Beleidsnotitie

Inzichten en conclusies uit de Academische Werkplaats 'Geef bevlogenheid vleugels: de basis van gewoon goede zorg'.

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Het Nederlandse zorgstelsel staat voor aanzienlijke uitdagingen. De dubbele vergrijzing leidt tot een toenemende vraag naar gezondheidszorg, terwijl het aantal zorgverleners schaars is. Dit resulteert in een groeiende druk op de zorgsector. Deze uitdagingen hebben aanzienlijke gevolgen voor het welzijn van zorgprofessionals, met hoge percentages ziekteverzuim en een groot verloop in ziekenhuizen als gevolg[1,2]. Het vergroten van de veerkracht en vitaliteit van zorgprofessionals is essentieel voor het bieden van hoogwaardige en veilige zorg, en het legt de basis voor een cultuur van voortdurende verbetering in een lerende cultuur[3,4]. In de afgelopen jaren zijn er tal van initiatieven en programma's ontwikkeld om het welzijn van zorgprofessionals te verbeteren, waarbij de nadruk vooral ligt op het optimaliseren van de vitaliteit van individuele zorgverleners. Er is veel minder aandacht besteed aan interventies op team- en organisatieniveau, en het perspectief van de zorgprofessionals zelf blijft vaak onderbelicht. Het doel van de Academische Werkplaats 'Geef Bevlogenheid Vleugels: De basis van gewoon goede zorg' was om inzicht te verkrijgen in de contextfactoren in de werkomgeving die van invloed zijn op het welzijn en de vitaliteit van zorgpersoneel. Hiermee wilden we aanknopingspunten identificeren voor verder onderzoek en beleid om de bevlogenheid van zorgprofessionals te behouden en uitval te verminderen.

Binnen de bovengenoemde Academische Werkplaats is het afgelopen jaar gewerkt aan verschillende onderzoeksprojecten:

- Project 1a - De kwaliteit van zorg, de werkcontext en het welzijn van zorgprofessionals: inzichten uit data (kwantitatief)
- Project 1b - De complexiteit- en kwaliteit van zorg, de werkcontext en het welzijn van zorgprofessionals: inzichten uit de praktijk (kwalitatief)
- Project 2 - De impact van medische technologie op de werkbelasting en het welzijn van zorgprofessionals: inzichten uit de literatuur (scoping review)

Samenvatting Academische Werkplaats Geef bevlogenheid vleugels: de basis van gewoon goede zorg

Project 1a:
- Het integreren van verschillende datasets in een UMC is complex en tijdrovend, met problemen in toegankelijkheid en datakwaliteit.
- Kwaliteit van zorg, medewerkerstevredenheid en patiënttevredenheid zijn complexe concepten met onduidelijke parameters.
- Het was moeilijk om causale verbanden te vinden tussen afdelingskenmerken en het welzijn van zorgprofessionals.

Project 1b:
- Zorgprofessionals ervaren complexiteit en kwaliteit van zorg op verschillende manieren, met evenwicht als cruciaal voor welzijn.
- Stressfactoren op het werk kunnen leiden tot ontevredenheid en verminderde inzetbaarheid.
- Positieve factoren op de werkplek, zoals coping-mechanismen en samenwerking, bevorderen het welzijn.

Project 2:
- Onderzoek naar medische technologieën richt zich vooral op effectiviteit en efficiëntie, met weinig aandacht voor welzijn van zorgprofessionals.
- Het gebruik van medische technologie kan zowel positieve als negatieve effecten hebben op workflow en welzijn.
- Gebrek aan standaardisatie in meeteenheden en uitkomstmaten bemoeilijkt vergelijkingen tussen studies.

Conclusies en adviezen:

De onderzoeksprojecten uitgevoerd binnen de Academische Werkplaats 'Geef bevlogenheid vleugels: de basis van gewoon goede zorg' bieden waardevolle inzichten en adviezen voor het welzijn van zorgprofessionals in Nederland:

1. **Maatwerk is noodzakelijk**: Het welzijn en de vitaliteit van zorgprofessionals worden beïnvloed door diverse factoren op verschillende niveaus (individueel, team, organisatie en maatschappelijk). Het is essentieel om maatwerk te bieden en verstoringen in de balans te signaleren en aan te pakken.
2. **Investeer in geavanceerde technologieën**: Gezien de complexiteit van het verkrijgen en integreren van diverse datasets is investeren in geavanceerde technologieën en systemen voor effectieve data-integratie noodzakelijk. Diepere datakoppeling maakt een betere interpretatie van resultaten mogelijk.
3. **Uniforme aanpak voor data**: Het ontwikkelen van een uniforme aanpak voor het verzamelen en analyseren van gegevens over medewerkerstevredenheid, patiënttevredenheid en kwaliteit van zorg is van belang om concrete afdelingskenmerken en causale verbanden te identificeren.
4. **Betrek zorgprofessionals**: Het perspectief en de ervaringen van zorgprofessionals zijn cruciaal. Regelmatige feedbacksessies met zorgverleners op alle niveaus zijn waardevol om uitdagingen, behoeften en suggesties voor verbeteringen in kaart te brengen.
5. **Richt interventies op team- en organisatieniveau**: Afdelingskenmerken en de balans tussen zorgcomplexiteit en kwaliteit van zorg hebben invloed op het welzijn van zorgprofessionals. Interventies moeten zich richten op team- en organisatieniveau, met speciale aandacht voor de impact van personeelswisselingen.
6. **Balans tussen technologie en welzijn**: Het is essentieel om een gezonde balans te creëren tussen technologische efficiëntie en het welzijn van zorgprofessionals. Bij de ontwikkeling van richtlijnen voor medische technologieën moet rekening worden gehouden met de ervaring en het welzijn van zorgprofessionals.

Het samenvoegen van deze inzichten en het nemen van gerichte acties op basis van deze adviezen kan bijdragen aan een verbeterd welzijn en een hogere bevlogenheid van zorgprofessionals in de Nederlandse zorgsector.

Project 1a

In dit project lag de focus op het koppelen en exploreren van cross-sectionele real-world data in een universitair medisch centrum (UMC) voor het identificeren van afdelingskenmerken geassocieerd met de mate van verzuim en bevlogenheid van zorgprofessionals. De volgende inzichten zijn hieruit naar voren gekomen:

Het verkrijgen en integreren van verschillende soorten datasets (waaronder gegevens over medewerkerstevredenheid, patiënttevredenheid, zorgkwaliteit, human resources en zorgprocessen) is een complex en tijdrovend proces. Barrières doen zich met name voor op het gebied van toegankelijkheid, data-architectuur en gegevenskwaliteit. Datasets hebben doorgaans verschillende structuren en bronhiërarchieën, wat het koppelen op een gelijkwaardig (gedetailleerd) niveau bemoeilijkt. In dit project heeft dit geleid tot de aggregatie van gegevens op hogere niveaus, wat leidt tot het verlies van informatie en het bemoeilijken van de interpretatie van de resultaten. Op het moment van onderzoeksniveau (op het niveau van specialistische afdelingen) is het lastig om specifieke afdelingskenmerken te identificeren die geassocieerd zijn met het welzijn en de bevlogenheid van zorgprofessionals.

Kwaliteit van zorg, medewerkersbeleving en patiënttevredenheid zijn complexe concepten die niet in enkele dataparameters te vatten zijn. Het is vaak onduidelijk hoe bepaalde parameters precies bijdragen aan de definitie van het concept, wat heeft geleid tot een uitgebreide selectie van gegevens. Parameters worden op verschillende manieren gemeten en zijn onderhevig aan verschillende invloedsfactoren. Met name bij vragenlijsten zoals het MBO en de PEM is het niet altijd duidelijk welk specifiek aspect van een concept wordt gemeten. Daarnaast bestaan er onzekerheden over de validiteit van de meetinstrumenten, wat de interpretatie van de resultaten bemoeilijkt.

Met de huidige onderzoeksopzet en database was het niet mogelijk om causale verbanden tussen afdelingskenmerken en het welzijn van zorgprofessionals vast te stellen. Het vergelijken van groepen zorgprofessionals op basis van verzuimpercentages en de mate van bevlogenheid op afdelingsniveau laat zien dat er aanzienlijke verschillen tussen deze groepen bestaan. Vooral op het gebied van afdelingsgrootte en personeelsbehoud zijn interessante associaties naar voren gekomen. Gegevens uit het MBO en de PEM lijken slechts in beperkte mate geassocieerd te zijn met zowel het verzuim als de mate van bevlogenheid.

Project 1b

In dit project is met behulp van focusgroep gesprekken inzicht verkregen in de relatie tussen complexiteit en kwaliteit van zorg en het ervaren welzijn van artsen en verpleegkundigen in een UMC. De volgende inzichten zijn hieruit naar voren gekomen:

Verpleegkundigen en artsen in een UMC ervaren de complexiteit en de geleverde kwaliteit van zorg op verschillende manieren. De complexiteit van de zorg wordt beïnvloed door factoren zoals de coördinatie van de zorg en de kenmerken van de patiënt. Percepties van de kwaliteit van zorg zijn gerelateerd aan de beschikbare tijd en aandacht voor de patiënt, evenals aan patiënttevredenheid en het verlenen van de noodzakelijke basiszorg zoals zorgprofessionals dat het liefst zouden willen bieden. Een evenwicht in de verhouding tussen de complexiteit van de zorg en de kwaliteit van de zorg lijkt essentieel voor het welzijn van deze groepen zorgprofessionals.

Beide groepen zorgprofessionals ervaren verschillende stressfactoren in hun werkomgeving die een negatieve invloed hebben op hun welzijn, voornamelijk door het verhogen van de ervaren werkdruk. Voor artsen zijn de belangrijkste stressfactoren gerelateerd aan hoge verantwoordelijkheden, de verwachtingen van de patiënt, personeelswisselingen en wet- en regelgeving. Voor verpleegkundigen behoren onder andere de beperkte beschikbaarheid van tijd en middelen voor de logistieke organisatie van zorg, personeelswisselingen en de verplaatsing van zorg(verantwoordelijkheid) tot belangrijke stressfactoren. De aanwezigheid van deze stressoren kan leiden tot een hoger niveau van ontevredenheid en verminderde inzetbaarheid van deze zorgprofessionals. Bovendien kunnen ze ook gevolgen hebben voor de geleverde kwaliteit van zorg en daarmee voor de gezondheid van de patiënten.

Zowel verpleegkundigen als artsen ervaren naast stressfactoren ook positieve invloeden in hun werkomgeving die hun welzijn kunnen bevorderen. Voor artsen zijn belangrijke bevorderende factoren onder andere het hebben van coping mechanismen, het kunnen stellen en bewaken van grenzen, en hun hoeveelheid werkervaring. Voor verpleegkundigen zijn waardevolle bevorderende factoren onder andere samenwerking en ondersteuning in het team, het bestaan van protocollen en instructies, en mogelijkheden voor bijscholing.

Project 2

In dit project is een literatuurstudie opgezet in de vorm van een scoping review. Hierbij is inzicht verkregen in de impact van het gebruik van medische technologieën op de workflow en het welzijn van artsen en verpleegkundigen in het ziekenhuis. De volgende inzichten zijn hieruit naar voren gekomen:

In huidige medtech implementatie- en evaluatie studies is er nog weinig aandacht voor de invloed van het gebruik van nieuwe zorginnovaties op het welzijn en de ervaringen van zorgprofessionals. De focus ligt in de literatuur vooral op de invloed van medische technologie op de effectiviteit, patiëntveiligheid, efficiëntie en kosten-effectiviteit.

Het gebruik van (nieuwe) technologieën beïnvloed huidige zorgprocessen. De impact van Medtech op werkflow- en het welzijn van zorgprofessionals in ziekenhuizen is in hoge mate heterogeen en kan een positieve dan wel negatieve invloed hebben. De richting van deze effecten op de onderzochte constructen komen niet noodzakelijk overeen en kunnen tegenstrijdig zijn. Met andere woorden: een hogere mate van efficiëntie in de werkflow komt niet altijd overeen met een groter ervaren welzijn van zorgprofessionals, en omgekeerd.

Bij het beoordelen en evalueren van medische technologieën is er een gebrek aan standaardisatie van (passende) meeteenheden en -instrumenten en uitkomstmaten. Hierdoor bestaat er een grote diversiteit binnen onderzoeken zonder eenduidige resultaten. Dit belemmert het vergelijken van de impact op zorgprofessionals binnen en tussen medische technologieën.

Conclusies en adviezen

De resultaten van de onderzoeksprojecten uitgevoerd binnen de Academische Werkplaats ‘Geef bevlogenheid vleugels: de basis van gewoon goede zorg’ bieden waardevolle inzichten in de uitdagingen waarmee zorgprofessionals in het Nederlandse zorglandschap worden geconfronteerd. Het welzijn en de vitaliteit van zorgprofessionals binnen afdelingen is afhankelijk van een breed scala aan interne en externe factoren en karakteristieken op individueel-, team-, organisatie- en maatschappelijk niveau, welke onderling met elkaar interageren en veelal aan verandering onderhevig zijn. Maatwerk lijkt nodig voor het bereiken van een juist evenwicht. Hiervoor is data-input nodig uit verschillende invalshoeken om de gezondheid van zorgprofessionals op afdelingsniveau te monitoren en verstoringen in de balans te signaleren en bij te sturen. Gezien de complexiteit van het verkrijgen en integreren van verschillende datasets (project 1a), lijkt het noodzakelijk te investeren in geavanceerde technologieën en systemen die effectieve data-integratie mogelijk maken. Datakoppeling zal op diepere niveaus mogelijk gemaakt moeten worden om resultaten ook daadwerkelijk goed te kunnen interpreteren. Het ontwikkelen van een uniforme aanpak is van belang voor het gevalideerd verzamelen en analyseren van gegevens over medewerkersbeleving, patiënttevredenheid, kwaliteit van zorg en andere relevante parameters. Het is aannemelijk dat dit zal bijdragen aan het identificeren van concrete afdelingskenmerken en het kunnen leggen van causale verbanden. Echter is het gebruik en sturing vanuit enkel data niet voldoende. Het betrekken van het perspectief en ervaringen van zorgprofessionals is belangrijk voor het in kaart brengen van achterliggende mechanismes en het ontwikkelen van effectief beleid. Regelmatige en gestructureerde feedbacksessies met zorgverleners (from bed side to board room) op alle niveaus lijken daarbij waardevol, waarbij aandacht wordt besteed aan hun ervaringen, uitdagingen, behoeften en suggesties voor verbeteringen. De bevindingen van project 1a en 1b, waarbij afdelingskenmerken en de balans tussen zorgcomplexiteit en kwaliteit van zorg van invloed zijn op het welzijn van zorgprofessionals, benadrukken het van belang van de ontwikkeling van interventies die zich richten op team- en organisatieniveau. Het is belangrijk om een focus te leggen op het als team omgaan met de vele

personeelswisselingen zodat de impact van het verloop van collega's op individuele zorgprofessionals kleiner wordt. Tot slot is het essentieel om een gezonde balans te creëren tussen technologische efficiëntie en het welzijn van zorgprofessionals. Inzichten uit project 2 laten zien dat zorginnovaties wel degelijk een grote impact kunnen hebben op het werkplezier en de vitaliteit van zorgprofessionals, ongeacht de impact op werkflow efficiëntie. Bij de ontwikkelingen van richtlijnen voor de beoordeling, implementatie en evaluatie van medische technologieën is het daarom van belang om de ervaring en het welzijn van zorgprofessionals mee te nemen. De verwachting is dat dit de ontwikkeling van gebruiksvriendelijke technologieën zal stimuleren die de werkflow verbeteren zonder nadelige gevolgen te hebben voor de zorg werkvloer.

