems more helpful. In future shift planning systems, the design of nurse involvement should specifically be optimized for meaningful nurse control about these subjectively important shifts.

This notion is further supported, considering that the participants also appreciated certain forms of automation. Specifically, some participants mentioned that the feature of automatically recurring long-term preferences such as a weekly sports

club (see also Study 3) would be desirable. This is a good example of an automation feature that adds value for the nurses, does not take away nurse control for subjectively important wishes, and reduces their workload.

Finally, the most positive effects on nurses' experiences resulted specifically from the two practices that require direct interactions between them. The "external resources" practice is based on a face-to-face negotiation between two colleagues and led to higher subjective well-being, fairness, and team spirit than an automated alternative. The "informal rules" practice is based on a face-to-face negotiation in the team and had positive effects on fairness and team spirit. Unlike the "rescheduling" practice, social interactions and nurse-based decision-making are inherent to these practices, and they cannot simply be added as another feature to a shift planning system that is otherwise supposed to be fully automated. Instead, they require nurse-centered, direct involvement to be part of the design. Our findings indicate that this is desirable from the nurse perspective.

Design Shift Planning to Improve Subjective Experiences of Nurses

Some earlier system proposals have already considered nurse-oriented features such as fairness (Constantino et al., 2011; C.-C. Lin et al., 2015) or well-being (Petrovic, 2019; Petrovic et al., 2020). These features are typically considered as "objective" criteria in the computer-supported shift planning literature. In the fully automated shift planning paradigm, this "objectivity" is crucial, because it makes the criteria formalizable and accessible for algorithmic processing. For example, Constantino and colleagues (2011) suggested to (automatically) balance nurse wishes that are integrated in the shift plan, to optimize fairness.

However, this "objective" approach has several problems. First, there is no such thing as "objective fairness", as outlined in the introduction. Second, fairness does not only concern the result of a decision-making process, but also the process itself (Colquitt, 2001; Colquitt & Zipay, 2015). Study 2 and 5 confirmed that shift planning systems which involve nurses in important decision-making processes are perceived as fairer, independent of the results. Finally, from our perspective, fairness in shift planning only makes sense in the first place if we talk about fairness as experienced by the affected nurses. A solution that satisfies a fairness definition of the algorithm developers does not help nurses in their everyday lives. To put it more drastically: We think that a completely unequal solution that integrates five wishes of one nurse and only one wish of another nurse can be preferable to one where both get three wishes granted, if that is what both nurses think is the fairest solution. Such subjective perspectives of nurses should be considered more prominently in future designs of computer-supported shift planning systems. At the end of the day, the nurses should be satisfied with the systems, rather than the designers and their theoretical assumptions.

Embed Conflict Negotiation Practices in the Broader Work Context

We found positive effects of the interactive conflict negotiation practices, but simply adding a nurse control feature that enables them to negotiate may not be sufficient to make the system work well in practice. Nurses need to stay motivated to participate over a longer time period if the system is supposed to be sustainable (Bailyn et al., 2007). Thus, socially embedding such a shift planning system, guiding the nurses through the process, and enabling a cooperative culture, could be necessary for them to even engage in conflict negotiations. On the one hand, the user interface could support this, for example by indicating where conflicts may arise, where nurses in other wards may be available (because they have not submitted a wish themselves), and by allowing manual entries of flexible solutions. On the other hand, socially embedding such a system and motivating nurses to participate may require good leadership skills of the group leader or other people in the healthcare institution (see e.g., Study 4 and Bailyn et al., 2007).

One specific case where this could be especially important is the fourth scenario of our study, where nurses are faced with a seemingly unavoidable conflict. Although the decision was delegated to the algorithm in our case, it could be desirable if the group leader takes responsibility for such difficult decisions, for a couple of reasons. First, these situations may be rather rare (e.g., once in nine months in Study 4), so efficiency is not a core concern here. Second, human-made decisions have been found to increase nurses' experience of having voice in the decision-making process, compared with algorithmic decisions (Schlicker et al., 2021). In other words, the mere fact that a human makes the decision can signal that the nurses' wishes are taken seriously (see also Binns, 2020). And third, communication between leaders and nurses plays a more generally important role for nurses' fairness perceptions in inclusive shift planning (Wynendaale et al., 2021).

