Algorithmic Fairness in Shift Scheduling – Assessing the Fairness Perceptions of Healthcare Workers

Completed Research Paper

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Abstract

Fairness in shift scheduling is essential for workers because it substantially affects their well-being and private lives. Since creating fair shift schedules is difficult due to numerous constraints, algorithmic support is increasingly used. However, the perceptional basis for fairness from the workers' perspective is still missing for optimizing algorithmic shift scheduling systems. Drawing from organizational justice theory (OJT), we conducted 19 semi-structured interviews with healthcare workers from three Swiss hospitals. The iterative thematic analysis refines established fairness dimensions and provides a comprehensive, context-specific, multi-level understanding of how healthcare workers perceive fairness in their organizational and operational framework. We extend the literature by providing application-specific norms and important determinants of fair shift scheduling procedures in healthcare facilities, which can be the basis for fair algorithmic scheduling systems and support healthcare facilities and software developers to evaluate and optimize their current shift scheduling approaches.

Keywords

Algorithmic fairness, fairness perceptions, healthcare workers, shift scheduling

Introduction

Shift work is an essential component of many sectors, which enables around-the-clock operations. Since this requires workers to work outside of ordinary hours, shift schedules, which operationalize shift work, significantly impact workers' job satisfaction and well-being (Dall'Ora et al., 2016). Creating high-quality shift schedules is complex because various legal and operational requirements must be considered. In the healthcare sector, the complexity of shift scheduling is amplified by strict regulations, fluctuations in demand for personnel, globally persistent personnel shortages, and high turnover rates due to low job satisfaction. At the same time, ensuring sufficient skilled personnel on duty is critical for maintaining quality of care and patient safety (Burke et al., 2004; Erhard et al., 2018; OECD, 2023).

Owing to the high complexity, algorithms have become more widely employed to manage healthcare shift scheduling. As fairness in shift scheduling is recognized as a critical factor influencing job satisfaction, the implementation of fairness within these algorithms is essential (Schlicker et al., 2021). Even though most shift scheduling algorithms incorporate employee preferences and basic fairness metrics to incorporate fairness in shift schedules, they often lack a comprehensive understanding of when and how healthcare workers perceive fairness (Erhard et al., 2018; Uhde et al., 2020). The IS literature has criticized fairness metrics that do not consider fairness perceptions, as the discrepancy between metrics and perceptions is rooted in fairness's complex and context-dependent nature (Dolata et al., 2022). The first attempts to understand the fairness perceptions of healthcare workers in shift scheduling have been made, but a holistic understanding is still lacking (Schlicker et al., 2021; Uhde et al., 2020). This study addresses this gap by

developing and examining the relevance of different aspects shaping healthcare workers' fairness perceptions in shift scheduling, guided by the research question: *How do healthcare workers perceive and assess different fairness aspects in the context of shift scheduling?*

We apply an exploratory qualitative methodology to answer the research question and to advance our understanding of healthcare workers' fairness perceptions in shift scheduling. This qualitative approach is suitable because the subject matter is highly complex, and relevant aspects have been largely unexplored. The data collection is conducted through semi-structured interviews with healthcare workers in Swiss hospitals. The data are then analyzed using an iterative thematic analysis to identify the aspects shaping fairness perceptions, drawing on the interview data and the organizational justice theory (OJT), which has been proven to capture fairness perceptions in organizational settings (Rupp et al., 2017). These aspects are subsequently illustrated in an accessible thematic map. We contribute to an extended understanding of fairness in healthcare shift scheduling, including norms or aspects of fair shift scheduling procedures, and provide the necessary groundwork to adjust the OJT to healthcare shift scheduling. For practice, software developers and healthcare facilities can use this refined understanding to evaluate and optimize their shift scheduling approaches.