Referenties

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The perceived impact of well-being of the health and care workforce on the quality of care: a qualitative study

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Abstract

Introduction: Well-being and vitality of healthcare professionals are fundamental prerequisites for the delivery of safe and high quality care. However, the current healthcare system is overloaded, and working conditions are becoming increasingly complex. Currently, there is still uncertainty regarding the relationship and underlying mechanisms between the complexity and quality of care and the perceived well-being of healthcare professionals. Regularly, perspectives of healthcare professionals are lacking, and there appears to be a mismatch between the system and the employees. The research question of this study is: 'how do physicians and nurses in an academic medical center in the Netherlands experience healthcare complexity and the delivered quality of care in relation to their individual well-being?'.

Method: In this qualitative research, a purposive sample of physicians and nurses from a single academic medical center was utilized. Participant recruitment for focus group discussions took place from July 2023 to August 2023, via managers, project leaders, emails, and flyers. Approximately 65 nurses and 25 physicians were approached for participation. Informed consent was obtained from participants before the start of data collection. Data were analyzed by two researchers using the thematic analysis methodology in the software program Atlas Ti.

Results: A total of 17 participants took part, including 10 nurses and 7 physicians. From the nursing data, 81 quotations were coded, using 67 unique codes a total of 242 times. From the physician data, 80 quotations were coded, using 78 unique codes a total of 237 times. Results are described on the themes of complexity, quality, stressors & facilitators, and well-being.

Conclusion: Nurses and physicians experience the complexity and quality of care different. Healthcare complexity, influenced by care coordination and patient factors, poses a challenge that affects their work. At the same time, healthcare quality influences their professional satisfaction, with patient-centered care, basic care, and patient satisfaction being important. A balance between healthcare complexity and quality seems essential for well-being. Staff turnover and changing teams leads to frustration, as do time and resource constraints in organizing care. On the other hand, improving patient health and delivering high-quality care enhance professional satisfaction. Healthcare professionals emphasize that coping mechanisms, work experience, team support, and work routines are conducive to dealing with healthcare complexity and maintaining care quality.

Implications for practice: Understanding the experiences of physicians and nurses will help gain a better grasp of factors influencing care quality and well-being. Findings should be considered in the development of interventions and policies.

Introduction

Well-being and vitality of healthcare professionals are fundamental prerequisites for safe care and high quality care [1–3]. The current healthcare system is overloaded, and work is becoming increasingly complex [4]. Pressure on healthcare professionals is rising on various fronts: changing and increasing expectations from patients and the sector, insufficient staffing, personal safety risks and rising costs [5]. Absenteeism or sick leave rates have reached record highs in recent years, and the turnover of healthcare professionals from the field is high[6,7]. The absenteeism rate in the healthcare and welfare sector was 7.0% in 2023, which is 2% higher than the average absenteeism rate in the Netherlands[8]. Twenty four percent of employees in health and care indicated that absenteeism is (partly) caused by work [8]. The Dutch Central Bureau for Statistics describes that, one in ten employees in the health and care sector left the sector. Likewise, thirteen percent leave the sector after two years[9].

Quality of care is described as delivering healthcare according to the following principles Safe: Avoiding harm to patients from the care that is intended to help them Effective: Providing services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit (avoiding underuse and misuse, respectively). Patient-centered: Providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions. Timely: Reducing waits and sometimes harmful delays for both those who receive and those who give care. Efficient: Avoiding waste, including waste of equipment, supplies, ideas, and energy. Equitable: Providing care that does not vary in quality because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status. [10]. In the Netherlands, recent efforts have focused on enhancing patient-centered care, embracing technological innovation, digitizing healthcare processes, and promoting transparency regarding quality indicators[11]. Collaboration between healthcare institutions has also been emphasized the need to foster an integrated and efficient care chain. To ensure quality and maintain accessibility in the face of increasing demand, there is a trend towards concentrating complex and highly specialized medical care in University Medical Centers (UMCs), while decentralized care is provided for chronic care and elective treatment in proximity to patients[11,12]. However, the approach to addressing complexity in healthcare remains a subject of limited understanding [13]. Complexity in healthcare emerges from interactions and adaptations among various actors such as, patients, informal caregivers, healthcare management and various healthcare professionals. Factors like knowledge, education, traditions, and culture can influence or impede the complexity of healthcare. Highly complex healthcare involves actions and patients with low predictability and a higher risk likelihood, necessitating the involvement of multidisciplinary teams[13].

Current features of healthcare such as high workload, growing regulations, and expectations regarding the delivery of complex care can lead to diminished well-being among healthcare professionals[15]. In our approach we used the following definition of well-being at work: creating an environment to promote a state of satisfaction in which an employee can thrive and realize their full potential for themselves and their organization[16]. Well-being encompasses psychological, physical, and social well-being[17]. Various models and concepts of well-being are presented in the literature. The Self-Determination Theory[18], indicates that both employees' performance and well-being are influenced by the type of motivation they experience[18]. The Job Demands-Resources model (JD-R model) facilitates categorization of the interaction between work and well-being[20]. Essentially, the JD-R model integrates two processes: the stress process, caused by excessive workload and a lack of resources, and a motivation process stimulated by abundant work resources, which can lead to positive outcomes such as organizational commitment, intention to stay, and job performance[20].

An example of such interaction between the organization of complex healthcare and its impact on healthcare professionals is the occurrence of moral stress in the workplace[21,22]. The system

created for control and accountability has become detatched from the meaning and purpose of delivering healthcare. Moral stress arises when healthcare providers are unable to put their own and/or professional norms and values about good care into practice due to external factors such as organizational constraints or healthcare complexity. Healthcare professionals operating in critical care environments, such as the intensive care unit, are at a higher risk of experiencing ethical conflicts due to intense working environments, frequent exposure to death, and significant technological advancements[22,23]. This phenomenon was amplified during the Covid-19 pandemic[24]. Experiencing moral stress in the workplace can influence aspects of perceived quality of care and is associated with burnout, reduced job satisfaction, and the intention to leave the profession[25–27]. There also appears to be a connection between emotional exhaustion of healthcare professionals and incidences of pneumonia and pressure ulcers in the department[28]. There are many unanswered questions about the relationship and underlying mechanism between the complexity and quality of care and the perceived well-being of healthcare professionals[28]. The association between well-being outcomes (e.g., stress), work-related outcomes (e.g., workload), and quality of care (e.g., infections and mortality) is however wellknown[29–31].

There are several areas within healthcare that focus on improving individual healthcare professionals' well-being and vitality. However, interventions aimed at optimizing the work context and collaboration within and between teams seem to receive less attention[32]. This lack of focus on healthcare professionals' perspectives often results in a mismatch between the system and the employees, evident through an overload of forms, rules, protocols, and procedures.

To address this issue and bridge the gap in understanding the underlying mechanisms, we conducted a study in a university medical center. Our study aims to explore how physicians and nurses experience healthcare complexity and the quality of care provided in relation to their own well-being. By understanding this perceived association between the quality and safety of care, patient experience, and employee well-being, we can identify opportunities for implementing tailored interventions.

Method

Design

In this study a generic qualitative approach was applied with a descriptive design to map and understand the experiences of physicians and nurses. This type of research has an exploratory nature and is suitable for eliciting knowledge, opinions, experiences, and perceptions from respondents[33]. The COREQ checklist with criteria for reporting qualitative research was utilized for reporting the results[34].

Population

The study population comprised physicians and nurses from a single university medical center in the Netherlands. Participants were eligible if they had an employment contract with the relevant UMC at the time of data collection, excluding students. A purposive sampling strategy was chosen based on professional background. Enhancing reliability, to ensure variation in age, gender, medical specialty, and work experience respondents were selected achieving heterogeneity in respondent experiences. The aim was to recruit a minimum of six nurses and six physicians to achieve data saturation.

Procedures

The recruitment of participants took place from July 2023 to August 2023. To recruit nurse participants, managers from various nursing departments were approached, and informational flyers were distributed on the departments. Nurses who were on day shift on the day of data collection were also personally invited via email. In total, approximately 65 nurses were approached for participation in the study. Physicians were individually approached through the project leader's network or via email invitations. Moreover, medical departments were informed with a request to promote participation among medical colleagues. In total, approximately 25 physicians were approached for participation in the study. Informed consent was to be obtained from the participants before the commencement of data collection.

Data collection

Two focus group interviews were conducted in August 2023. The discussions took place in the education center of the respective UMC and were supported by a brief presentation providing context and background information.The first session targeted nurses, and the second session physicians. Both researchers played an active role during the interviews, serving either as the facilitator or as the note-taker. The duration of the sessions ranged from 55 to 65 minutes. A discussion guide was used to ensure all relevant topics were covered in a structural manner during the interviews. Based on the research question, the following themes were explored: perceived complexity of care, perceived quality of care delivery, and the impact of these themes on the well-being of physicians and nurses (physical well-being, emotional well-being, and social well-being). At the conclusion of the sessions, participants received a gift voucher for appreciation.

Data Analysis

The two focus group interviews were recorded and subsequently transcribed, resulting in textual qualitative data. Two researchers analyzed the data using the thematic analysis methodology in the software program Atlas Ti (v5.20.0-2023-11-28, © 2002–2023 – ATLAS.ti Scientific Software Development GmbH). Thematic analysis is a flexible and effective method for systematically generating qualitative research findings by identifying, analyzing, and reporting patterns (themes) in the data[35]. This methodology involves three phases: familiarization, coding, and thematizing. During the familiarization phase, the researchers repeatedly reviewed the transcriptions to become familiar with the content of the data. During reading, the researchers independently reflected on the data by making brief notes to identify concepts in the dataset relevant to answering the research question.

These notes were then compared and discussed. In the next phase, the researchers independently coded the data (open coding). Data was searched for obvious patterns and themes, and codes were assigned to specific text fragments. During axial coding, codes were clustered and related to broader categories to identify the main underlying themes. The individual codebooks were discussed and compared to reach consensus for the common codebook. The final codebook can be found in Appendix X. The entire dataset was then recoded by both researchers, and discrepancies were discussed. In the thematization phase, themes were identified based on the coded data and discussed during a joint analysis session.

Results

Sample description

In total, 17 participants took part in the focus group interviews, comprising 10 nurses and 7 physicians (Table 1). All participants provided consent for their involvement in the research, as well as for the processing and utilization of the collected data, by signing an informed consent form. Among the nurse participants, the majority were female (80%), while among the physician group, the majority were male (71%). Both groups exhibited heterogeneity in terms of average age. The majority of participating physicians had been working at the UMC for 1-10 years or 20-30 years. Among the nurses, a significant majority had been working at the UMC for 1-10 years. Both groups demonstrated variability in the representation of medical specialties. Among the physicians, five specialties were represented, with a focus on anesthesiology and ophthalmology. Among the nurses, four specialties were represented, with an emphasis on major specialties such as surgery, internal medicine, and oncology.

Tabel 1. Sample characteristics

	Total	**Physicians**	**Nurses**
Participants	17 (100%)	7 (41%)	10 (59%)
Gender participants			
Female	10 (59%)	2 (29%)	8 (80%)
Male	7 (41%)	5 (71%)	2 (20%)
Age in years			
18-25	3 (18%)	0 (0%)	3 (30%)
26-35	4 (23%)	2 (29%)	1 (10%)
36-45	3 (18%)	1 (14%)	3 (30%)
46-55	5 (29%)	2 (29%)	3 (30%)
56-65	2 (12%)	2 (29%)	0 (0%)
Work experience in years			
1-10	10 (59%)	3 (43%)	7 (70%)
11-20	3 (18%)	1 (14%)	2 (20%)
20-30	4 (23%)	3 (43%)	1 (10%)
Specialisms/ward			
Intensive care	1 (6%)	1 (14%)	0 (0%)
Psychiatry	1 (6%)	1 (14%)	0 (0%)
Anesthesiology	2 (12%)	2 (29%)	0 (0%)
Ophthalmology	2 (12%)	2 (29%)	0 (0%)
Oncology	4 (23%)	1 (14%)	3 (30%)
Surgery	3 (18%)	0 (0%)	3 (30%)
Internal medicine	3 (18%)	0 (0%)	3 (30%)
Pediatrics	1 (6%)	0 (0%)	1 (10%)

Experiences of nurses

In total, 81 quotations were coded from the nursing data. A total of 67 unique codes were used, with a cumulative frequency of 242 occurrences.

<u>Complexity in coordinating care</u>

Nurses experience complexity in the logistical organization of patient care and departmental management, in the implementation of policies and policy changes, and in multidisciplinary collaboration with multiple specialties. These aspects were often mentioned in conjunction with the complexity of the patient's medical conditions. The administrative burden, the feeling of having to

juggle multiple tasks, and the need to streamline and navigate care were perceived as complex. Nurses explained that order changes often arise because different specialties are involved in the care of a single patient. Finding the main thread and priorities in this context is perceived as complex. Furthermore, it is common for orders to be communicated later in the day due to patients being placed on 'wrong' departments, requiring further coordination among physicians and supervisors. Finally, it is noted that changes in orders are not always communicated and are not clearly communicated.

'Yes, for example, in our case, psychiatry often comes back into the consultation, or dietetics, physiotherapy, occupational therapy. Try structuring care around that. Or when people have more traumatic injuries, things from cardiology, neurology. All these specialties together, one says this, the other says that.' - Nurse"

Patient complexity

Nurses often experience complexity in the nature and quantity of the patient's medical conditions. For example they mentioned the care for an elderly patient population with frequently occurring co-morbidities. The frequent switching between patients and interacting with different colleagues adds an extra layer of complexity. In addition, nurses experience complexity in performing nursing procedures, both in terms of the nature and quantity.

'One complexity is, I think, when people have an IV, and then a catheter, a PICC line, a drain, a nasogastric tube, oxygen, and they are also confused. That does make it very complex, indeed.' - Coordinating Nurse"

Quality of care

According to nurses, the primary pillar for quality is the time and attention one can provide to a patient. This was frequently mentioned by several participants. Additionally, patient satisfaction and the ability to perform necessary care actions are important aspects that nurses consider as indicators of quality. Examples of care actions include assisting with patient mobilization, changing IV lines, or providing oral care and repositioning the patient in bed. Expressing appreciation from patients is cited as an example of patient satisfaction, along with taking into account the patient's preferences (shared decision-making), and, for instance, combining and scheduling various clinic appointments on the same day. Patient satisfaction is often mentioned in conjunction with the time and attention provided by the nurse.