Limitations and Further Research

Although the inclusive shift planning system was well-received by the nurses in our study, there are some healthcare contexts in which such negotiations that rely on interpersonal communication may be challenging in practice. One such case is outpatient care, where colleagues may not meet each other regularly. Of course, nurses can use other forms of communication, but the team dynamics may be more generally affected by such a work setting and discourage pro-social behavior (see Addendum 2). Thus, we think that shift planning systems for such specific healthcare contexts need to be studied in more detail in the future.

In addition, our study only covered practices of prospective shift planning. Short-term changes of the shift plan, for example if some nurses call in sick, pose another challenge in shift work that we did not cover here. Creating new shift plans and changing existing ones are often considered as separate processes from a management perspective. But from the nurse perspective, they both affect their work

and private time schedules. Thus, inclusive practices of short-term changes are an additional important topic for future work.

As with any study, the method we chose (EVM) also comes with certain problems and advantages. Positive aspects include that it allowed us to experimentally vary and control the exact conflict negotiation practices in each condition, while preserving immersive and realistic overall scenarios. But of course, an online study alone with a specific sample from one cultural context is not sufficient. Future work should include long-term studies using interactive prototypes that implement these interactive conflict negotiation practices, and confirm or further specify the positive effects we found.

Finally, shift planning itself needs to be understood within the broader organization of healthcare in our societies. Of course, improving such central processes can have positive effects. But the Covid-19 pandemic has revealed severe systemic problems in the healthcare systems of many countries. Currently, nursing is not an attractive job. Only few people want to enter the profession (Hemsley-Brown & Fokkett, 1999), and many nurses retire early or switch to different jobs (Chan et al., 2013). Among the remaining nurses, there is a growing trend towards part-time instead of full-time employment (e.g., in Germany; Federal Statistical Office of Germany, 2001, 2019). As one participant pointed out in the open comments, many problems of shift planning are a consequence of the overall nurse shortage. This leads to a vicious circle where nursing becomes overwhelmingly exhausting to many, and because of that one participant suggested allowing nurses to retire early. We think that fundamental changes are needed to make the nursing profession more attractive again, and to create more sustainable working conditions. Improving shift planning processes is important in this regard, but to overcome the structural problems, it needs to be complemented with fundamental improvements to the healthcare system.

General Discussion

At the outset of this thesis, I outlined a paradoxical situation with current healthcare systems in many societies. Although the central purpose of healthcare systems is to promote health in the society, the way healthcare work is organized discounts the health and well-being of the nurses who run the system itself, for the sake of presumed efficiency. The goal of this thesis was to take a first step towards healthcare work organization that considers nurses' needs and well-being as a top priority. In this final section, I will summarize the central findings of the five studies, what they contribute to the existing literature, and their central implications for future work.

Summary of Findings

Fairness plays a central role in shift planning, and Study 1 focused on nurses' experiences of fairness. We found that distributive fairness from the nurse perspective is a dual concept. On an abstract level, equality is the guiding allocation norm. For example, nurses thought that resources such as free weekends should be distributed evenly within the team. But in the case of specific planning conflicts, they expected decisions to be made based on a different allocation norm, that is, based on individual needs. In addition, nurses demanded to be involved in the decision-making process. Concerning informational fairness, we found a dilemma between transparency and privacy. In need-based conflict resolution, the personal circumstances of everyone involved provide the basis for decision-making. Revealing these personal information can be a privacy issue. In contrast, not revealing them leaves nurses whose wishes are denied without explanation. Finally, respectful conduct and a positive team spirit promote cooperative behavior and make shift planning easier.

Study 2 confirmed the central findings from Study 1. Nurses applied equality as the predominant norm in shift planning on an abstract level. But they considered specific conflict resolutions as fairest if based on individual needs. Equality-based decisions were experienced as less fair and equity, that is performance-based decision-making, was considered as least fair. Study 2 also confirmed that nurses find inclusive decision-making fairer than fully automated decision-making, even if an explanation for the decision is given and independent of the outcome.

One especially sensitive topic in need-based conflict resolution is the potential work-family backlash (Young, 1999). Nurses with children have a higher need for planning flexibility than nurses without children. Although their colleagues generally accepted that, they were concerned that their own needs might be neglected. In a brief, unpublished study (Addendum 1), we found that some parent nurses had negotiated special contract conditions, which in turn redirected some external pressures such as unflexible business hours of kindergartens to their colleagues.