Literature Review

Foundations of Healthcare Shift Scheduling

Healthcare shift scheduling problems typically consider hard and soft constraints. Hard constraints must always be satisfied. These include legal requirements, such as minimum rest periods, and operational requirements, such as personnel qualifications. Soft constraints are ideally satisfied but can be violated in the final shift schedule. These include shift preferences and fairness metrics. Additionally, many constraints are organization-specific and not applicable to other healthcare facilities (Erhard et al., 2018). The three approaches for solving scheduling problems in the healthcare sector are cyclical scheduling, self-scheduling, and preference scheduling. Cyclical scheduling establishes a fixed shift schedule, and the healthcare workers are continuously rotated through this schedule. Even though this fixed shift rotation ensures equality among healthcare workers and compliance with hard constraints, it is rarely applied in practice due to its limited flexibility in meeting dynamic demand in healthcare facilities and the preferences of healthcare workers (Burke et al., 2004). In contrast, self-scheduling systems transfer the responsibility of creating shift schedules from supervisors to employees, which enables a high degree of employee participation. Self-scheduling in healthcare facilities has gained attention recently due to improved job satisfaction and work-life balance. However, it increases the complexity for employees, which can lead to violations of hard constraints. Application software can support self-scheduling (Wynendaele et al., 2023).

The most common approach is preference scheduling. This approach considers individual preferences when creating flexible schedules while complying with various constraints. Since manually generating preference shift schedules is challenging and time-consuming due to the numerous requirements, algorithms increasingly support the generation of these schedules to manage the complexity (Schlicker et al., 2021). A common aim of these algorithms is to balance employee preferences based on fairness, but they lack a foundation in healthcare workers' fairness perceptions (Erhard et al., 2018). In addition to preferences, shift scheduling algorithms often integrate fairness metrics as soft constraints. These metrics include the equal distribution of unpopular shifts or free weekends (Erhard et al., 2018). However, two aspects need to be considered. Firstly, the definition of fairness metrics varies significantly in the literature. The developers of the algorithms design these fairness metrics and usually target equality among healthcare workers (Uhde et al., 2020). Secondly, few shift scheduling algorithms and integrated fairness metrics from the literature have been tested in practice to assess their impacts on fairness perceptions. This is partly due to the high cost of adapting new algorithms for healthcare facilities. However, the developers' notions about fairness can substantially deviate from the healthcare workers' fairness perceptions (Erhard et al., 2018).

Algorithmic Fairness

There is no universally accepted definition of algorithmic fairness, but definitions often highlight the absence of systematic bias toward particular individuals or groups based on their characteristics in algorithmic decision-making. Algorithmic fairness is typically approached from either a technical or social perspective. The technical perspective focuses on developing metrics to guarantee fairness by

mathematically quantifying bias, which requires a thorough a priori understanding of where and why discrimination occurs. This can be challenging, given the complexity of real-world situations. The social perspective emphasizes embedding algorithmic fairness in a social or organizational context (e.g. examining fairness perceptions) but largely treats technological solutions as a black box (Caton & Haas, 2024; Dolata et al., 2022). Therefore, Dolata et al. (2022) emphasize the interdependencies between the technical and social perspectives and strongly advise the integration of both perspectives to achieve a holistic sociotechnical view. Otherwise, solutions to algorithmic unfairness may be ineffective if they fail to consider both perspectives. However, before such an integration can occur, it is important to develop a comprehensive understanding of both perspectives.

Since we aim to complement the dominant technical perspective on algorithmic fairness in healthcare shift scheduling with a social perspective, we engage with OJT as a well-established approach in IS research for examining fairness perceptions (Dolata et al., 2022). OJT captures the fairness perceptions of employees in organizational decision-making based on four dimensions: distributive, procedural, interpersonal, and informational fairness (Rupp et al., 2017). Since individuals maintain similar fairness requirements for human and algorithmic decision-making, the OJT is often employed to study algorithmic fairness perceptions in technology-driven organizational change (Ochmann et al., 2024). The limited literature addressing fairness perceptions in healthcare shift scheduling is typically based on the OJT (e.g. Schlicker et al., 2021). To our knowledge, only Uhde et al. (2020) have pursued a thorough understanding of fairness perceptions in this area based on all fairness dimensions. However, their research has limitations, such as the small number of interviews and the limited coverage of interpersonal and informational fairness.

Distributive Fairness. Distributive fairness captures individual fairness perceptions regarding the allocation of decision-making outcomes (Rupp et al., 2017). The standard allocation norms are equity, equality, and need. Firstly, *equity* assumes that employees compare their ratio between the allocated outcomes (e.g. salary or shift schedules) and inputs (e.g. quality of work) to the ratio of their peers to form their fairness perceptions. This norm promotes economic productivity because employees who contribute higher inputs are rewarded with higher outcomes (Deutsch, 1985). Secondly, *equality* demands that the outcomes are distributed uniformly among employees independent of individual inputs. This norm fosters social relations by emphasizing the equal consideration of each employee (Deutsch, 1985). Thirdly, *need* requires that the outcomes are allocated according to the need for specific outcomes, independent of inputs. This norm facilitates well-being because it grants outcomes to individuals to achieve this objective. However, the objective definition and prioritization of needs is often difficult (Deutsch, 1985). In the context of healthcare shift scheduling, previous research either remained inconclusive (Schlicker et al., 2021) or preferred the equality norm, with the need norm as a fallback in case of conflict (Uhde et al., 2020).