'Yes, because if you can give that bit of attention to the patient or special care, you also bring a sense of calm to the department.' - Nurse

'Yes, I really think there's a shortage there, having a good conversation with the patient.' - Coordinating Nurse"

Stressors

Nurses indicated that various factors have a negative impact on the perceived complexity, quality, workload, and or personal well-being. The so-called stressors frequently mentioned in relation to perceived workload include limited availability of time and staffing capacity, turnover of colleagues and changes in teams, limited patient flow in the chain, and the shifting of care (responsibility). The fact that patient admissions are becoming shorter and procedures more intensive, with the nurse as the central point of contact for the patient and/or family, also contributes to this perceived workload. Moreover, there is often uncertainty about patient plans/orders and treatment, causing nurses to

perceive the delivery of appropriate care, multidisciplinary collaboration, and organization of care as complex. The limited availability of time not only leads to higher perceived workload among nurses but also to reduced perceived quality of care concerning attention to the patient and the ability to provide the right basic care. This stressor is also often mentioned in combination with its impact on nurse deployability and dissatisfaction. Other stressors mentioned by nurses include inefficient communication with (multidisciplinary) colleagues, rotating shifts and limited recovery time, administrative tasks, and the amount of work experience.

'No new staff has been hired. So, the tasks are there, and we take them on, which actually shouldn't be the case. As a result, I get less patient care and more administrative tasks, which I really don't like as a nurse.' - Nurse Case Manager

'Yes, but that causes a drain on the nursing units; you notice it very strongly. There are always new people coming in that you have to coach, and the people who have been there longer are constantly burdened with that, while they already have enough with their own work.' - Coordinating Nurse"

Facilitators

In addition to stressors, there are also factors that can have a positive impact on the perceived complexity, quality, workload, or personal well-being. However, these were less frequently mentioned in the session. The facilitator most often mentioned is teamwork and support in the team, which promotes both the quality of care and the well-being of nurses. Besides this, the presence of protocols and instructions not only improve quality but also have a positive impact on the well-being of nurses because they provide them with guidance and confidence. Other facilitators include training, learning opportunities, and staff changes. Working routines ensure that nurses perceive care as less complex because they have to think less consciously about the tasks to be performed.

'Yes, it just gives you a sense of security. I like to look things up to see if I'm doing it right. I find it very pleasant that I can look it up and not have to ask a colleague all the time. Or that you do it together with a colleague and support each other in that.' - Coordinating Nurse

'Sometimes you have a few patients who are very ill, or they are delirious. Sometimes there are no sitting students available, yes, then you just keep going and hope, fingers crossed, that your patient doesn't fall, for example. That's not always fun.' - Senior Nurse"

Well-being nurses

Nurses often experience the influence of the work context on their own health and well-being. A large proportion of nurses indicated experiencing feelings of dissatisfaction in the form of frustration and demotivation. This outcome is often described in combination with factors that nurses consider important for the quality of care, namely, having attention and time for the patient and being able to provide basic care. Additionally, health can be influenced through an imbalanced work-life ratio, insufficient recovery time, and heavy physical exertion. These aspects, often arising from stressors, can indeed lead to reduced personal deployability and commitment. However, the work context can also positively influence the well-being of nurses by increasing job satisfaction through receiving appreciation and experiencing a sense of fulfillment, often in interaction with the patient.

'Yes, if you have enough staff, then it's not a problem, then it's a fun challenge. We all really want to learn and are willing to do a lot and take care of others, but you need time for that, otherwise, it only frustrates.' - Coordinating Nurse

'I do think that on a day when you can deliver good quality, you go home much happier, like yes, I got it all done, or I did it well.' - Coordinating Nurse

'He and his mother were so grateful, they had no stress. You need time for that. Yes, then you go home happily because during your shift, you've already been able to process everything, so you don't sit in the car on the way home or at home thinking, oh, what did I actually do today.' - Nurse"

Wellbeing patients

A third of the participants in the session with nurses indicated that the available care affects the physical health and recovery of the patient. This was often stated in conjunction with the amount of time and attention nurses can dedicate to the patient and the experience of dissatisfaction within the team. Furthermore, it is equally often mentioned that the available care can also negatively influence the duration and intensity of a patient's hospital stay, as well in combination with a sense of dissatisfaction among nurses.

Experiences of physicians

In total, 80 quotations have been coded from the data. Seventy-eight unique codes were used, amounting to a total of 237 instances.

Complexity in coordinating care

Physicians mainly experienced complexity in multidisciplinary collaboration with multiple specialties, in the ongoing developments in the patient population and care trajectories, in the logistic organization of care around the patient and departmental management. These aspects are repeatedly noticed in conjunction with the complexity of medical conditions in patients. The extensive coordination between colleagues and patients plays a significant role in the perceived complexity. Additionally, physicians express that healthcare has changed significantly and increased in complexity over the past 15 years due to the availability of new innovative technologies, the need for information to go through more channels, the introduction of more regulations, and increased collaboration within the healthcare chain. Moreover, there is a frequent experience of a lack of overview and control, which used to be more associated with a general practitioner.

'There are many captains on the ship.' – Medical specialist

'That clashes occasionally. Cases are becoming increasingly complex because, for example, there are different technologies. Then you have another multidisciplinary meeting about something. Progress is not quick; everything is much more complicated.' – Medical specialist"

Patient complexity

Physicians frequently expressed that the nature and quantity of medical conditions are perceived as complex. An explanation given for this is the provision of tertiary care in the hospital, an increase in comorbidities, and more vulnerable patients. One-third of the physicians also highlight the complexity arising from the variety of medical treatments. Someone points out that from the patient's perspective, complexity cannot be considered a static concept, as conditions can now be treated more effectively.

'I experience complexity in care, at least in the sense that you no longer have a patient with just one thing wrong or where you perform just one treatment. A simple gallbladder in this hospital, you can be sure it has various comorbidities that you need to take into account.' - Resident physician"

Quality of care

According to physicians, the primary pillar for quality of care is the level of patient satisfaction, as mentioned by multiple participants. They indicate that when a patient is satisfied, and they have

been able to make a difference, it is perceived as good quality of care. Apart from providing good quality of care for the individual patient, several physicians wonder about the consequences of this for the quality of care at the societal level. Furthermore, the ability to perform necessary treatments and attention to the patient are also considered important pillars for quality by the physicians. For example, it was mentioned that there are issues with delivering certain drugs, causing the patient to switch medication every six months, which significantly affects the quality of care.

'I do agree with your opinion. A very complex patient, you think about that with more people, and that way, you can provide better care with more experience. But then the question is, is that also the best care for that patient? And how is that for the larger group?' - Resident physician"

Stressors

Physicians indicated that various factors can have a negative impact on the perceived complexity, quality, workload, or personal well-being. Stressors that were most prominent expressed during the group discussion included the responsibility felt by the physician, patient expectations and behavior, staff turnover, and laws and regulations. Physicians feel that they sometimes have to make significant decisions in a relatively short time and juggle many tasks simultaneously. At the same time, the physicians describe the conspicuous change in this increasingly individualistic society. Turnover in colleagues and changes in teams create a sense of discomfort and uncertainty. These three stressors were most frequently mentioned together in the sessions in combination with perceived workload and reduced well-being. Likewise, laws and regulations were most frequently highlighted in the session as an inhibiting factor for complexity and quality. Other examples of mentioned stressors included limited staff capacity, restricted patient flow, and the amount of work experience someone has. Finally, it was stated that changes and innovations sometimes make healthcare more complex and sometimes help make healthcare less complex. Approximately one-third of the physicians described a negative impact of changes and organizational factors on quality.

'You're almost every day with a different team in the operating room. And in emergency care, you also have different colleagues around you every time. That is complex because you have to look at the dynamics each time and find your place again. I sometimes find that uncomfortable.' - Resident physician"

Facilitators

To a lesser extent, physicians described facilitating factors. Coping mechanisms and setting boundaries were the most prominent mentioned during the session. Coping and setting boundaries appear to be perceived the most crucial factors for promoting personal well-being for physicians, as these are often mentioned together. About half of the physicians state that having more work experience is the key facilitator for coping with the experienced complexity. Furthermore, physicians mentioned that having challenges contributes to their well-being. Finally, collaboration in teams and experiencing support through teamwork were described as facilitators contributing to the experience of well-being and quality.

'That aspect is becoming increasingly important to me, to protect my privacy as much as possible. Many people don't like that. You became a doctor to help someone, but at some point, you also have to stand up for yourself in that regard.' - Medical specialist

'Something that I found complex in the early stages of my career doesn't feel complex at all now because I have more experience.' - Medical specialist"

Well-being physicians

A frequently arising question in the group discussion with physicians was the perception of influence

on their own health and well-being. This influence was more often expressed in a negative sense (discontent, discomfort) than in a positive sense (job satisfaction). Examples of discontent include the constant need to be on, the desire for rest, frustration due to limited availability of resources, and the continuous encounter with resistance draining one's energy. Discomfort mainly revolves around changing teams. It is mentioned that 'you don't know what to expect from each other' with unfamiliar colleagues, requiring a constant search for a specific workflow. Two physicians indicate experiencing an impact on the level of personal deployability.

'There are occasional things that don't go smoothly. That has everything to do with a shortage of personnel and who knows what else. It does influence how much time and energy you have to invest to get something done. People who hide behind rules. Then I think, darn it, come on. It throws me off balance, frustrated.' - Medical specialist"

Well-being patients

More than half of the respondents in the focus group session with physicians indicated that the available care influences the physical health and recovery of the patient. This is mentioned, for example, in the context of attention and timing of care. Physicians feel that attention to the patient and the right timing of care can contribute to good patient care and their own well-being. Additionally, physicians state that the increase in complexity in organizing care and compliance with laws and regulations can have a negative impact on the health and recovery of the patient. For instance, it is sometimes challenging to arrange a specific drug or a bed for a patient., Influences on the health and recovery of the patient are often mentioned in conjunction with personal discontent.

'Sometimes, you know that choice A is actually the best for the patient, but it takes too much time and energy to achieve, which I don't have, so I opt for B. That does affect my job satisfaction.' - Medical Resident"

Discussion

This study provides some essential building blocks for a bedside to board room approach for possible interventions or preventive measures. In this study, the perception of healthcare complexity and delivered quality of care in relation to individual well-being was explored among physicians and nurses in an academic medical center. By understanding this perceived association between the quality and safety of care, patient experience, and employee well-being we identified opportunities for tailored interventions. Two focus group discussions revealed that nurses and physicians in an academic center experience the complexity and delivered quality of care in different ways. Our result stress that a one size fits all approach will not reach full potential. Healthcare complexity is often considered a challenge that affects the work of the nurses and the physicians. At the same time, the delivered quality of care influences their professional satisfaction. A balance in the relationship between complexity and quality of care appears to be essential for the experience of well-being..

Our data show that medical and nurses focuse on a different level in the healthcare organization. Nurses focus more on the personal and departmental perspectives level. Physicians provided also a more overarching explanation of the topics from a societal perspective. Within the theme of healthcare complexity, organizing care logistics and medical conditions around the patient emerged as important aspects for both nurses and physicians. These factors align with the work environment of an academic center that delivers highly complex tertiary care [12]. Also, frequent diagnostic or treatment plan changes contribute to an increase in the complexity of care. This involves alterations in diagnostic or treatment plans due to the involvement of various specialties, making priority-setting at times perceived as complex. Late and unclear communication regarding alterations in these plans is also mentioned, attributed to off-site patient placements and the necessary coordination between resident physicians and medical specialists. While nurses mainly focus on experiencing unclear diagnostic or treatment plans, physicians express complexity in collaborating with many different colleagues and teams. This can be attributed to the fact that physicians often switch teams and/or settings, such as in the surgical and/or intensive care complex, and alternate between working in the outpatient clinic and the inpatient ward.

The concepts of quality of care is perceived similarly by both physicians and nurses, even though patient satisfaction was more frequently discussed by physicians, and time and attention for the patient were emphasized by nurses. It is possible that nurses also view these factors of time and attention as essential elements for patient satisfaction. Furthermore, limitations in available time and resources, as well as staff turnover, are perceived as challenging by both groups of healthcare professionals.

Physicians specifically mention that having significant responsibility and more expertise sometimes impacts their own well-being, and patient expectations influence the experience of workload. The absence of a coordinating practitioner in an individualizing society where patients are becoming increasingly assertive is felt by this group. Patients, empowered by digitization, have growing opportunities to gather information and express their preferences[36]. This societal pressure, along with patient expectations and doubts from patients, is highlighted not only in this study but also in other studies with various designs, portraying stressed and overworked physicians[36–38]. These issues contribute not only to stress and burnout among physicians but also to delays and longer waiting times for patients[36].

For physicians, having more work experience, coping mechanisms, and setting boundaries are identified as key facilitating factors for their own well-being. For nurses, experiencing support and having access to guidelines and protocols are essential factors. Thus, physicians tend to identify primary facilitating elements within their own personal competencies, while nurses, on the other hand, appeal to a broader range of facilitators, often located outside their individual capacities. Both

align with the Job Demands-Resources (JDR) model theory, where work-related resources (e.g., a supportive team) and personal resources (e.g., coping mechanisms and setting boundaries) emerge[20]. These resources are considered protective factors for professionals' engagement and well-being[39]. Notably, nurses perceive guidelines and protocols as tools providing structure, while physicians view them as hindrances. The discussion often revolves around regulatory pressure and risk management[12]. Advocacy for reduced regulations and guidelines is prompted due to a lack of coordination[40]. Professionals may lose track because the clarity of current regulations is not always evident, leading to uncertainty about whether individual patient preferences can be honored[40]. On one hand, nurses tend to organize care through more protocols and checklists[41], viewing them as valuable for delivering quality care[42]. On the other hand, a multitude of standards and varying opinions on what constitutes quality of care and how to measure it create tensions in practice[42].

This study has some inherent limitation. Firstly, the existing cultural differences between nurses and physicians may have influenced the research results. Although they share the common goal of providing high-quality care to patients, there are clear differences in professional identity, collaboration culture, values, and skills between nurses and physicians[43]. These differences are shaped by their unique roles, responsibilities, generations, specialization directions, education, and training[44,45]. Notably, during the conversations, physicians appeared to find it generally more challenging to articulate or share the impact of complexity and quality of care on individually experienced well-being. This could be related to the high-performance and hierarchical culture in the medical profession, where little space seems to exist for emotions and vulnerability[46]. Doctors are often expected to adhere more strongly to medical ideals of objectivity, neutrality, and omnipotence. The emphasis is on taking the lead and assuming responsibility for decisions. Nurses operate from a care perspective in which emotion and intuition play a greater role[47,48]. Additionally, these professionals are more trained to work in teams and collectively solve problems[47,48].

Another limitation of this study is the potential presence of the Hawthorne effect. The Hawthorne effect is the observation that individuals alter or improve their behavior when they are aware of being observed[49,50]. More broadly, the effects are noticeable in all areas involving human interaction, forming the basis of qualitative research methodologies[49,50]. In focus group discussions, the Hawthorne effect is multiplied by the number of participants[49,50]. Each participant is not only aware of being observed by the facilitator but also by other participants (group effect), which may influence the sharing of experiences and information[49,50]. The effect could have gone both ways it could have had a positive influence because sharing and thinking about these issues could have led to more openness by the participants however it could also be that with senior nurses or doctors present speaking up was more difficult.

Furthermore, the results of this study are based on qualitative findings from two focus group discussions conducted within a single university medical center. For potential generalizability and increased reliability of the results, additional research should be conducted with doctors and nurses from other medical centers. Furthermore, it should be noted that the focus group methodology itself has limitations, such as potential bias, influence, and the role of the facilitator during the sessions.