In Study 3, we transferred the theoretical findings to practice. We developed a conceptual design for an interactive, nurse-centered shift planning system. Given

the important role of inclusive decision-making for subjective fairness, we focused on interactive shift planning practices that directly involve nurses in core decisions. This shift planning process entailed eight interactive shift planning practices that allowed for fair shift planning as sketched in Studies 1 and 2. Moreover, these practices were designed to support subjective well-being through positive shift planning experiences that address psychological needs. For example, the “wishes” practice addressed autonomy and the “conflict hero” practice addressed popularity (specifically the facet “helping others”) in the team. The practices served as the conceptual framework for a prototypical tablet app that nurses could use at work to plan autonomously.

In a further study published in the context of a doctoral consortium (Addendum 2), we explored the potential for pro-social practices outside of shift planning in various healthcare settings. The rationale behind this study was that such practices might improve the team spirit and thereby indirectly support a cooperative attitude in shift negotiations. We found that different healthcare settings (outpatient care, residential care, day care) come with different opportunities for pro-social practices, and that the team can play diametrically opposed roles. The outpatient nurse profited from working mostly on her own. She managed to negotiate regular work times that fit with her personal needs and did not need to consider the needs of her colleagues. In contrast, the nurse in the residential care setting highlighted the importance of a positive team spirit, which was sometimes more important for her than her own needs. Furthermore, we found that clear task assignments can help nurses to go beyond their (clearly defined) duties, and helps their colleagues to recognize that.

In Study 4, we tested the prototype from Study 3 in a retirement community for nine months. Overall, Study 4 provided insights about the highly social nature of shift planning. Nurses were particularly conscious about the impact of their shift planning activities on their team. Thus, they used the individual planning practices cautiously, and we found substantial individual differences in their appropriation. Nurses with a more structured private life used the system more intensely than their colleagues with a more spontaneous lifestyle. In addition, we found that justifications for wishes were used as a relic from non-autonomous decision-making to signal importance. But they did not transport the subjective importance appropriately.

We also found several pro-social planning practices on the group level. Rather than relying on a post hoc conflict resolution process, nurses performed several informal practices that prevented conflicts from happening in the first place. They flexibly rearranged their private plans wherever possible, or tried to find a solution that worked for everyone involved by activating external resources. Expected conflicts, for example around Christmas, were solved with equality-based informal rules. One unexpected conflict that involved the entire retirement community and overlapped with the school holidays could not be resolved appropriately and led to a top-down decision by the general manager.

Study 4 also revealed how the release date of shift plans can affect nurses’ lives. Early planning provides nurses with more stability, but increases the financial risks of the management. In our study, the release date was quite late (two weeks before

the shift plan set in). As a result, nurses used their wishes for “non-leisure” errands, such as doctor’s appointments.

Concerning leadership in autonomous shift planning, we found several functions that were still addressed by the leader. The ward leaders in Study 4 made small changes to the shift plan based on their knowledge about each team member and group compositions. They also initiated the resolution of predictable conflicts, such as shift assignment on Christmas. Moreover, they occasionally supported their team members in taking time for themselves.

In Study 5 we investigated the effects of the informal conflict negotiation practices from Study 4 on fairness, well-being, and team spirit. We compared these interactive practices with a fully automated shift planning process, and found positive effects on fairness and team spirit. In addition, the “external resources” practice, which involved a direct negotiation between two nurses about a particular planning conflict, also had positive effects on the emotional experience and psychological need fulfillment. This final study confirmed the potential of an interactive shift planning approach to directly improve the experience of fairness and well-being, compared with fully automated shift planning.

Contribution to the Field(s)

The research presented in this thesis was primarily informed by two different research traditions. Thus, one of the core contributions of this work is that it bridges between shift planning research as a subfield of operations research, and Human-Computer Interaction research.