Procedural Fairness. Procedural fairness captures the fairness perceptions of affected individuals related to the internal decision-making processes (Rupp et al., 2017). Thibaut and Walker (1975) formulated the concepts of process control, which allows employees to voice concerns and opinions, and decision control, which allows employees to influence decision-making outcomes directly. Further, Leventhal (1980) defined six procedural rules to ensure a fair process: accuracy, bias suppression, consistency, correctability, ethicality, and representativeness. In healthcare shift scheduling, employee involvement is critical because (non-)involvement leads to perceived procedural (un)fairness (Uhde et al., 2020). Specifically, self-scheduling is perceived as fair, although drawbacks include the difficulty of resolving over- and understaffing and the manipulation by co-workers (Wynendaele et al., 2023). Algorithmic shift scheduling is perceived as more objective and less prone to bias in the scheduling process, whereas human shift scheduling is perceived as offering more opportunities to voice individual views (Schlicker et al., 2021).

Interpersonal fairness. Interpersonal fairness targets the politeness, respect, and dignity employees receive during their interactions with supervisors. This can be as involved as giving all employees polite and personal attention by listening to concerns or demonstrating empathy (Greenberg, 1993). In healthcare shift scheduling, Uhde et al. (2020) found that respectful treatment is essential to interpersonal fairness perceptions and healthcare worker well-being.

Informational fairness. Informational fairness emphasizes the importance of providing truthful and thorough explanations to affected individuals regarding the applied procedures and outcome allocations. Such explanations can mitigate the adverse effects of negative outcomes (Greenberg, 1993). For healthcare shift scheduling, informational fairness perceptions are affected by a trade-off between transparency and

privacy. Transparency is essential for understanding the reasoning behind shift schedules, whereas workers may have requests based on sensitive matters that require confidentiality (Uhde et al., 2020).

Methodology

Data Collection

The qualitative approach followed the interpretivist paradigm, which emphasizes creating a new, richer understanding of the studied domain through the interpretation of subjective meanings, such as lived experiences, individual beliefs, and recollections of events (Saunders et al., 2023). This paradigm fits the research objective since we explored the perceived fairness of healthcare workers to develop the relevant aspects shaping fairness perceptions in shift scheduling.

The OJT offers themes in the form of well-established fairness dimensions to investigate employees' fairness perceptions in organizational settings, such as healthcare facilities. Uhde et al. (2020) partly adopted these fairness dimensions in their questionnaire to examine the ideal state of healthcare shift scheduling with a focus on shift swapping and special contract conditions. We substantially modified their questionnaire to thoroughly cover the current and ideal state of healthcare shift scheduling and to move the focus away from shift swapping and special contract conditions to a comprehensive coverage of all fairness dimensions, which was reflected in the deeper coverage of interpersonal and informational fairness. The inclusion of questions about the current and ideal state helped participants to more accurately reflect on the perceived potential and their expectations regarding fairness in shift scheduling. During the data collection phase, the questionnaire was continuously reviewed and refined to mitigate concerns of potential interviewer bias and to improve the precision of the questions (Saunders et al., 2023).

Three healthcare facilities in Switzerland supported the data collection, which enhanced the transferability and avoided convergent sense-making within a healthcare facility (Eisenhardt, 1989). In selecting the specific participants, we used the purposive sampling technique to gather heterogeneous cases holding rich information regarding the research question. In contrast to the small, homogenous sample of Uhde et al. (2020), our larger, heterogeneous sample allowed for a broader identification of themes (Saunders et al., 2023). We conducted 19 semi-structured interviews in German with healthcare workers (17 female, 2 male) in various nursing roles during June and August of 2024. On average, participants were 38.4 years old, with ages ranging from 25 to 62, and had 18.4 years of work experience, ranging from 4 to 43 years.