This study also has several strengths. Firstly, the focus group discussions were conducted based on a predefined topic list, providing a uniform structure during the conversations and enhancing the transferability of the study[51,52]. Furthermore, notes were taken and the discussions were recorded using a voice recorder, followed by transcription, thereby increasing the internal validity/credibility of the collected data[51,52]. Likewise, two researchers independently analyzed the collected data. The data was coded independently, and multiple interpretative discussions were held to achieve consensus on findings. Moreover, participants were approached for a member check, enhancing the intersubjectivity of the current research[51,52].

The insights gained from this study are crucial for creating a healthy work environment that is

conducive to the well-being of both physicians and nurses, ultimately contributing to the enhancement of current healthcare practices. When developing policies or conducting further research, it is essential to consider the described facilitating factors and barriers, as well as the key pillars for the well-being of healthcare professionals. The turnover of colleagues and changes in teams were identified by both groups of healthcare professionals as significant stressors. Additionally, collaboration and support were highlighted by both groups as crucial facilitators. Further research should focus on appropriate interventions aimed at preventing team turnover or supporting teams in adapting to a changing work environment for effective collaboration. Finally, it was notable that nurses and physicians perceive regulations and protocols differently. To gain a more comprehensive understanding, future research could specifically investigate this aspect. Insight into the delineation of when and which regulations are supportive and when and which regulations are hindering in light of regulatory pressure and risk management. Through a quantitative study, the extent of perception differences can be explored. Additionally, it would be interesting to compare various contexts to determine whether these perspectives are context-dependent.

Conclusion

Nurses and physicians in a hospital perceive the complexity and delivered quality of care in different ways. Care complexity, influenced by care coordination and patient-related factors, are often considered as a challenge affecting their wellbeing at work. At the same time, the delivered quality of care influences their professional satisfaction. Key factors for both doctors and nurses include time and attention for the patient, the ability to perform necessary basic care, and patient satisfaction. A balance in the relationship between care complexity and quality of care appears essential for experiencing well-being. Excessive turnover of colleagues and changing teams can lead to frustration and discomfort, as can perceived barriers in the availability of time and resources for organizing care logistically. On the other hand, patient health and the ability to provide high-quality care seem to be crucial pillars for the well-being of healthcare professionals, as they appear to enhance professional satisfaction. Additionally, healthcare professionals emphasize the positive influence of their own coping mechanisms, having work experience, receiving support within the team, and having routine and workflow when dealing with care complexity and maintaining a high level of care quality. Physicians tend to deploy facilitators within their own personal competencies, while nurses, in contrast, appeal to a broader range of facilitators, often located outside their individual capacities and more on the team. The findings of this study should be taken into consideration within the current healthcare landscape, especially in policy changes, implementation of interventions, and restructuring of care. This could involve strengthening facilitators (e.g., time and attention for patients (space for patient-centered care) and colleagues) and eliminating barriers (e.g., frequent patient plan changes or team changes).

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Additional file

Additional file 1: Codebook nurses

Thema	Code-group	Short code	Long code
Complexity	Patient complexity	Treatment & tasks	Nurses experience complexity in the quantity/nature of nursing procedures
	Coordination of care	Patient plan	Nurses experience complexity in patient plan (changes)
	Coordination of care	Chain care	Nurses experience complexity in the flow within the chain
	Coordination of care	Organize	Nurses experience complexity in the logistical organization of care around/for the patient and department management
	Patient complexity	Medical conditions	Nurses experience complexity in the nature and quantity of medical conditions in patients
	Coordination of care	Collaboration	Nurses experience complexity in collaborating with multiple specialties in a multidisciplinary setting
	Coordination of care	Prioritize	Nurses experience complexity in establishing priorities
	Coordination of care	Switching	Nurses experience complexity in frequent switching with patients/colleagues
	Coordination of care	Development	Nurses experience complexity due to developments in patient populations and care pathways
c	Definition of quality	Patient satisfaction	For nurses, the patient's experience is a crucial pillar for quality
	Definition of quality	Attention	For nurses, time and attention for the patient are essential pillars for quality
	Definition of quality	basic care	For nurses, performing the necessary care interventions is a fundamental pillar for quality
Stressors & facilitators	Collaboration	Division of tasks	Performing non-function-related tasks has a +/- impact on the perceived complexity/quality/workload/well-being
	System	Administration	Conducting administrative tasks has a +/- impact on the perceived complexity/quality/workload/well-being
	System	System	Brief and action-intensive patient admissions have a +/- impact on the perceived complexity/quality/workload/well-being
	System	Patient flow	Limited patient flow in the chain and the transfer of care (responsibility) have a +/- impact on the perceived complexity/quality/workload/well-being
	System	Availability of time and resources	Limited availability of time, resources, and staffing has a +/- impact on the perceived complexity/quality/workload/well-being
	Collaboration	Lack of clarity	(Lack of) clarity regarding patient plans and treatment has a +/- impact on the perceived complexity/quality/workload/well-being

	Collaboration	Communication	(In)efficient communication with colleagues and parents/family has a+/- impact on the perceived complexity/quality/workload/well-being
	System	Roster scheduling	Rotating shifts and limited recovery time have a +/- impact on the perceived complexity/quality/workload/well-being
	Collaboration	Personnel changes	Turnover of colleagues and changes in teams (e.g., onboarding) have a +/- impact on the perceived complexity/quality/workload/well-being
	Function/role	Contact person	Serving as the central point of contact for patients and/or family has a +/- impact on the perceived complexity/quality/workload/well-being
	Individual	Autonomy	(Lack of) control/grip and independence has a +/- impact on the perceived complexity/quality/workload/well-being
	Individual	Challenge	(Lack of) challenge has a +/- impact on the perceived complexity/quality/workload/well-being
	Individual	Trust	Nurses experience a +/- influence on levels of self-confidence or trust in the team/colleagues
	Individual	Work experience	The amount of nursing experience has a +/- influence on the perceived complexity/quality/work pressure/well-being
	Individual	Routine	Working routinely has a +/- influence on the perceived complexity/quality/work pressure/well-being
	Support	Education	Education and learning opportunities have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Support	Protocols	Protocols and instructions have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Support	Support	Team collaboration has a +/- impact on the perceived complexity/quality/work pressure/well-being
Wellbeing	Work performance/ Patient wellbeing	Health & recovery patient	The available care influences the physical health and recovery of the patient
	Work performance/ Patient wellbeing	Duration of stay of patients	The available care influences the duration and intensity of the hospital stay
	Work performance/ Patient wellbeing	Job satisfaction	Nurses experience a sense of satisfaction (e.g., fulfillment, appreciation, joy, relaxation)
	Work performance/ Patient wellbeing	Dissatisfaction	Nurses experience a sense of dissatisfaction (e.g., frustration, discontent)

	Work performance/ Patient wellbeing	Wellbeing	Nurses experience an impact on their health (e.g., energy levels/fatigue, physical strain, stress, recovery, work-life balance)
	Work performance/ Patient wellbeing	Employability	Nurses experience an impact on their personal employability (e.g., commitment, development, and professional choices)

Additional file 2: Codebook physicians

Thema	**Code-group**	**Short code**	**Long code**
Complexity	Patient complexity	Treatment & tasks	Physicians experience complexity in the quantity/nature of care procedures
	Coordination of care	Patient plan	Physicians experience complexity in patient care plan (changes)
	Coordination of care	Chain care	Physicians experience complexity in patient flow (and collaboration) in the healthcare chain
	Coordination of care	Organize	Physicians experience complexity in (logistically) organizing care around/for the patient and departmental management
	Patient complexity	Medical conditions	Physicians experience complexity in the nature and quantity of medical conditions in patients
	Coordination of care	Collaboration	Physicians experience complexity in multidisciplinary collaboration with multiple specialties
	Coordination of care	Prioritize	Physicians experience complexity in setting priorities
	Coordination of care	Switching	Physicians experience complexity in frequent switching with patients/colleagues
	Coordination of care	Development	Physicians experience complexity in developments in patient population and care trajectories
Quality of care	Definition of quality	Patient satisfaction	For physicians, the patient experience is a crucial pillar for quality
	Definition of quality	Attention	For physicians, time and attention to the patient are essential pillars for quality.
	Definition of quality	Basic care	For physicians, performing the necessary care procedures/treatments is a pillar for quality
Stressors & facilitators	Collaboration	Division of tasks	Performing non-function-related tasks has a +/- impact on the perceived complexity/quality/work pressure/well-being
	System	Administration	Conducting administrative tasks has a +/- impact on the perceived complexity/quality/workload/well-being
	System	System	Brief and action-intensive patient admissions have a +/- impact on the perceived complexity/quality/workload/well-being
	System	Regulations	Laws and regulations, as well as quality requirements, have a +/- impact on the perceived complexity/quality/work pressure/well-being

	System	Innovation	Change and innovation in the field have a +/- impact on the perceived complexity/quality/work pressure/well-being
	System	Patient flow	Limited patient flow in the chain and the transfer of care (responsibility) have a +/- impact on the perceived complexity/quality/workload/well-being
	System	Availability of time and resources	Limited availability of time, resources, and staffing has a +/- impact on the perceived complexity/quality/workload/well-being
	System	Timing	Acute situations and timing have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Collaboration	Lack of clarity	(Lack of) clarity regarding patient policy and treatment has a +/- impact on the perceived complexity/quality/workload/well-being
	Collaboration	Communication	(In)efficient communication with colleagues and parents/family has a+/- impact on the perceived complexity/quality/workload/well-being
	System	Roster scheduling	Rotating shifts and limited recovery time have a +/- impact on the perceived complexity/quality/workload/well-being
	System	Expectations	(Changes in) patient or system requirements and expectations have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Team	Personnel changes	Turnover of colleagues and changes in teams (e.g., onboarding) have a +/- impact on the perceived complexity/quality/workload/well-being
	Function/role	Contact person	Serving as the central point of contact for patients and/or family has a +/- impact on the perceived complexity/quality/workload/well-being
	Function/role	Responsibility	Sense of responsibility and/or expertise has a +/- impact on the perceived complexity/quality/work pressure/well-being
	Function/role	Professional development	Ambition and competition have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Individual	Coping	A coping mechanism and/or setting boundaries have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Individual	Autonomy	(Lack of) control/grip and independence has a +/- impact on the perceived complexity/quality/workload/well-being
	Individual	Challenge	(Lack of) challenge has a +/- impact on the perceived complexity/quality/workload/well-being
	Individual/ Collaboration	Trust	Physicians experience a +/- influence on levels of self-confidence or trust in the team/colleagues
	Individual	Work experience	The amount of work experience has a +/- influence on the perceived complexity/quality/work pressure/well-being

	Individual	Routine	Working routinely has a +/- influence on the perceived complexity/quality/work pressure/well-being
	Support	Education	Education and learning opportunities have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Support	Protocols	Protocols and instructions have a +/- impact on the perceived complexity/quality/work pressure/well-being
	Support	Support	Team collaboration has a +/- impact on the perceived complexity/quality/work pressure/well-being
Welzijn	Work performance/ Patient wellbeing	Health & Recovery patient	The available care influences the physical health and recovery of the patient
	Work performance/ Patient wellbeing	Duration of stay of patients	The available care influences the duration and intensity of the hospital stay
	Work performance/ Patient wellbeing	Job satisfaction	Physicians experience a sense of satisfaction (e.g., fulfillment, appreciation, joy, relaxation)
	Work performance/ Patient wellbeing	Dissatisfaction	Physicians experience a sense of dissatisfaction (e.g., frustration, discontent)
	Work performance/ Patient wellbeing	discomfort	Physicians experience a sense of discomfort and unfamiliarity (e.g., uncertainty, discomfort)
	Work performance/ Patient wellbeing	Wellbeing	Physicians experience an impact on their health (e.g., energy levels/fatigue, physical strain, stress, recovery, work-life balance)
	Work performance/ Patient wellbeing	Employability	Physicians experience an impact on their personal employability (e.g., commitment, development, and professional choices)

Exploring hospital data for factors associated with employee sick leave and work engagement.

1 February 2024

This report was prepared in the context of the Dutch project '*Geef bevlogenheid vleugels: de basis van gewoon goede zorg*' by Tom Bazuin (UMCG) under daily supervision of Michiel Oerbekke (Cochrane) and Iris Reijmerink (UMCG) and project lead Maarten van der Laan (UMCG) and steering group members Lotty Hooft (Cochrane), Arie Franx (Erasmus MC), Dave Dongelmans (Amsterdam UMC), Annelies Visser (Amsterdam UMC), Götz Wietasch (UMCG) and Leontien Sturms (NFU).

ABSTRACT

Background: In the current healthcare landscape, the well-being of healthcare professionals is a critical concern. High working load and ever-present shortages emphasize the importance of addressing their well-being. Simultaneously, an increasing trend of departing healthcare professionals can be seen, further jeopardising well-being and possibly quality of care. Sick leave and engagement serve as valuable indicators, yet exact mechanisms behind how these and other department characteristics are related, are unknown.

Aim: We aim to gain insight into department-level factors influencing sick leave and engagement, offering valuable insights for targeted interventions and policymaking.

Method: In this cross-sectional database study, data from multiple in-hospital sources were integrated into three databases. Data on patient population, employee population, process of care, quality of care, employee satisfaction and patient satisfaction were analysed at department level to identify differences, correlations, and predictors. Multiple statistical tests were performed. In addition, scatter plots were observed for nursing departments and for physicians and residents.

Results: Multiple parameters seem to be associated with sick leave and engagement, most notable are both differences and correlations on parameters regarding capacity and turnover. When analysing data on a lower aggregation level, other parameters such as age of the healthcare professional, seem to be associated with both sick leave and engagement. Most data on experiences, both patients' and employees', do not show associations with sick leave or engagement.

Conclusion: Department capacity and turnover are characteristics that possibly relate to sick leave and engagement. Sick leave seems to be higher in departments with more capacity and higher turnover. Furthermore, data on experiences, do not relate with sick leave or engagement, thereby questioning the evidence for these questionnaires.

Keywords: sick leave, engagement, healthcare professional, well-being, hospital data

1. INTRODUCTION

In the current healthcare landscape, the well-being of healthcare professionals (HCPs) has taken centre stage as an urgent and critical concern. (1) With an aging population, demand for HCPs is growing. In the Netherlands, it is estimated that there will be a shortage of 135,000 HCPs by 2032. (2,3) However, simultaneously, an increasing trend of departing HCPs can be seen, attributed by multiple factors, such as high workload and burnout . (4) The challenges posed by recent global health crises, including the COVID-19 pandemic, have amplified the need to address the physical, mental, and emotional welfare of those on the frontlines in healthcare. (5)

An employee's absence from work due to short or long -term sickness, can give valuable insights into the well-being of employees. (6,7) In the Netherlands, the healthcare sector has been dealing with high rates of sick leave, steadily increasing from 4% in 2013 to 8% in 2022, the highest of all sectors in the Netherlands. (8) This can be attributed to factors such as the demanding nature of working in healthcare and a tough work-life balance. The staff shortages arising from sick leave will exert greater pressure on the remaining employees, leading to a rise in workload and a rise in healthcare costs. (9,10) This situation not only impacts the quality of care patients receive but also significantly affects the well-being of the HCP themselves. (11) They tend to feel more burned out and lose joy in working, thus losing engagement. (12) The loss of engagement is particularly problematic as low engaged HCPs are less satisfied with their work, lose productivity and are ultimately more likely to leave their job. (13,14) Sick leave and engagement are valuable measures to estimate general well-being of HCPs working in a hospital department. (6,15) To alleviate the growing demand for future HCPs, understanding how to maintain engagement and reduce sick leave in the current workforce is imperative. One way to understand this, is to investigate mechanisms that underlie this.