Shift Planning in Operations Research

Concerning shift planning in operations research, previous work had already covered several technical approaches to support shift planning through automated problem-solving and a thorough understanding of the relevant factors in shift planning (Burke et al., 2004; Van den Bergh et al., 2012). There were also several attempts to include fairness (Constantino et al., 2011; C.-C. Lin et al., 2015; Warner, 1976) and well-being (Gärtner, Bohle, Arlinghaus, Schafhauser, & Widl, 2018; Petrovic, 2019; Petrovic et al., 2020) as nurse-oriented factors. However, this research field primarily approaches shift planning from the perspective of healthcare management, which is, for example, reflected in the lack of studies that directly involve nurses with their perspective.

In contrast, the self-scheduling literature and more recent, computer-supported approaches to self-scheduling (Bailyn et al., 2007; M. L. Miller, 1984; Nabe-Nielsen et al., 2012; Rönnberg & Larsson, 2010) have approached shift planning with a focus on its impact on nurses. But the systems presented so far had not yet managed to successfully integrate high nurse control while limiting workload, and to systematically study the effects on experienced fairness and well-being.

This thesis closes this gap. Specifically, it adds a detailed understanding of nurses' fairness experiences that is needed in automatic shift planning approaches, so that future systems can meaningfully integrate fairness mechanisms that go beyond theoretical assumptions and address practical needs. It also shows in a detailed shift planning process how such a system can look like. But the thesis also outlines a solution for the problems encountered by previous computer-supported self-scheduling approaches, and overcomes what seemed like an inherent trade-off between nurse control and work overload. One crucial insight is that many shift planning decisions can be automated, and that this automation can be in the interest of the nurses. However, it is important to specifically provide control to nurses for subjectively important shift planning decisions.

A final important finding from Study 4 is that in practice, conflicts and sophisticated conflict resolution processes do not necessarily play such a central role as it may seem in the literature. Nurses managed to avoid all but one conflicts during the nine-month field study. If conflicts are so rare in practice, it may be questionable whether complex, automatic processes to resolve them are warranted. Of course, there are many other aspects where automation can be advantageous, for example for identifying situations where conflicts may arise, so that nurses can find ways to plan differently, or for planning all parts of the shift plan where no nurse has particular preferences.

Human-Computer Interaction and Computer-Supported Cooperative Work

This thesis also closes a gap in the Human-Computer Interaction literature. Technological interventions in healthcare work settings have been a major research area in the field (Fitzpatrick & Ellingsen, 2013). Previous work included studies about medical records and electronic documentation (Bardram & Houben, 2018; Bossen, Jensen, & Witt, 2012; Jagannath, Sarcevic, Young, & Myers, 2019; Zhou, Ackerman, & Zheng, 2009, 2010), and information flow during shift changes (Stisen & Verdezoto, 2017; Tang & Carpendale, 2007). It also covered work organization *during* shifts, for example during surgeries (Bardram, 2000; Bardram & Hansen, 2010; Mentis, Reddy, & Rosson, 2010), or concerning the temporal and spatial coordination of staff, patients, and equipment (Bardram & Bossen, 2005; Bossen & Foss, 2016; Pine & Chen, 2020; Reddy & Dourish, 2002; Stisen, Verdezoto, Blunck, Kjærgaard, & Grønbaek, 2016). However, few studies have been concerned with shift planning itself. The most closely related work by Nunes and colleagues (2018) focused on self-care practices of nurses, to help them cope with problems related to shift work. This thesis adds a series of nurse-centered studies that provide a detailed picture of the shift planning process itself.

Beyond shift planning and hospital work, there has been a long tradition (Hackman, 1986; Oldham & Hackman, 1978) and a recently growing interest in the literature about worker-centered design (e.g., CHIWORK Collective et al., 2022; Fox et al., 2020; Karusala et al., 2021; Laloux, 2014; Laschke, Braun, Neuhaus, & Hassenzahl, 2020;

A. Zhang, Boltz, Wang, & Lee, 2022). In that regard, this thesis offers a case of how work practices that may seem “mundane” or even annoying (such as conflict resolution) can also be understood as an opportunity to improve the overall work experience. Similar approaches, for example in the communication between physicians with different specializations (Laschke et al., 2020) have already been presented, and this work contributes a detailed case on shift planning. More broadly speaking, it also relates to recent critical approaches to automation that do not focus on efficiency alone, but instead try to promote well-being and positive experiences of the users (e.g., Klapperich et al., 2020).