Data Analysis

We followed common guidelines for thematic analysis to identify, analyze, and report themes across the interview data (Braun & Clarke, 2006; King & Brooks, 2017). The initial themes were informed by a priori themes called *justice rules*, which incorporated all fairness dimensions of the OJT (Colquitt & Rodell, 2015). Subsequently, we iteratively connected and re-categorized emerging themes and codes to first-, second-, and third-order themes, which were illustrated in a thematic map. Along with multiple internal reviews of the themes and codes, we also engaged with the literature to base emerging themes on existing concepts, which increased the comparability with the existing literature and increased our awareness of other theme features. The thematic map served as an indicator of whether the developed themes captured the healthcare workers' fairness perceptions. If this was not the case, an additional iteration of the data analysis process was necessary (Braun & Clarke, 2006). After 13 interviews, we developed the first consolidated thematic map. Since the adjustments to the thematic map for the remaining six interviews were minor, we concluded that data saturation was achieved with the number of conducted interviews (Eisenhardt, 1989).

Results and Discussion

The iterative thematic analysis identified themes that described the fairness perception of healthcare workers. Guided by the thematic map (Figure 1), the following sections report and discuss these themes.

Legal and Operational Requirements

The legal and operational requirements affected the fairness perceptions of the participants because they limited the opportunities to implement a shift schedule they perceived as fair. Legal requirements reduced

the flexibility to adapt shift schedules to the healthcare workers' preferences because of mandatory rest periods between shifts or the number of allowed shift type rotations that had to be satisfied: "*The labor law, […], I do not find it fair. […] It could have been scheduled differently, but you are not allowed to do so. For example, due to the rest periods*" (I10). Similarly, personnel shortages and staff turnovers were recognized as a source of perceived unfairness since a shift schedule satisfying operational requirements could consider fewer preferences in this case. The addition of this theme marked the most notable enhancement compared to the OJT. On the one hand, in times of personnel shortages in the entire healthcare sector (OECD, 2023), it is not surprising that the resulting inflexibility to adjust shift schedules is recognized by healthcare workers. On the other hand, legal requirements for shift schedules are mainly perceived as unfair. We argue that legal requirements may proactively avert situations that are perceived as unfair, such as ignoring contractual agreements. Still, employees may only notice instances where legal requirements impede their fairness perceptions and subconsciously ignore others where these requirements prevent unfair situations.
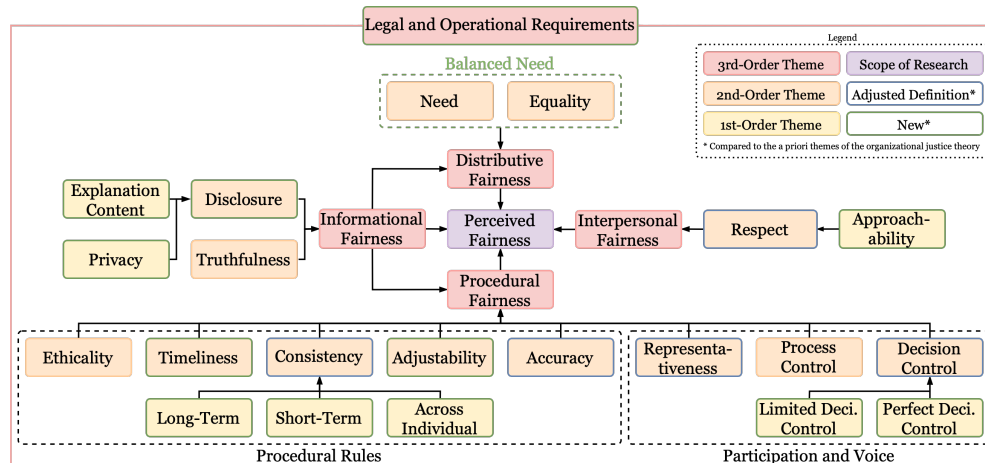