While prior research has predominantly centred on the individual HCP, there appears to be a notable scarcity in studies delving into the broader context of work environment and organizational culture. (16,17) This limited perspective hampers our understanding and inhibits effective solutions for improving HCPs' well-being. This study evaluates the broader picture, by using data gathered throughout hospitals. These data is gathered for internal and external (national) monitoring and accountability. A multitude of data is generated in hospitals every year, ranging from patient experiences to employee satisfaction and from numbers regarding process of care to specific characteristics of patients in a specific department. These department characteristics are often used to assess department performance. (18) Hospital policymakers use this to target their strategy. However, literature linking data on a department-level on sick leave, patient experience is limited. Combining data from different sources, such as quality indicators or the patient experiences monitor, within a single hospital may provide an useful tool to generate powerful quality indicators for steering

and monitoring quality of care, patient experience and engagement within departments, which might give policymakers more grip on how and where to support HCP on department-level.

There is a fast amount of quality and safety data, HCP data and data on patient experience which is collected by healthcare organisations and not being used to learn or to improve. One of the cornerstones of creating a learning organisation is a well-integrated feedback loop based of own data. (19) Moreover, using data derived from one's own practice is essential in Evidence Based Medicine and shapes shared discission making. It would be extremely useful to use these data to learn and improve than just sending out reports to supervising agencies.

By understanding how sick leave and engagement differ among departments, and their association with hospital performance measures, we aim to explore hospital data to identify risk factors of sick leave and loss of engagement. These factors might help policymakers recognize departments at risk of high sick leave or low engagement as a careful entry point to decide whether department-wide well-being interventions need to be implemented or (re-)evaluated.

2. METHOD

2.1 Study design and setting

In this this cross-sectional database study with data gathered from year 2022, conducted in a single University Medical Centre (UMC) in the Netherlands, data from the world of systems, such as quality indicators and data on sick leave, and data from perceptions, such as data from the employee satisfaction survey, were combined.

2.2 Data collection and analysis

Data was requested at the hospital's business intelligence centre regarding the patient characteristics, process of care parameters and quality of care indicators (indicators from the Dutch national register hospital care as well as nursing parameters). The hospital's department of quality and safety provided parameters regarding incidents and calamities. The human resource department provided parameters on employee population as well as data from the employee satisfaction survey. Data were stored in several different databases, not yet interoperable. The collected data was categorized in six categories: 1) patient population; 2) employee population; 3) process of care (e.g., clinical admissions); 4) quality of care; 5) employee satisfaction survey (in Dutch: *Medewerker BelevingsOnderzoek*, abbreviated as MBO); and 6) patient experience monitor (PEM). Three datasets emerged from the original dataset with different definitions of departments. In the first dataset, parameters are organised at a high level, namely at specialty level (e.g. cardiology, surgery, etc.) in the hospital, and contain all HCPs working with patients in that department. In the second dataset, parameters are organised at a lower level, namely nursing departments, and include only nurses working in that particular department. In the third and final dataset, parameters are organised again at specialty level, yet this time only including doctors, both physicians and residents (not) in training, in that particular department. For all datasets, medical and nursing students or those working without patient contact were excluded. The main analysis was performed for dataset one. While not a priori defined, to better understand possible mechanisms found in the main analysis, an exploratory sub-analysis was performed for the second and third dataset. An overview of the requested parameters can be found as a codebook of the dataset in supplementary file one.

2.3 Statistical analysis

For statistical analysis, SPSS IBM software version 28 was used. Data was analysed for two outcomes: 1) sick leave, and 2) engagement. Depending on the type of analysis, sick leave and engagement were defined as continuous or dichotomized (high vs. low) variables. For sick leave, the median rate of all departments was used as a cut-off to dichotomize departments as high versus low

sick leave. Engaged departments were identified in a plot on their respective vitality and connectedness scores, a process used in the UMC where this study took place to define engagement. The cut-off was set at the medians of both vitality and connectedness. The quadrant with departments having high vitality and connectedness scores were assumed an engaged department, whereas departments in the quadrant with low vitality and connectedness scores were assumed unengaged and thus at risk for burn-out or bore-out. Departments from which data was insufficient or missing were excluded for analysis. Furthermore, differences between groups using student T-tests or the Mann Whitney-U test (depending on normality) and correlations with the Pearson or Spearman coefficient (depending on normality) were explored, without adjusting for multiple testing, and multiple linear regression models for identifying independent associations were used. Assumptions for multiple linear regression were checked and variables were transformed where necessary to meet these assumptions. Choices for variables in the regression models were directed by theory from the Job Demands and Resources-model (JDR-model). (20) The JDR-model, developed by Schaufeli and Bakker outlines how job demands and resources influence employee well-being, resulting in a selection of parameters for six different categories: 1) energy sources; 2) stressors; 3) well-being; 4) organisation; 5) quality of care; and 6) patient experience. The regression models were constructed using a backwards method with $p = .05$ for inclusion and $p = .10$ for exclusion. For explorative purposes under the constraint of a lack of power, the same models (backwards method) were also constructed when using $p = .20$ and $p = .30$ for in- and exclusion, respectively. Albeit these need to be interpreted with additional carefulness.

To give insights in how data is correlated, not necessarily linearly, on a lower level, meaning in the second and third dataset, scatter plots were made for all parameters against sick leave and engagement. These plots were inspected by the authors.

2.4 Lessons learned

Although not predefined as an objective or outcome, along the way we have documented some lessons learned when requesting and linking data from different sources within a single hospital where data sources were not immediately interoperable. Barriers were noted and categorized into different domains.

3. RESULTS

3.1 Department characteristics

For the main analysis, data on nearly 100 parameters were requested of which a selection was made of 35 most used and most applicable parameters (6 categories: patient population, employee population, process of care, quality of care, MBO and PEM), divided over 25 departments. Not all data for all the departments was accessible, due to multiple reasons. For instance, some data was not collected for all departments and some data could not be released, as this could breach privacy regulations due to small sample size of that specific department.

An overview of the most important parameters, their mean or median and standard deviation (SD) or interquartile range (IQR), respectively, and the *n* departments the parameter could be provided for, can be found in table 1. For further understanding the parameters of the MBO, a brief explanation is given in table 2.

Table 1: overview of department characteristics

	Variable	n	Missing	Mean	SD	Median	IQR	Min.	Max.
	Sick leave (outcome)	23	2	6.40	2.101	6.20	2.2	2.3	11.1
General	Patient age	24	1	53.38	13.190	-	-	6	81
	Patient stay	23	2	6.67	5.87	-	-	0.00	28.8
	Unique patients	20	5	11081.35	7129.30	-	-	1491	29501
	Staff age	23	2	40.61	1.973	-	-	37	46
	Capacity in FTE	23	2	-	-	102.40	192.3	16.5	482.7
Workload	Casemix patients	22	3	-	-	0.635		0.16	1.70
	Secondary diagnoses	20	5	-	-	12.65		0.60	50.0
	Patients per FTE	21	4	-	-	17.00		0.00	58.0
Employee satisfaction survey (MBO)	Job satisfaction	22	3	-	-	4.00		2.8	4.3
	Autonomy	22	3	3.10	0.4556	-	-	2.3	4.0
	Development	22	3	-	-	3.70	0.40	3.0	4.1
	Challenge	22	3	-	-	3.90	0.20	2.8	4.7
	Team	22	3	-	-	4.20	0.20	4.0	4.7
	Appreciation	22	3	3.33	0.400	-	-	2.4	4.0
	Supervisor	22	3	3.89	0.318	-	-	3.3	4.4
	Acceptable workload	22	3	3.10	0.432	-	-	1.8	3.9
	Health	22	3	3.20	0.448	-	-	2.3	4.3
	Connectedness	22	3	-	-	6.90	0.50	4.40	8.00
	Vitality	22	3	-	-	6.30	0.80	3.70	7.70
Reten-tion	Inflow compared to capacity	23	2	-	-	3.60	5.10	0.00	14.8
	Outflow compared to capacity	23	2	-	-	5.80	4.10	0.00	19.1
	Ratio inflow vs outflow	23	2	-	-	0.90	0.80	0.00	2.10
Quality of Care	HSMR (mortality)	20	5	-	-	45.00		0.00	452
	OLO (stay)	22	3	24.16	12.986	-	-	4.40	66.70
	Readmission ratio	20	5	98.10	29.100	-	-	40.0	152.0
	Pain in rest (%)	22	3	49.20	15.463	-	-	21.6	80.0
	Decubitus score	22	3	14.46	10.972	-	-	0.00	46.6
	Delirium score	21	4	-	-	28.20	20.4	0.00	66.7
	Patient incidents	24	1	-	-	72.00		8.0	535.0
	Patient calamities	24	1	-	-	0.00		0.00	6.0
	Occupational incidents	22	3	-	-	4.50		0.00	49.0
Patient Experience	Time om waiting list	7	15	10	-	-	62.70	25.4	37.1
	Trust in doctor	9	19	6	93.58	4.358	-	-	85.2
	Trust in nurse	9	19	6	-	-	87.40	5.5	80.7

	Available time for patient	9	21	4	96.83	1.121	-	-	95.4
	Nurse's time	9	19	6	76.40	6.011	-	-	64.0
	Shared decision-making clinic	8	16	9	84.74	5.864	-	-	70.3
	Shared decision-making outpatient	9	21	4	91.43	2.468	-	-	85.0
	Contradictory information	9	19	6	-	-	85.50	7.0	70.9
	Treatment with respect	9	19	6	92.86	4.130	-	-	84.2
	SD: standard deviation; IQR: interquartile range; MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek); FTE: full time equivalent; HCP: healthcare professional; HSMR: hospital standardized mortality rate; OLO: unexpected long hospital stay (in Dutch: onverwachte lange opnameduur)								

Table 2: explanation of MBO parameters

Parameter	**Explanation from survey**
MBO - Job satisfaction	*I enjoy my work*
MBO - Autonomy	*I can independently, within reasonable limits, determine how and when I do my work*
MBO - Development	*I have the opportunity to develop myself*
MBO - Challenge	*My work is appropriately challenging*
MBO - Team	*The relationship with my colleagues is good (in the team)*
MBO - Appreciation	*I receive sufficient appreciation for my work*
MBO - Supervisor	*The relationship with my supervisor is good*
MBO - Acceptable workload	*There is an acceptable workload*
MBO - Health	*I can do my work without negative effects on my health*
MBO - Vitality	*Indicate where you are on the balance of fatigue to vitality, with 1 indicating fatigue and 10 indicating vitality*
MBO - Connectedness	*Indicate where you are on the balance of distance to connectedness, with 1 indicating*
MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek)	

3.2 Examining high and low groups

The median sick leave rate of all departments was 6.2%. Based on this median, departments were categorized as either high or low sick leave. (Table 3)

Table 3: overview of distribution of departments, according to sick leave.

Group 1 **Low sick leave**	**Group 2** **High sick leave**	**Group 3** **Excluded**
Surgery	Anaesthesiology	Geriatrics
Dermatology	Cardiology	Emergency medicine
Gastro-enterology	Cardiothoracic surgery	
Maxillofacial surgery	Intensive Care	
Neurosurgery	Internal Medicine	
Ophthalmology	Paediatrics	

Plastic Surgery	Otorhinolaryngology	
Rheumatology	Pulmonology	
Urology	Neurology	
	Obstetrics & gynaecology	
	Orthopaedics	
	Psychiatry	
	Radiology	
	Radiotherapy	

The median vitality and connectedness, representing the engagement of departments, was 6.3% and 6.9% respectively. Based on both medians, departments were categorized as either high engaged (vitality > 6.3, connectedness >6.9) or low engaged (vitality < 6.3, connectedness <6.9). (Table 4) Departments that did not meet criteria for either group, were excluded from the analysis.

Table 4: overview of distribution of departments, according to engagement.

Group 1 **Low engaged departments**	**Group 2** **High engaged departments**	**Group 3** **Excluded**
Anaesthesiology	Cardiology	Psychiatry
Surgery	Cardiothoracic Surgery	Neurology
Internal Medicine	Dermatology	Maxillofacial surgery
Paediatrics	Pulmonology	Urology
Otorhinolaryngology	Rheumatology	Ophthalmology
Gastro-enterology	Plastic Surgery	Obstetrics & Gynaecology
Neurosurgery	Orthopaedics	Intensive Care
Radiotherapy		Geriatrics
Radiology		Emergency medicine

3.2.1 High versus low sick leave

When comparing high and low sick leave groups, significant differences were found for capacity ($U = 104.00$, $p = .009$), suggesting that departments with high sick leave are departments with relatively more employees. In addition, significant differences were detected for secondary diagnoses ($U = 76.50$, $p = .040$), thus suggesting sick leave is higher in departments where there are more patients that are diagnosed with extra diagnoses. The standardised mortality rate (HSMR), also significantly differed between high and low sick leave groups ($U = 69.00$, $p = .048$), suggesting that mortality might be higher in departments where sick leave was higher. Although not significant, both in- and outflow compared to capacity (as measured in percentual change in full time equivalent (FTE) per total FTE), seem to be different between the high and low sick leave group. ($U = 93.00$, $p = .059$ and $U = 90.50$, $p = .083$, respectively). Both are higher in the high sick leave group. Parameters from the MBO did not show significant differences between groups. Neither did parameters from the PEM. An overview of all parameters can be found in table 5.