Limitations

Finally, this work has some limitations that should be addressed in future work. First, the main focus of research and design was the shift planning process. Study 3 outlined further practices that become important in later phases during a shift work cycle: Dealing with changes to the plan on short notice (e.g., finding replacements for nurses), and looking back at or evaluating past shift plans. These phases introduce further complexities. For example, seeking replacement implies that nurses need to be contacted during their free times, which crosses the line between work and private life. It also requires some technical infrastructure and planning practices that cannot always be performed in face-to-face conversations. In contrast, some interactions with the shift plan, for example informing a nurse that her personally important wish has been included in the final version, may reduce tension and can have positive effects, also in the free time.

A second limitation relates to the samples of the studies. Most nurses worked in Germany, and a few worked in Austria and Japan (Addendum 2). But healthcare systems vary drastically between different countries (e.g., Aluttis et al., 2014; OECD, 2021), and local organization of care work may look very different. For example, some of the findings cannot directly be transferred to healthcare settings in the Global South (see e.g., Akrich, 1992; Ismail, 2022; Karusala, 2022) or even different healthcare settings in Europe, such as outpatient care (for outpatient care specifically, the Dutch company Buurtzorg has introduced a different nurse-centered model, see e.g., Laloux, 2014).

Third, some related and relevant topics have only been covered on the side, and they each may warrant an entire thesis on their own. This includes the complexities around the work-family backlash presented in Addendum 1 and the potential for pro-social work practices beyond shift work in Addendum 2. In addition, an analysis of the economic efficiency of nurse-centered shift planning, that includes factors such as retention rates, sick leaves, and outsourcing of costs to nurses (see introduction) would make such approaches more comparable for healthcare managers and their perspective on shift planning.

Finally, the focus on nurses is only one approach. Manager-centered shift planning has been studied before, but possible alternatives include a patient-centered approach, society-centered shift planning, or a combination of several perspectives.

Conclusion

I would like to close by returning once more to the paradoxical situation outlined in the introduction: That current healthcare systems do not appropriately account for the health and well-being of nurses. Grounded in previous work, the shift planning system presented in this thesis demonstrated that a future in which healthcare work is organized in a way that promotes nurses' well-being is possible, and that it can already work in practice today. But this change does not happen by itself. It requires efforts to prioritize criteria such as the health and well-being of nurses and further aspects such as their experience of fairness early on in the design of work organization systems. If the technological development is guided by such values and then optimizes further criteria such as efficiency, nursing may become more attractive again for young people and fewer experienced nurses may leave the profession early.

Some questions still remain unanswered. Shift planning is only one aspect of healthcare work and needs to be understood in context. It relates to the type of care work, institutional settings, group composition, and other factors. In addition, policy-making influences the options healthcare institutions have in supporting their nurses and has a promising leverage to improve their situation. Shift planning systems as presented here play a key role, but we need to complement them with collective efforts on other levels.

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Appendices

Appendix A: Variations of the Vignettes Used in Study 2

Vignette Variations		
Argument Norms	need	“because you have/your co-worker has an important appointment with the doctor.” “because you/your co-worker want(s) to go to a friend’s wedding.”
	equality	“because you have/your co-worker has gotten almost no wishes granted recently.”
	equity	“because you/your co-worker has had almost no weekends off recently.” “because you/your co-worker stand(s) in for sick co-workers all the time.” “because you/your co-worker had especially exhausting shifts recently.”
Locus of Decision	system	“the system decides in favor of ...”
	nurses	“the system asks you and your co-worker to find a solution. Together, you decide in favor of ...”
Winner	participant	“yourself”
	co-worker	“your co-worker”
Reason	need	“because your/your co-worker’s need seems to be higher at that time.”
	equality	“in order to assure that the free time is distributed equally among all employees.”
	equity	“as a recognition for your/your co-worker’s commitment.”