Figure 1. Thematic Map

Distributive Fairness

The evaluation of distributive fairness in shift scheduling concentrated on the allocation norm, which determined how shifts were assigned to healthcare workers. The implementation of equality in shift schedules was only perceived as fair by a few participants: "*I believe a shift schedule would be fair if everyone did the same [amount of each] shift types, everyone does the same number of weekends*" (I06). Instead, the overwhelming majority of participants referred to the importance of incorporating needs into a shift schedule. This contrasts with Uhde et al. (2020), who suggested that equality should be the standard norm in shift schedules, whereas need could support conflict resolution. Furthermore, this finding contrasts with the shift scheduling literature focusing on equality. These discrepancies reflect the lack of reasoning based on healthcare workers' fairness perceptions in shift scheduling algorithms (Erhard et al., 2018). However, each participant highlighted the requirement to balance the needs granted among the healthcare workers, which was not considered in the original need norm. A common imbalance was family backlash (Uhde et al., 2020), where healthcare workers with family obligations had a higher chance of having their needs considered compared to their co-workers: "*A team cannot accommodate ten moms who all have their own needs, and the co-workers have to adapt*" (I14). Since neither the equality nor the need norm was appropriate for describing a fair shift allocation, we introduced a combination of both norms called balanced need. This norm emphasized considering needs but balancing the granted needs among employees, implying elements of equality without calling for strict equality within a ward. Conversely, healthcare workers should be willing to accept that some needs were not granted to fulfill the needs of co-workers: "*A certain amount of flexibility can also be expected from us, so it is acceptable for everyone*" (I05). In line with Deutsch (1985), compiling an exhaustive list of justified needs was impossible due to the sheer number of possible needs. Examples of needs included health conditions, biorhythms of workers, childcare, and private matters: "*Someone with children at home cannot work on some days because they do not have a babysitter. Or elderly parents who need care at a specific time. Or any unexpected deaths in which someone suddenly needs to have time off, even though they are on duty. There are so many different things*" (I12). Nevertheless, it may be easy for individual healthcare workers to list and prioritize

their fundamental needs. Thus, we propose the distinction between needs and preferences (Deutsch, 1985). Preferences do not require fulfillment since they improve but are not ultimately required for well-being (e.g. preference for day shifts). This notion is usually implemented in current shift scheduling algorithms (Erhard et al., 2018). In contrast, needs may be non-negotiable from a healthcare worker's perspective because they are essential for their well-being (e.g. health conditions prevent night shifts).

Procedural Fairness

The themes for procedural fairness were organized into two categories. The first category, participation and voice, represented opportunities for healthcare workers to affect the schedule or the scheduling process. The second category, procedural rules, emphasized the rules that ensure a fair shift scheduling process.

Participation and Voice

We determined three levels of control, each characterized by increasing control over the final schedule. The lowest level, process control, referred to the possibility of voicing requests and preferences. This type of control only consisted of indirect control over the final schedule because the realization of the requests in the final schedule was not guaranteed. The participants generally perceived process control as fair: "*It is fair if they [the employees] can make requests and if they are taken into account to the greatest extent possible*" (I07). Due to the non-binding nature, the participants did not express reservations about process control. Instead, they typically had the desire to increase process control: "*I think you should be allowed to place more requests*" (I02). The medium level, limited decision control, allowed the healthcare workers to affect parts of their schedule directly. One type of limited decision control was assigning fixed working days or getting fixed shifts off. Another type was contractually agreed flexibility for the healthcare workers. Multiple participants could specify their exclusive availabilities from which the employer could choose. Thus, these participants were not scheduled for a shift they were unwilling to do: "*It [the scheduling approach] is flexible because I can provide several shifts. And they [the supervisors] can schedule me based on them. I believe it is a very fair approach*" (I08). The highest level, perfect decision control, implied that the healthcare workers could directly affect their entire shift schedule, which is essentially self-scheduling. Even though no participant experienced self-scheduling at their workplace, multiple participants perceived it as the optimal solution: "*The only option that could be considered [to increase fairness] is to allow the team to schedule the shifts themselves*" (I03). This desire of healthcare workers to participate in the scheduling process confirms the findings in healthcare shift scheduling (e.g. Uhde et al., 2020) and the literature on the OJT (Thibaut & Walker, 1975). However, in contrast to process control, the fairness perceptions regarding both levels of decision control were divided because creating a fair shift schedule respecting hard constraints could be challenging, especially in larger teams: "*This [self-scheduling] is quite an effort. The bigger the team, the more difficult it is likely to be. And rules are required to ensure that people do not only care about themselves, and others have to compensate or pick up the slack*" (I04). These worries mirror previous findings for self-scheduling (Wynendaele et al., 2023).