Table 5: overview of tested parameters for sick leave

		Low sick leave			High sick leave			t / U	Sig.
	Variable	**n**	**Mean/ median**	**SD/ IQR**	**n**	**Mean/ median**	**SD/ IQR**		**p-value**
General	Patient age	9	53.22	5.608	13	50.69	15.326	t = -.471	0.643
	Patient stay	9	5.34	2.963	13	7.07	7.211	t = .675	0.507
	Unique patients	8	9244.50	5502.98	11	13289.09	7623.32	t = 1.274	0.220
	Staff age	9	41.07	2.70	14	40.31	1.368	t = -.888	0.384
	Capacity in FTE	9	48.20	60.20	14	164.70	171.70	U =104.00	0.009*
Workload	Casemix patients	9	0.490	0.66	12	0.760	0.82	U = 52.00	0.917
	Secondary diagnoses	9	10.60	9.80	11	13.50	27.8	U = 76.50	0.040*
	Patients per FTE	9	22.00	23.0	12	15.50	19.0	U = 40.00	0.345
Employee satisfaction survey (MBO)	Job satisfaction	9	3.90	0.10	13	4.00	0.20	U = 78.00	0.209
	Autonomy	9	3.01	0.506	13	3.12	0.432	t = .557	0.583
	Development	9	3.90	0.60	13	3.70	0.30	U = 49.00	0.556
	Challenge	9	3.90	0.30	13	3.90	0.20	U = 49.50	0.556
	Team	9	4.20	0.50	13	4.20	0.20	U = 53.00	0.744
	Appreciation	9	3.41	0.454	13	3.27	0.366	t = -.811	0.427
	Supervisor	9	3.94	0.394	13	3.85	0.263	t = -.704	0.490
	Acceptable workload	9	3.01	0.597	13	3.16	0.282	t = .796	0.435
	Health	9	3.28	0.652	13	3.15	0.247	t = -.668	0.577
	Connectedness	9	6.90	0.60	13	6.90	0.40	U = 58.50	1.00
	Vitality	9	6.30	1.10	13	6.30	0.80	U = 45.00	0.393
Reten-tion	Inflow compared to capacity	9	3.10	5.70	14	6.05	4.18	U = 93.00	0.062
	Outflow compared to capacity	9	3.10	6.80	14	6.00	2.20	U = 90.50	0.083
	Ratio inflow vs outflow	7	0.50	0.60	14	0.95	1.10	U = 68.50	0.149
Quality of Care	HSMR (mortality)	9	32.00	55.0	10	69.00	81.0	U = 69.00	0.048*
	OLO (stay)	9	21.07	5.09	12	25.44	16.71	t = .755	0.459
	Readmission ratio	9	96.33	41.452	10	102.20	12.985	t = .426	0.693
	Pain in rest (%)	9	53.50	12.658	12	46.30	17.727	t = -1.034	0.314
	Decubitus score	9	11.53	8.093	12	13.967	9.00	t = .639	0.530
	Delirium score	9	26.10	24.5	11	28.20	20.3	U = 56.50	0.603
	Patient incidents	9	46.00	66.0	14	89.00	162	U = 96.50	0.033*
	Patient calamities	9	0.00	1.0	14	1.00	1.00	U = 79.00	0.336
	Occupational incidents	8	1.00	6.0	12	8.00	30.0	U = 78.50	0.016*
Patient Experience Monitor (PEM)	Time om waiting list	7	56.40	27.6	8	64.65	17.9	U = 38.00	0.281
	Trust in doctor	9	94.06	4.509	9	93.87	4.018	t = -.094	0.926
	Trust in nurse	9	87.20	5.60	9	90.70	6.90	U = 57.00	0.161
	Available time for patient	9	96.53	0.915	11	96.79	0.870	t = .644	0.528
	Nurse's time	9	76.01	6.028	9	77.63	5.988	t = .573	0.575
	Shared decision-making clinic	8	86.64	3.995	8	82.84	7.033	t = -1.329	0.205
	Shared decision-making outpatient	9	92.50	2.093	11	90.56	2.612	t = -1.799	0.089
	Contradictory information	9	82.40	8.80	9	85.50	4.80	U = 45.00	0.730

	Treatment with respect	9	92.04	5.247	9	93.62	3.070	t = .779	0.448
MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek); FTE: full time equivalent; HCP: healthcare professional; HSMR: hospital standardized mortality rate; OLO: unexpected long hospital stay (in Dutch: onverwachte lange opnameduur)									

3.2.2 High versus low engagement

When comparing high engaged departments with low engaged departments, significance was found for capacity (U = 4.00, p = .030), illustrating that in departments where engagement is high, capacity is relatively lower. In addition, decubitus scores are higher in high engaged departments (U = 26.50, p = .012). Nearly all parameters originating from the MBO seem to be higher in the high engaged departments. Significant differences were found for autonomy (U = 32.50, p = .010), challenge (U = 34.00, p = .005), job satisfaction (U = 35.00, p = .003), appreciation (U = 33.50, p = .005), experienced health (U = 34.50, p = .003), team (U = 30.50, p = .030), development (U = 32.50, p = .010) and work environment (U = 33.00, p = .010). No significant differences were found for the PEM between high engaged and low engaged departments, nor were differences found for indicators regarding retention of personnel. An overview of all parameters can be found in table 6.

Table 6: overview of tested parameters for engagement

		Low engagement			High engagement			U	Sig.
	Variable	**n**	**Median**	**IQR**	**N**	**Median**	**IQR**		**2-tailed**
General	Patient age	5	58,00	5,00	7	60,00	15,00	U = 20.00	.755
	Patient stay	5	5,80	6,35	7	6,10	5,10	U = 25.00	.268
	Unique patients	4	14873,50	20096,75	7	6583,00	5199,00	U = 8.00	.315
	Staff age	5	39,20	2,80	7	40,60	3,50	U = 29.00	.071
	Capacity in FTE	5	208,70	163,65	7	46,00	55,80	U = 4.00	.030
Workload	Casemix patients	4	0,69	0,80	7	0,93	0,77	U = 19.00	.412
	Secondary diagnoses	3	13,00	n/a	7	12,30	15,10	U = 8.00	.667
	Patients per FTE	4	19,50	35,00	7	21,00	21,00	U = 16.00	.788
Employee satisfaction survey (MBO)	Work enjoyment	5	3,80	0,70	7	4,10	0,10	U = 35.00	.003
	Autonomy	5	2,90	0,60	7	3,40	0,40	U = 32.50	.010
	Development	5	3,40	0,70	7	4,00	0,10	U = 32.50	.010
	Challenge	5	3,70	0,65	7	4,10	0,30	U = 34.00	.005
	Team	5	3,80	0,10	7	3,90	0,20	U = 30.50	.030
	Appreciation	5	4,10	0,15	7	4,30	0,20	U = 33.50	.005
	Supervisor	5	3,70	0,75	7	3,90	0,40	U = 22.50	.432
	Acceptable workload	5	2,90	0,70	7	3,40	0,60	U = 31.50	.018
	Health	5	2,90	0,60	7	3,60	0,70	U = 34.50	.003
Reten-tion	Inflow compared to capacity	5	7,20	4,40	7	3,10	5,60	U = 9.00	.202
	Outflow compared to capacity	5	8,10	9,05	7	4,30	6,80	U = 6.00	.073
	Ratio inflow vs outflow	5	1,20	1,05	5	1,00	1,30	U = 13.00	1.00
Quality of Care	HSMR (mortality)	3	48,00	n/a	7	9,00	69,00	U = 6.50	.383
	OLO (stay)	4	21,55	15,58	7	23,10	15,70	U = 19.00	.412
	Readmission ratio	3	118,00	n/a	7	95,00	49,00	U = 4.00	.183
	Pain in rest (%)	4	58,50	24,43	7	54,90	26,40	U = 11.50	.648
	Decubitus score	4	7,95	10,83	7	17,10	9,30	U = 26.50	.012
	Delirium score	4	29,45	25,65	7	25,60	19,30	U = 13.00	.927
	Patient incidents	5	59,00	269,50	7	65,00	70,00	U = 14.00	.639
	Patient calamities	5	1,00	4,50	7	0,00	0,00	U = 5.00	.048
	Occupational incidents	5	2,00	26,50	4	5,00	38,25	U = 10.50	1.00
Patient Experience Monitor (PEM)	Time om waiting list	3	56,40	n/a	5	64,10	39,55	U = 9.00	.786
	Trust in doctor	4	94,70	5,70	7	93,80	1,70	U = 9.00	.412
	Trust in nurse	4	90,15	3,80	7	87,40	7,60	U = 10.00	.527
	Available time for patient	4	97,20	0,92	7	96,90	1,90	U = 9.50	.412
	Nurse's time	4	77,25	7,43	7	78,90	10,00	U = 17.00	.648
	Shared decision-making clinic	3	84,80	n/a	6	83,00	10,85	U = 6.50	.548
	Shared decision-making outpatient	4	91,10	3,28	7	92,30	5,60	U = 17.00	.648
	Contradictory information	4	95,40	0,47	7	94,20	3,10	U = 12.00	.788

	Treatment with respect	4	93,25	7,23	7	93,20	3,60	U = 13.00	.927
MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek); FTE: full time equivalent; HCP: healthcare professional; HSMR: hospital standardized mortality rate; OLO: unexpected long hospital stay (in Dutch: onverwachte lange opnameduur)									

3.3 Examining correlations

3.3.1 Sick leave and department characteristics

Sick leave was correlated with all parameters gathered. Significant correlations were found for capacity ($r = .679$, $p < .001$) and outflow compared to capacity ($r = .425$, $p = .043$). In addition, significant correlations were found for patient incidents ($r = .575$, $p = .004$) and work-related incidents ($r = .464$, $p = .040$). HSMR also seems to increase when sick leave is higher (or vice versa), this correlation is however not significant ($r = .447$, $p = .055$). No significant correlations were found for PEM, nor for the MBO. An overview of all parameters can be found in supplementary file two.

3.3.2 Engagement and department characteristics

When correlating engagement with all characteristics, significances can be found for the age of the HCP ($r = .443$, $p = .039$). As for sick leave, negative correlations can be found between engagement and capacity and outflow compared to capacity ($r = -.578$, $p = .005$ and $r = -.452$, $p = 0.035$, respectively). Nearly all parameters originating from the MBO seem to be positively correlated with engagement. Significant correlations were found for acceptable workload ($r = .574$, $p = .005$), experienced health ($r = .766$, $p < .001$), job satisfaction($r = .766$, $p < .001$), autonomy ($r = .487$, $p = .021$), development ($r = .640$, $p = .001$), challenge ($r = .641$, $p = .001$), team ($r = .515$, $p = .001$) and appreciation ($r = .515$, $p = .014$). One parameter from the MBO did not show to be significantly correlated with engagement, namely the satisfaction with the Supervisor ($r = .242$, $p = .278$). Decubitus scores and patient calamities were also significantly correlated with engagement ($r = .574$, $p = .008$ and $r = -.458$, $p = .032$, respectively). Again, no correlations were found for the PEM. An overview of all parameters can be found in supplementary file three.

3.4 Multivariable associations

3.4.1 Independent predictors of sick leave

The results of the regression models can be found in table 7, presented below. For model 1 (energy sources), the parameter Team was a significant predictor of sick leave ($B = -4.029$, $p = .050$). In model 2 (stressors), no parameters showed to be an independent predictor for sick leave. For model 3 (well-being), both vitality and job satisfaction were identified as a significant predictor of sick leave ($B = -0.177$, $p = .012$ and $B = 0.670$, $p = .038$, respectively). In model 4 (organisation), capacity was found as a significant predictor ($B = 1.381$, $p = .003$). For model 5 (quality of care), no significant predictor was

identified. For model 6 (patient experience), three independent predictors of sick leave were identified, namely Waiting list, Trust nurse and Time nurse (B = .118, p = .005 and B = .002, p = .069 and B = -.330, p= .010, respectively).

In addition to these models, additional regression models were performed with an entry of $p < .2$ and removal set at $p < .3$. The results of this analysis can be found in supplementary file four.

Table 7: Independent predictors of sick leave in categories determined from the JDR-model identified from multiple regression analyses.

	Tested variables input	**Tested variables output**
Model one Energy sources		***Constant** (B = 23.287, p = .010)*
	MBO - Autonomy	-
	MBO - Supervisor	-
	MBO - Team	MBO - Team (B = -4.029, p = .050)
	MBO – Development*	-
	MBO - Appreciation	-
	MBO - Challenge	-
Model two Stressors		***Constant** (B = 6.564, p = .000)*
	MBO - Workload	-
	Patients per FTE†	-
	Casemix†	-
	Secondary diagnoses†	-
	Occupational incidents‡	-
Model three Well-being		***Constant** (B = 3.051, P= .323)*
	MBO - Health	-
	MBO – Vitality*	MBO – Vitality (B = -.177, p = .012)
	MBO - Connectedness†	-
	MBO - Involvement	-
	MBO – Job satisfaction*	MBO – Job satisfaction (B = .670, p = .038)
Model four Organisation		***Constant** (B = -.106, p = .955)*
	Inflow compared to capacity†	-
	Outflow compared to capacity†	-
	Unique patients	-
	Capacity‡	Capacity (B = 1.381, p = .003)
	Age of HCP	-
Model five Quality of care		***Constant** (B = 6.371, p = .000)*
	Patient incidents‡	-
	Calamities†	-
	HSMR‡	-
	OLO	-
	Readmission ratio	-
Model six Patient experience		***Constant** (B = 12.250, p = .060)*
	Waiting list	Waiting list (B = .118, p = .005)
	Trust physician	-
	Trust nurse*	Trust nurse (B = .002, p = .069)
	Time physician	-
	Time nurse	Time nurse (B = -.330, p = .010)
	Shared decision making	-

MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek); FTE: full time equivalent; HCP: healthcare professional; HSMR: hospital standardized mortality rate; OLO: unexpected long hospital stay (in Dutch: onverwachte lange opnameduur)
* transformed variable: squared; † transformed variable: square root; ‡ transformed variable: natural logarithm

3.4.2 Independent predictors of engagement

The results of the regression models can be found in table 8, presented below. For model 1 (energy sources), both Team and Challenge were significant independent predictors of engagement (B = 2.249, p < .001 and B = 3.606 and p < .001, respectively). In model 2 (stressors), two significant independent predictors were identified, namely Workload and Patients per FTE (B = 4.503, p < .001 and B = .414, p = .010, respectively). For model 3 (well-being), Health and Job satisfaction were found as significant predictors of engagement (B = 1.002, p = .002 and B = .524, p < .001, respectively). In model 4 (organisation), in- and outflow compared to capacity and age of the HCP were identified as independent predictors of engagement (B = .918, p = .037 and B = -1.357, p = .001 and B = .475, p = .013, respectively). For model 5 (quality of care) and model 6 (patient experience), no significant predictors were identified.

In addition to these models, additional regression models were performed with an entry of p < .2 and removal set at p < .3. The results of this analysis can be found in supplementary file five.

Table 8: Independent predictors of engagement in categories determined from the JDR-model identified from multiple regression analyses.