Appendix B: The Vignettes Used in Study 5

Scenario	Conflict Negotiation	Automatic
rescheduling	<p>It is early in March and an old friend has recently contacted you. He will be in your area in the second week of April. You want to meet him and he has already said that the Friday would be good for him. Thus, you have already requested that Friday as a day off.</p> <p>During a shift you hear from a colleague, that she has also requested the same day off. Her grandfather will turn 90 on that day and she would like to go to the family party. From experience you know that requests can not always be integrated into the schedule, for example if several colleagues request the same day off.</p> <p>You send a short message to your friend, asking if Wednesday or Thursday would also be good for him. On these days, nobody else has requested a day off yet. If it works, you can change your request. Otherwise you cannot say for certain, whether you will get the day off or not. The system normally handles such conflicts well and it will automatically try to include as many requests as possible.</p>	<p>It is early in March and an old friend has recently contacted you. He will be in your area in the second week of April. You want to meet him and he has already said that the Friday would be good for him. Thus, you have already requested that Friday as a day off.</p> <p>During a shift you learn that a colleague has also requested the same day off. Her grandfather will turn 90 on that day and she would like to go to the family party. From experience you know that requests can not always be integrated into the schedule, for example if several colleagues request the same day off.</p> <p>You send a short message to your friend and tell him that you cannot say for certain, whether you will get the day off or not. The system normally handles such conflicts well and it will automatically try to include as many requests as possible.</p>
resources	<p>You have made a doctor's appointment for early May. With this doctor it is difficult to get appointments. If you cancel an appointment, it often takes weeks to get a new one. You have requested this appointment as a free shift on the tablet.</p> <p>During a break a colleague tells you that he has requested the same shift off. He is a single father and has to fetch his child from the day care center earlier than usual on that day. You know that other colleagues are on vacation or have a professional training on that day, so that probably one of you two has to work.</p> <p>You try to find a solution together. Maybe a healthcare worker from a different group can help out? Maybe you can split the shift somehow so that he works the first half and you the second? If you find a solution, you can directly enter it in the system and it will be integrated in the plan. Otherwise the system tries to automatically find a good solution, even in such tense situations. However, not all requests can be granted in every case.</p>	<p>You have made a doctor's appointment for early May. With this doctor it is difficult to get appointments. If you cancel an appointment, it often takes weeks to get a new one. You have requested this appointment as a free shift on the tablet.</p> <p>During a break you learn that a colleague has requested the same shift off. He is a single father and has to fetch his child from the day care center earlier than usual on that day. You know that other colleagues are on vacation or have a professional training on that day, so that probably one of you two has to work.</p> <p>Even in such tense situations the system tries to automatically find a good solution. However, not all requests can be granted in every case.</p>
informal rule	<p>The shift plans for December will have to be made soon. Normally most colleagues either want Christmas or New Year's Day off and they enter their requests. Just like many other colleagues, you would like to have Christmas off this year. Based on experience, not all requests can always be granted.</p> <p>In your group you have come up with an informal rule: Whoever works on Christmas gets New Year's Eve off and vice versa. During a team meeting your group leader brings up the topic: Who works when? Together you try to find a solution, so that everyone has either Christmas or New Year's Day off. If you find such a solution, it will directly be integrated into the schedule. If that does not work, the system will try to automatically find a good solution, so that as many requests as possible can be granted.</p>	<p>The shift plans for December will have to be made soon. Normally most colleagues either want Christmas or New Year's Day off and they enter their requests. Just like many other colleagues, you would like to have Christmas off this year. Based on experience, not all requests can always be granted.</p> <p>As soon as everyone has entered their requests, the system will try to automatically find a good solution, so that as many requests as possible can be granted.</p>
unavoidable	<p>Your employer has planned a company outing. Healthcare workers from all groups want to participate and so do you. Of course the company needs to keep running. Unfortunately the date is also during the holiday season, so that some colleagues are not there. The staff situation is already tense.</p> <p>A colleague from your group tells you that she also wants to go. But it is unlikely that both of you can go. You discuss all the options, but it is difficult. The date cannot be changed and you cannot ask anyone from other groups, because they are also short on staff. The last company outing happened a few years ago and your colleague has not work in your company at the time. There does not seem to be a solution for both of you to go. In the end, you simply both submit a request on the tablet and let the system decide who should go.</p>	<p>Your employer has planned a company outing. Healthcare workers from all groups want to participate and so do you. Of course the company needs to keep running. Unfortunately the date is also during the holiday season, so that some colleagues are not there. The staff situation is already tense.</p> <p>You learn that a colleague from your group also wants to go. But it is unlikely that both of you can go. You submit your request on the tablet and let the system decide who should go.</p>