Furthermore, representativeness evaluated the extent to which procedures considered the team's or individuals' concerns and values. This included the opportunity to regularly discuss and influence the rules of the procedures: "*The rules have to be discussed again and again and adapted again and again to suit the current situation*" (I08). An appropriate setting to discuss concerns about the procedures was within team meetings: "*Everyone can get involved [in the team meeting] if they think something is not okay or want to share their concerns. If they do not bring it up within this setting, it is entirely on them*" (I03). The main concern with this setting was the complexity of reaching a consensus within a (large) team and not with team members reluctant to share their opinions and concerns.

Procedural Rules

Similar to Leventhal (1980), five procedural rules—accuracy, adjustability, consistency, timeliness, and ethicality—complemented participation opportunities to ensure a fair scheduling process. Incomplete information could lead to perceived unfair scheduling decisions. For instance, if a request was not known to the supervisor: "*They let someone else use compensatory time who had worked more overtime. It was unfair for this person because they had been looking for a long time [for someone to swap the shift] and then had to work. […] They [the supervisors] just did not know*" (I12). Thus, accuracy described whether the necessary information was available and used accurately during the scheduling process. Further, some

participants even desired to establish an employee profile for upcoming scheduling periods: "*I believe that we should gather more [information] about how you like to work. Do you like early shifts? Not really. I would rather work late shifts. Or do you like night shifts?*" (I06).

The adjustability of schedules offered the opportunity for healthcare workers to swap shifts that conflicted with their preferences or private lives after the final shift schedule was published. Even though shift swapping was an informal process, it was generally perceived as fair because healthcare workers directly bargained with their co-workers and were not forced to swap shifts: "*There are just some artists [co-workers] who swap everything they do not like and somehow always manage to make it work. But in that sense, it is also fair because they [the other co-workers] do it voluntarily*" (I10). Two issues reduced the chances of swapping shifts and, subsequently, the adjustability of the shift schedules: Firstly, finding someone willing to swap shifts was tedious, especially for unpopular shifts. Secondly, if someone was willing to swap shifts, the resulting shift schedule still had to meet legal and operational requirements ("*We had times where we were understaffed, then it [shift swapping] was challenging [...] for the skill and grade mix to still align*" [I14]). We replaced the theme correctability of the OJT with this theme because shift swapping included the opportunity to adjust an error-free shift schedule (i.e. adhering to hard constraints).

Fairness perceptions suffered if some co-workers seemed to have an advantage in having their requests granted: "*If I grant a specific request to one person, I have to grant it to the others too, so it is fair*" (I16). We therefore defined consistency as the extent to which procedures were consistent and free of bias across individuals and time. This second-order theme was merged with the theme bias-suppression from the OJT since a bias would also imply an inconsistency. For consistency across time, we distinguished between short-term (e.g. months) and long-term consistency (e.g. years). Short-term consistency was perceived as fair because ever-changing schedules were disliked: "*I did not think that was fair. I was a bit upset that I was given any kind of plan. Some plans were great, and some were not, [...] because they adjust your plan:' Ah, she worked too much last month, so this month she works less'*" (I06). In contrast, long-term consistency was not always perceived as fair because changed concerns and values were not considered. For example, the representativeness decreased if new employees joined the ward: "*The employees who join have no idea about the agreement. I find that very difficult*" (I11).

The context-specific theme timeliness indicated whether the time between the publication of the schedule and the moment the schedule took effect was sufficient. A timely schedule publication was important for healthcare workers to arrange their private matters according to the schedule and to eventually swap shifts with co-workers if necessary: "*If I know when I am going to work long term, [...] I can plan my leisure time. What comes afterward [I cannot control]. For example, if I have a wedding on some weekend, I cannot be sure if I can attend this wedding*" (I07).

Finally, ethicality required procedures to adhere to ethical and moral standards. This theme from the OJT was not directly reflected in the data. In line with Schlicker et al. (2021), we emphasize the importance of consistency across individuals. Therefore, we argue that substantial violations of consistency across individuals would be incompatible with ethical standards (Leventhal, 1980). Previous research has also shown the positive effect of ethical behavior by supervisors on the fairness perceptions of employees (Al Halbusi et al., 2021). Thus, the scheduling process should undoubtedly consider ethical standards.