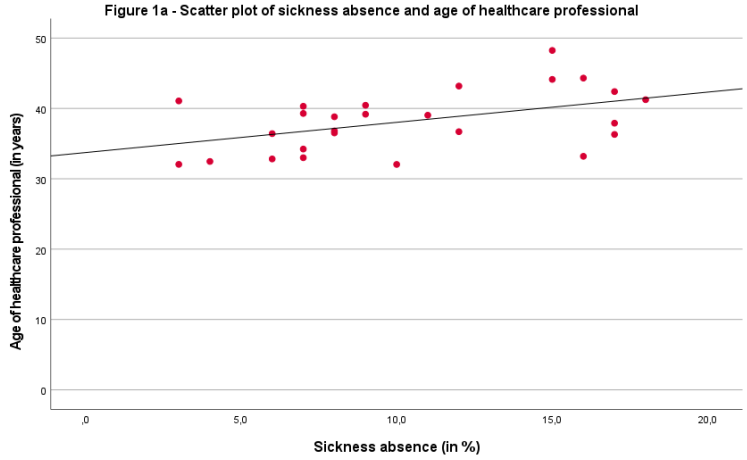
	Tested variables input	**Tested variables output**
Model one Energy sources		***Constant** (B = -10.532, p < .001)*
	MBO - Autonomy	-
	MBO - Supervisor	-
	MBO - Team	MBO - Team (B = 2.249, p < .001)
	MBO – Development*	-
	MBO - Appreciation	-
	MBO - Challenge	MBO – Challenge (B = 3.606, p < .001)
Model two Stressors		***Constant** (B = -.884, p = .647)*
	MBO - Workload	MBO – Workload (B = 4.503, p < .001)
	Patients per FTE†	Patients per FTE (B = .414, p = .010)
	Casemix†	-
	Secondary diagnoses†	-
	Occupational incidents‡	-
Model three Well-being		***Constant** (B = 1.866, p =.030)*
	MBO - Health	MBO – Health (B = 1.002, p = .002)
	MBO - Involvement	-
	MBO – Job satisfaction*	MBO – Job satisfaction (B = .524, p < .001)
Model four Organisation		***Constant** (B =-5.798, p = .439)*
	Inflow compared to capacity†	Inflow compared to capacity (B = .918, p = .037)
	Outflow compared to capacity†	Outflow compared to capacity (B = -1.357, p = .001)
	Unique patients	-
	Capacity‡	-
	Age of HCP	Age of HCP (B = .475, p = .013)
Model five Quality of care		***Constant** (B = 13.021, p < .001)*
	Patient incidents‡	-

	Calamities†	-
	HSMR‡	-
	OLO	-
	Readmission ratio	-
Model six Patient experience		***Constant*** *(B = 13.193, p < .001)*
	Waiting list	-
	Trust physician	-
	Trust nurse*	-
	Time physician	-
	Time nurse	-
	Shared decision making	-
MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek); FTE: full time equivalent; HCP: healthcare professional; HSMR: hospital standardized mortality rate; OLO: unexpected long hospital stay (in Dutch: onverwachte lange opnameduur) * transformed variable: squared; † transformed variable: square root; ‡ transformed variable: natural logarithm		

3.5 Examining nursing departments

Scatter plots were made for sick leave and engagement, on nursing department level. Interesting associations were observed for the age of HCP. The age of HCPs seems to be positively correlated with sick leave (r = .469, p = .016) (figure 1a) and negatively with engagement (r = -.249, p = .231) (figure 1b). Thus, when nurses get older, sick leave appears to increase and engagement to decrease.

Figure 1a - Scatter plot of sickness absence and age of healthcare professional



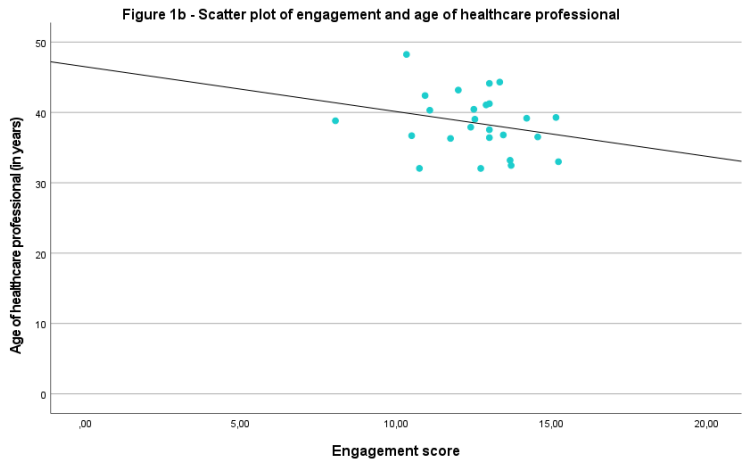
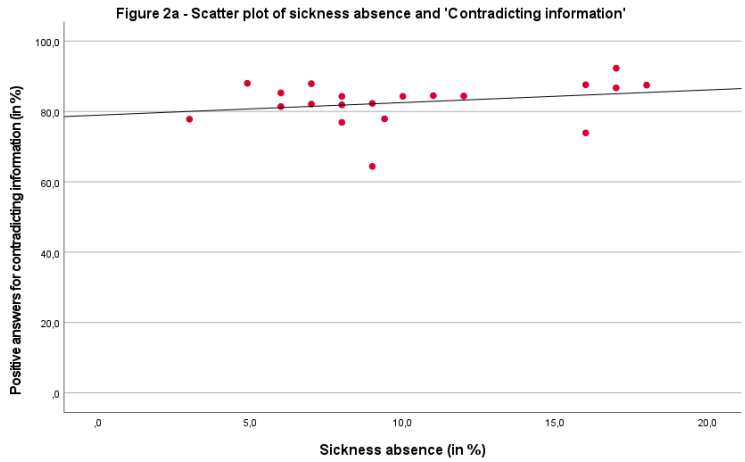


Figure 1 – scatter plots of the age of nurses in relation to both sick leave and engagement.

Age is displayed in years on the y-axes. In figure 1a, sick leave is displayed on the x-axis in percentages and in figure 1b, the x-axis is the sum of Vitality and Connectedness, thus engagement.

On nursing department level, data from the PEM also show minimal correlation with sick leave, yet not with engagement. An example of this can be seen for Contradicting information between physician and nurse, where a score of 100 meant that physician did not tell the patient contradicting information and a score of 0 meant that all information received was contradicting. A positive correlation can be observed between this and sick leave (r = .259, p = .270) (figure 2a), whereas this correlation does not seem to be present for engagement (r = -.029, p = .911) (figure 2b).



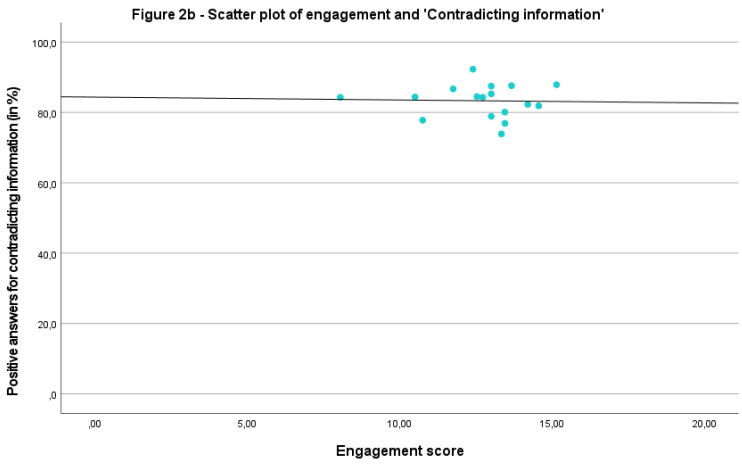
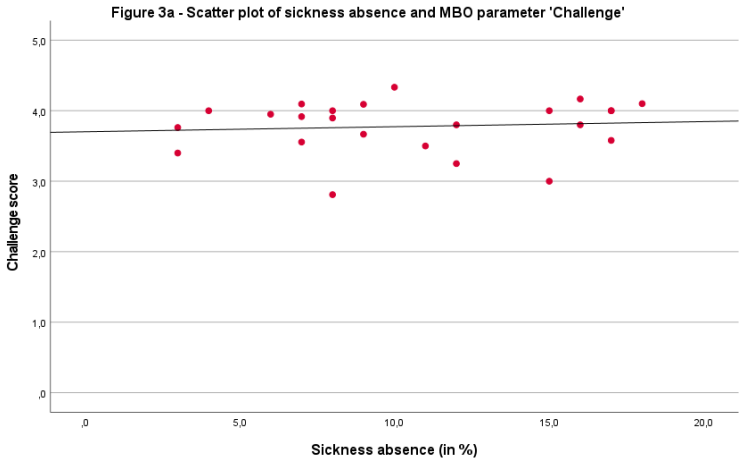


Figure 2 – scatter plots of the percentage of positive scores on 'Contradicting information between nurse and physician'.
On the y-axes, the percentage of positive responses on the question regarding contradicting information in the patient experience monitor, is displayed. In figure 2a, sick leave is displayed on the x-axis in percentages and in figure 2b, the x-axis is the sum of Vitality and Connectedness, thus engagement.

Parameters from the MBO do not seem to correlate with sick leave. Yet, correlations can be seen between these parameters and engagement. An example of this can be seen below, where sick leave ($r = .092$, $p = .669$) (figure 3a) and engagement ($r = .648$, $p < .001$) (figure 3b) were correlated with the MBO parameter Challenge, in which participants were asked whether their job is, in a good way, challenging.



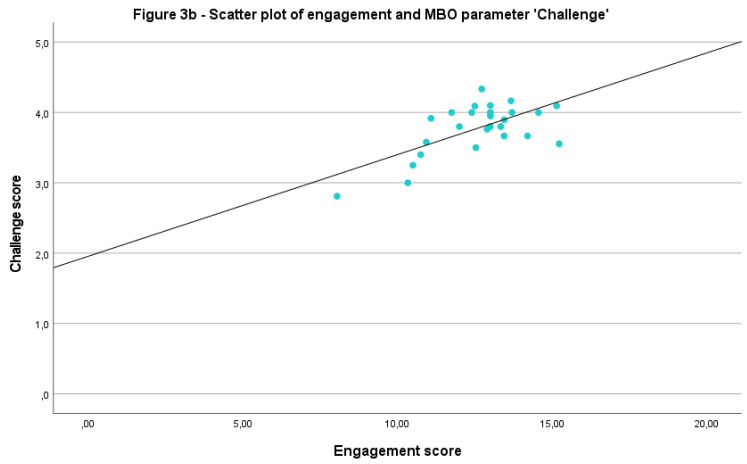


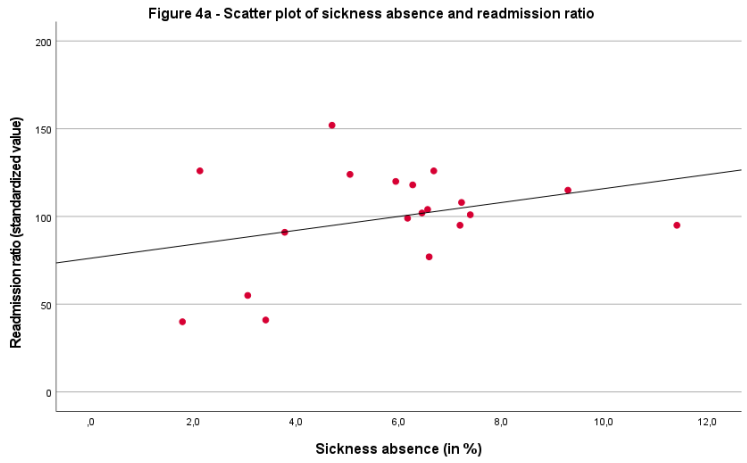
Figure 3 – scatter plots of the employee satisfaction survey parameter 'Challenge', which indicates whether participants find their job, in a good way, challenging.

On the y-axes, the mean score per department for 'Challenge' is displayed. In figure 3a, sick leave is displayed on the x-axis in percentages and in figure 3b, the x-axis is the sum of Vitality and Connectedness, thus engagement.

MBO: employee satisfaction survey (in Dutch: medewerker belevingsonderzoek)

3.6 Examining physicians and residents

When looking at scatter plots made for the residents and physicians per specialty, some correlations were observed. For quality of care, an observation can be made for the Readmission Ratio. A positive correlation can be seen for sick leave (r = .322, p = .178) (figure 4a) and a negative correlation for engagement (r = -.259, p = .284) (figure 4b).



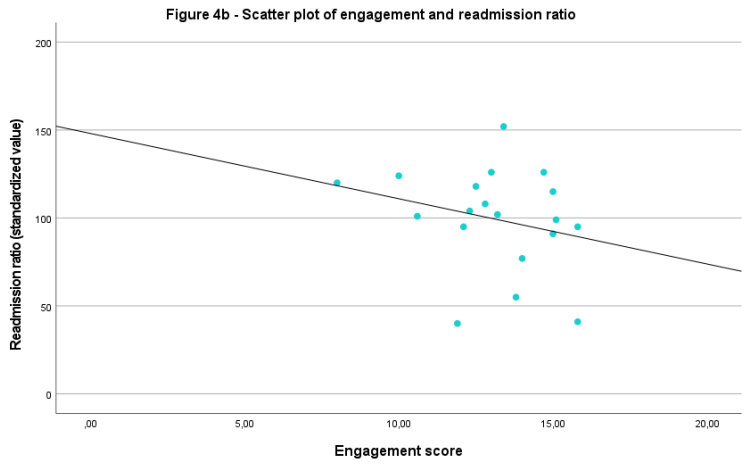
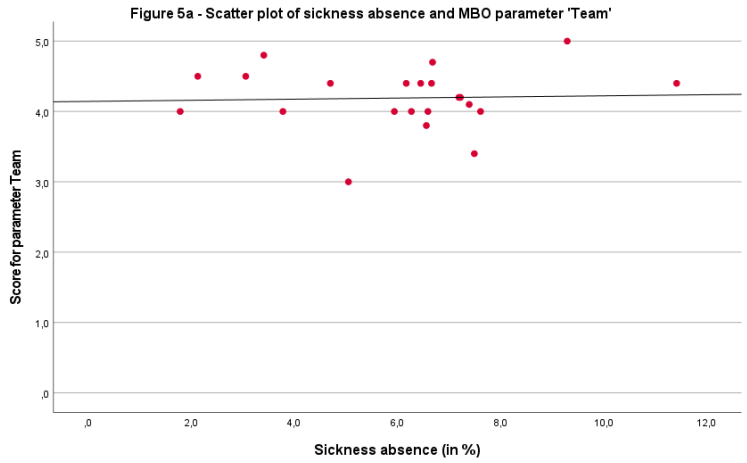


Figure 4 – scatter plots of readmission ratio.

On the y-axes, the readmission ratio. In figure 4a, sick leave is displayed on the x-axis in percentages and in figure 4b, the x-axis is the sum of Vitality and Connectedness, thus engagement.

As for nursing departments, data from the MBO generally do not show correlations with sick leave. Again, MBO data do seem to be correlated with engagement. Below an example of the parameter Team where no correlation can be seen for sick leave (r = .040, p = .858) (figure 5a) and a positive correlation can be seen for engagement (r = . 658, p < .001) (figure 5b).



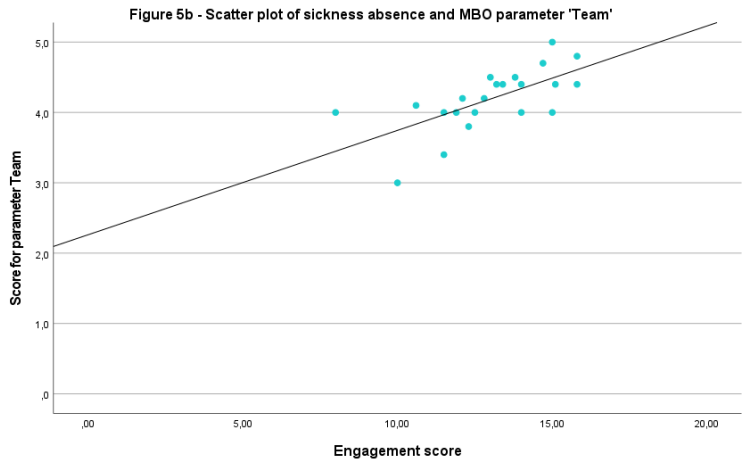
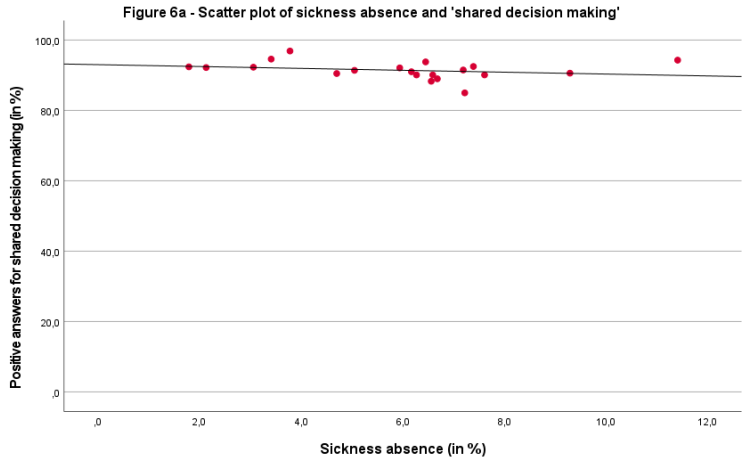


Figure 5 – scatter plots of the MBO parameter Team, in which participants were asked to rate the quote 'In this team, we help each other'.