Informational Fairness

The disclosure of perceived relevant information about schedules and procedures to healthcare workers mainly represented informational fairness (Schnackenberg et al., 2021). Adequate detail was required in the content of explanations without giving an overwhelming amount of information: "*I do not need to know for every plan how they did it exactly, how they came up with it. I believe it is just too much information at some point*" (I06). Thus, this theme replaced the theme justification of the OJT, which would have required the content of explanations to be thorough, independent of the perceived relevant information. Two types of explanation content were extracted. Firstly, the participants generally wanted to know the basic rules and requirements applied in the scheduling process: "*Which regulations do I have to consider? Which employees do I have at my disposal? Under what conditions? [...] What requirements do I have?*" (I07). Secondly, reasons for specific decisions, including exceptions to the rules, were perceived as relevant: "*In an emergency ward, you have more late shifts compared to early shifts. You have to explain why you have an employee who only works early shifts. I believe you have to disclose why that is*" (I11). In exceptional cases, some interviewees desired that the supervisor proactively initiated the explanation to the

affected employees: "*I would have wished that someone had approached me and said:' Look, there was no other way because of whatever reason'*" (I06). Regardless of the type of explanation content, the supervisor giving the explanation should protect the privacy of employees, including information about health conditions or private matters. Thus, they should first consult affected employees, allowing them to decide whether to disclose the information: "*The supervisor should talk to the employee beforehand, and the two should work together to find a solution on what they want to communicate to the team*" (I14). This result confirmed the importance of privacy in previous literature (Uhde et al., 2020). Besides the disclosure of information, truthfulness described whether the explanations by supervisors were perceived as honest. Truthfulness was violated if an explanation was incomprehensible or perceived as deceiving. In case of violation, explanations felt dishonest for the participants: "*It has often been said that it [the request] simply cannot be implemented. [...] I think that is not the right attitude, and it is not true either*" (I08). Notably, informational fairness positively affected procedural and distributive fairness by enhancing the understanding of the procedures and the final shift schedule because explanations could clarify situations that would have been perceived as unfair otherwise: "*I think transparency is essential because you know why they [co-worker] only work on Monday or Tuesday and what the reasons are*" (I03). This observation aligned with prior literature on informational fairness (Greenberg, 1993) and algorithmic fairness, which emphasizes the importance of transparency (Caton & Haas, 2024; Ochmann et al., 2024).

Interpersonal Fairness

Interpersonal fairness comprised the respectful treatment of healthcare workers. The interviewees felt respected by supervisors if they were taken seriously and treated with mutual respect. In contrast, less considerate behavior from the supervisors reduced the perception of interpersonal fairness among the healthcare workers. For instance, participant I08 noted unfair treatment during an earlier employment: "*There were unfair situations. [...] The interpersonal treatment was rougher, hierarchic, and less open-minded.*" Note that we merged the second-order themes respect and propriety from the OJT because refraining from improper remarks was also polite, rendering it impossible to distinguish between them. A narrower concept was approachability, which concentrated on specific interactions between supervisors and employees. Approachability was defined as the ease with which employees were able to talk to supervisors about their concerns (Porter et al., 2007). Even though respectful behavior provided the foundation, approachability also required an inviting climate in which to share concerns directly with the supervisor. Thus, approachability was a sub-theme of respect, but each participant emphasized it: "*The supervisors are very approachable. I can always go to them if something is bothering me, or I cannot handle it. [...] And they try to respect it the best they can*" (I14).

Theoretical and Practical Implications

We contribute to the literature on OJT, algorithmic fairness, and healthcare shift scheduling. Firstly, we apply OJT to healthcare shift scheduling, which results in a tailored understanding of fairness perceptions in this context (Colquitt & Rodell, 2015). We focus on all fairness dimensions equally to explore the fairness perceptions of healthcare workers, which enables us to integrate the multidimensionality of fairness and reveal relations between dimensions (Ochmann et al., 2024). Thus, we contribute the foundation for future research to adapt the OJT in the context of healthcare shift scheduling.

Secondly, we address the lack of a holistic understanding of healthcare workers' fairness perceptions in the previous healthcare shift scheduling literature, which predominantly focused on the technical perspective of algorithmic fairness. By grounding our results in the experiences and perceptions of healthcare workers, we provide a comprehensive social perspective that complements the technical perspective and enables the future development of a well-reasoned sociotechnical perspective on algorithmic fairness in healthcare shift scheduling, for example, by inspiring the design of fairness metrics (Dolata et al., 2022).

Thirdly, the thematic map provides a visual overview with insights into the fairness dimensions in the context of healthcare shift scheduling, which allows future research to explore specific aspects and deepen our understanding. Hereafter, we outline future research opportunities for distributive and procedural fairness. For distributive fairness, we have developed the norm *balanced need*. Healthcare workers primarily require a fair shift schedule to balance various needs and preferences among co-workers, requiring a combination of the equality and need norm from the OJT. Building on the existing technical literature and our contribution from a social perspective, future research can develop shift scheduling

algorithms that incorporate well-reasoned approaches for the allocation norm. For this, we propose a two-stage approach that should advance the implementation of balanced needs. In the first stage, we suggest refining the definitions for needs and preferences in healthcare shift scheduling since no formal definition of (balanced) needs exists due to its ambiguity (Deutsch, 1985). In the second stage, based on these distinct definitions for needs and preferences, it is essential to investigate how they can be implemented into shift schedules. For procedural fairness, we have shown that participation opportunities are complemented by procedural rules that ensure fair procedures, such as accuracy and ethicality. For instance, the accuracy-ethicality trade-off may be important in shift scheduling algorithms incorporating artificial intelligence because the data collection for training and running the underlying models could imply violations of the ethicality of procedures if employee data are used without consent (Leventhal, 1980). Although our findings have indicated that healthcare workers support the use of sensitive data in principle, future research should address trade-offs between accuracy and privacy for sensitive data in more detail (Caton & Haas, 2024).

Our findings provide practical implications for software developers and healthcare facilities. They can use the thematic map as a visual guideline, which can support identifying the sources of perceived unfairness from a healthcare worker's perspective in existing systems or serve as a checklist when developing a new shift scheduling system or algorithm. For procedural fairness, we have highlighted employee participation and the opportunity to voice requests and opinions. For example, representativeness enables the discussion of overarching topics with the team and incorporates values and concerns into the scheduling process. Representativeness as a continuous practice accommodates the dynamic nature of fairness perceptions (Dolata et al., 2022) and promptly captures changes in perceptions and integrates them into procedures. Note that flexible procedures and algorithms are required to incorporate agreed-upon values and solutions. For interpersonal fairness, the findings have underscored the importance of respectful treatment of healthcare workers and the approachability of supervisors. Thus, healthcare facilities should institutionalize these behavioral traits within their organization by prioritizing training in these traits and targeting efforts to facilitate this work climate. Even though implementing these traits is relatively straightforward for a human decision-maker, it is not obvious with the use of an algorithmic decision-maker and requires further research. For informational fairness, adequate explanations enable an understanding of the applied procedures and the final schedules. Furthermore, explanations positively influence procedural and distributive fairness perceptions without changing the scheduling process or allocation of shifts. Consequently, supervisors should proactively explain exceptional cases to affected individuals and host frequent team meetings to revisit the basic rules and requirements.

Limitations and Conclusion

Our study is not without limitations. Firstly, concerning the methodology, data were only acquired through interviews. However, data from multiple sources could provide stronger substantiation of the findings (Eisenhardt, 1989). Secondly, the sample primarily consists of healthcare workers connected to nursing. However, fairness perceptions could differ for different groups of healthcare workers (e.g. physicians) or healthcare facilities with different sizes or legal structures due to the context-dependency of fairness perceptions (Dolata et al., 2022). Thirdly, examining fairness from the perspective of different stakeholders remains necessary because both the recipient (e.g. healthcare worker) and the allocator (e.g. management) have requirements that must be considered (Caton & Haas, 2024; Rupp et al., 2017). We therefore call for future research to provide further confirmatory research with data from different sources and to address different stakeholder perspectives and their integration into healthcare shift scheduling.

In summary, we developed an understanding of how healthcare workers form their fairness perceptions regarding shift scheduling. Significant findings include a new allocation norm for shifts, a set of procedural rules complementing participation opportunities, the cross-effect of explanations on distributive and procedural fairness, and the accessible illustration of all aspects in a thematic map. By presenting a social perspective that complements the technical perspective on shift scheduling, we contribute to future research that pursues an integration of both into a sociotechnical perspective. Furthermore, we offer recommendations for healthcare facilities and software developers to assist in implementing fairer shift scheduling practices. This paper helps to address current challenges in the healthcare sector, such as low job satisfaction and high turnover rates. Although our findings are primarily applicable to the healthcare sector due to its unique characteristics, the aspects shaping fairness perceptions may inspire new approaches and research on shift scheduling in other sectors (Dall'Ora et al., 2016).

Acknowledgements

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