On the y-axes, the average score given for Team. In figure 3a, sick leave is displayed on the x-axis in percentages and in figure 3b, the x-axis is the sum of Vitality and Connectedness, thus engagement.

MBO: employee satisfaction survey (in Dutch: medewerker)

Again, as for nursing departments, minimal correlations can be seen for parameters of the PEM in physicians and residents. Both sick leave and engagement do not seem to correlate. An example can be seen below, where the correlations of the PEM parameter Shared decision making with sick leave (r = -.248, p = .292) (figure 6a) and engagement (r = .204, p = .389) are shown.



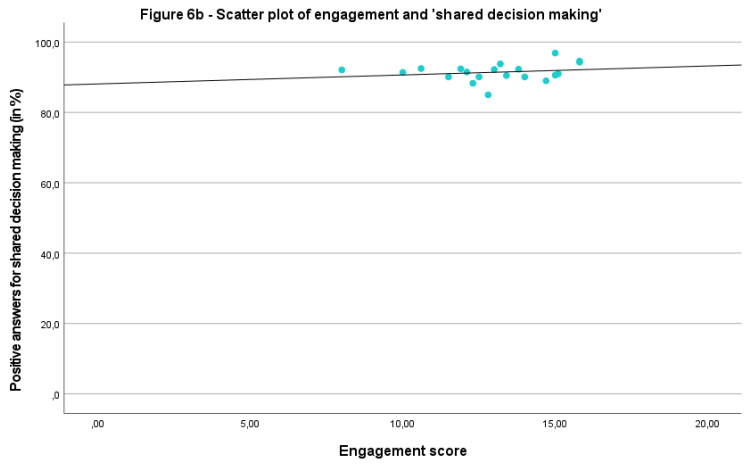


Figure 6 – scatter plots of the percentage of positive scores on 'Shared decision making' in the patient experience monitor. *On the y-axes, the percentage of positive responses on this question is displayed. In figure 6a, sick leave is displayed on the x-axis in percentages and in figure 6b, the x-axis is the sum of Vitality and Connectedness, thus engagement.*

3.7 Lessons learned

The process of retrieving data proved to be challenging. Five domains with multiple barriers were identified, where obstacles were observed when requesting and aggregating the hospital data. These are shown in table 6 below.

Table 6: identified domains and barriers in the process of retrieving data from hospital sources.

Domain	**Barriers**
Architecture	- Diverse structures and hierarchies in data sources proved challenging to identify equivalent building blocks among data sources. - Necessity for aggregation at higher levels, resulting in the loss of information. - Investment of significant time and capacity.
Quality	- Absence of a guide/code book for reading and interpreting data. - Missing data. - Inconsistent methods and time periods of data collection. - Utilization of raw data vs. data from dashboards.
Accessibility	- Ambiguity regarding ownership. - Consent from various committees/departments.

	- Divergent interests in data utilization. - Changes in IT systems. - Storage across various locations.
Safety	- Pseudonymization. - Lack of familiarity with GDPR (General Data Protection Regulation).
Knowledge	- Lack of knowledge and user experience with available data. - Absence of codebooks.

DISCUSSION

This study maps sick leave and engagement against a large number of departmental characteristics in a large UMC, collected for a variety of control, monitoring or accountability objectives. Multiple department characteristics differed between high and low sick leave and engagement groups, respectively, and were associated with sick leave or engagement. Employee turnover, departmental personnel capacity and employee satisfaction were most notable as associations with engagement and/or sick leave. In addition, there is a number of parameters that were not associated with sick leave or engagement on department level in our dataset(s) and might therefore not be suitable to map employee well-being on department level.

Associations exist between sick leave, engagement, and personnel turnover. Departments with high sick leave and low engagement often experience higher turnover, and vice versa. Though this might not seem surprising, it does demonstrate the usefulness of this data and support the possibility to steer on other parameters than just quality indicators. Other studies have observed a comparable phenomenon. A study by Ligibel et al. reported a higher intention to leave in burned out physicians. (21) Although we had no access to reasons for sick leave, we did observe an association between low engaged departments with high sick leave and outflow of personnel. Another interesting association was observed for department capacity. The more FTE is registered in a department, the higher sick leave is and engagement lower. The opposite was observed previous studies, where downsizing a department made sick leave decrease. (22,23) A mediator in this might be team culture, as social cohesion decreases and cognitive load increases when team size increases. (24) Departments with a high number of employees could have less team cohesion, potentially making engagement lower and making it less hard to call in sick. (25)

Furthermore, indicators on self-reported patient satisfaction and experience, generally do not seem to be associated with sick leave or engagement in our data. There seems to be a multifactorial explanation for this: although employees feel less engaged and have a higher sick leave, HCPs do everything in their power to keep performance at acceptable levels, thus not influencing patient experience. This principle has been demonstrated by Demerouti et al. in airline pilots. (26,27) The secondary analyses at nursing department level support this, where we see associations between multiple PEM parameters (e.g., trust in physician) and sick leave, although not for engagement. Another explanation could be that patient experiences during their visits in hospital departments are not an adequate measure or proxy for the department's level of engagement or sick leave or that the instrument used is not valid to measure patient experiences on a department they had visited. In addition, literature on associations between patient experiences and well-being of the HCP is scarce. (28) Furthermore, we observed that the questions in the PEM measurement instrument were often

generic and could be interpreted in different ways. For the future, it could be interesting to develop a patient experience measurement instrument using rigorous clinimetric methods, such as the COSMIN Initiative proposes. (29)

Our results show that data from the MBO do not correlate with sick leave, although employee surveys are often used to map employee well-being. The MBO instrument might currently cover employee experiences, rather than questions aiming to measure well-being. Questions can probably be interpreted in different ways and may differ from the constructs we ideally would like to measure. (30) Similar to the PEM instrument, it could therefore be interesting to develop an instrument using clinimetric methodologies that is valid to measure healthcare professional well-being. (29) When interpreting associations of engagement with MBO data, it is of importance to note that engagement is a combined measure of two MBO parameters, an unvalidated method to measure engagement. Furthermore, significances must be interpreted with caution, as social desirability bias can play a role in self-reported instruments. (31,32) Though, engagement seems to be associated with the majority of the parameters asked in the MBO, possibly demonstrating the importance of the domains asked in the MBO on engagement, such as the amount of autonomy in work, team spirit and job satisfaction. (33,34) Better team spirit has been shown to be associated with higher engagement. (35,36)

Incidents are often used as an indicator of quality of care. While they do show associations on certain areas, such as patient incidents and sick leave, it is important to note that the amount of incidents is strongly dependent on the 'reporting culture', greatly differing between departments, and the absolute number of incidents, rarely exceeding 1 or 2 per year, and may therefore not be an accurate measure. (37)

Data on quality indicators, such as standardised mortality rate, readmission ratio and risk of decubitus, are in some models correlated with sick leave or engagement. These parameters are, however, extremely multifactorial, making it challenging to use them as individual parameters gauging sick leave and engagement on department-level. Risk of decubitus, for instance, is influenced by decreased mobility, malnutrition and hypoperfusion, and does not seem an isolated consequence of care provision in departments with high sick leave and low engagement. (38)

In our analyses, most patient population characteristics do not seem to be associated with sick leave and engagement on department-level sick leave or engagement. Yet, one of the patient population parameters that does seem to be associated with primarily sick leave, is secondary diagnoses during hospital stay. This implies that the more complex a patient becomes during their stay, the higher sick leave is or vice versa. The reason why engagement does not seem to be associated with secondary diagnoses, can be explained by the same principle as described for correlations for the PEM. Although under great pressure, a professional will continue to perform on a high level. (27)

The primary analyses were done at the department level, where all HCPs (nurses, physicians and residents) are categorized per specialty. By analysing at this level, our outcomes are subject to a large number of confounding factors and coincidences. With our secondary analyses performed on department level, but this time separating nurses and doctors, we tried to gain more insight into mechanisms that could play a role in sick leave and engagement within specific groups in departments. In our analysis at nursing department level, we found that when age of nurses increases, sick leave also increases and engagement decreases. These outcomes suggest that the older nurse might be more prone to burn-out, although literature on this is ambiguous. (39–41) A possible conclusion could be to better monitor the 'older nurse'. Interestingly, this phenomenon cannot be seen in our primary analyses, where the opposite was found. When a department is observed as a whole, increasing age seems to lead to increased engagement, thus lower burnout risk, which corresponds to general ideas on age and burnout risk. (42) These results demonstrate that evaluation on a high aggregated level results in data that cannot be used for steering or monitoring. Data need to be on care team level to be useful.

In the process of retrieving data, we identified multiple barriers that complicated data collection. One of these was the organization of data. Not all data were available at all levels, making it necessary to aggregate data at a higher level than desirable. For instance, data on quality indicators were not available at nursing department level, requiring us to analyse these data at a higher aggregation level, namely at departmental level. This was caused by the fact that various organizational units and supporting staff departments use different systems and portals that are not interoperable, creating isolated data silos within the hospital. Data from different sources can sometimes be combined, commonly however, linking data turns out to be impractical, as data can only be linked on the highest common level between sources causing aggregation of some data from other sources. Moreover, data were often incomplete. To better understand how these data are associated on a care team level, better organization and structuring of data is necessary. To address the challenges outlined in data organization, implementing a common data model such as the Fast Healthcare Interoperability Resources (FHIR) can significantly enhance data integration, at least for clinical data. (43–45) FHIR provides a standardized framework that promotes seamless communication between disparate healthcare systems, mitigating issues arising from incompatible data formats and disparate systems. By adopting FHIR, healthcare organizations can achieve a more cohesive and interoperable data environment, fostering efficient data sharing, and enabling a comprehensive understanding of patient information across various departments and sources.

Limitations

This study has several limitations. First, if differences, correlations, associations, or predictors were to be found, interpretating these as causal factors leading to the level of engagement or sick leave due to the observational nature of the data. Qualitative research could help better understand what factors are of influence and how they would form a mechanism with sick leave and engagement on department-level. Second, the power in our analyses was low, as we observed departments as cases, therefore making our findings more uncertain. In addition, the lack of multiple testing correction poses a risk to interpretation, potentially identifying factors that do not play a significant role in an underlying mechanism. Third, when analysing sick leave, we could not distinguish between short- and long-term sick leave. Although short term sick leave can be a predictor of long-term sick leave, differentiating between the two, might have given more information on which departments are at risk. (46,47) Finally, in this analysis, acute medicine was not separated from elective medicine and supporting specialties. For instance, the nature of working in surgery versus working in radiotherapy differs. Specialties with an acute character are often perceived as more stressful. (48) This study did not weigh in those factors and performing sub-analyses for acute and elective medicine would even further lower the statistical power in our analyses.

Conclusion

This study performed an exploration of already collected hospital data into the association between quality and safety of care, sick leave, engagement, and various other department characteristics. Thereby this study provides important lessons for creating a learning organisation as well as new parameters for steering and ultimately improving quality and safety by supporting HCP well-being. Key findings highlight significant associations with turnover, departmental personnel capacity, and certain parameters on patient and employee experience. In departments with (relatively) high personnel capacity and in departments where turnover is high, sick leave does seem to be higher and engagement does seem to be lower. This emphasizes the potential importance of focusing on employees working in these high capacity departments and to adequately track their well-being.

Furthermore, parameters on experiences, both of patients and employees, do not seem to be associated with other department-level characteristics, thereby questioning the evidence-based support for their surveyed domains and their use as a measure for quality of care.

In the future, data infrastructure should be improved to link hospital data to an aggregated level of care teams. In addition, more research should be done on how different department characteristics are of influence on HCPs' well-being and quality of care. Besides focusing future research on gathering and linking more quantitative data on lower levels, it is worth considering performing qualitative

research among HCPs to better understand mechanisms underlying well-being of the HCP with regard to department performance and characteristics.

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SUPPLEMENTARY FILE 1

All tested parameters can be found in a separate Excel-file.

SUPPLEMENTARY FILE 2

This table shows correlations of department characteristics with sick leave.

	Variable	**Correlation with sick leave**	
		Corr Coeff	Sign. (2-tailed0
General	Patient age	-0.068	0.763
	Patient stay	0.056	0.805
	Unique patients	0.259	0.284
	Staff age	-0.139	0.526
	Capacity in FTE	0.679	<0.001
Work-load	Casemix patients	-0.503	0.820
	Secondary diagnoses	0.337	0.146
	Patients per FTE	-0.314	0.166
Employee satisfaction survey (MBO)	Work enjoyment	0.143	0.525
	Autonomy	-0.043	0.850
	Development	-0.129	0.568
	Challenge	-0.234	0.296
	Team	-0.233	0.950
	Appreciation	-0.222	0.321
	Supervisor	-0.246	0.270
	Acceptable work load	-0.039	0.866
	Health	-0.0271	0.222
	Connectedness	-0.118	0.602
	Vitality	-0.296	0.181
Reten-tion	Inflow compared to capacity	0.380	0.74
	Outflow compared to capacity	0.425	0.043
	Ratio inflow vs outflow	0.174	0.449
Quality of Care	HSMR (mortality)	0.447	0.055
	OLO (stay)	0.067	0.773
	Readmission ratio	0.252	0.298
	Pain in rest (%)	-0.187	0.417
	Decubitus score	0.155	0.503
	Delirium score	0.142	0.550
	Patient incidents	0.575	0.004
	Patient calamities	0.346	0.106
	Occupational incidents	0.464	0.040
Patient Experience Monitor (PEM)	Time om waiting list	0.287	0.300
	Trust in doctor	-0.056	0.827
	Trust in nurse	0.297	0.232
	Available time for patient	0.089	0.708
	Nurse's time	-0.029	0.910
	Shared decision making clinic	-0.198	0.462
	Shared decision making outpatient	-0.277	0.237
	Contradictory information	0.031	0.902
	Treatment with respect	0.101	0.691

SUPPLEMENTARY FILE 3

This table shows correlations of department characteristics with engagement.

	Variable	**Correlation with sick leave**	
		Corr Coeff	Sign. (2-tailed0
General	Patient age	-0.025	0.912
	Patient stay	0.218	0.329
	Unique patients	-0.451	0.053
	Staff age	0.443	0.039
	Capacity in FTE	-0.578	0.005
Work-load	Casemix patients	0.222	0.334
	Secondary diagnoses	-0.049	0.839
	Patients per FTE	0.213	0.353
Employee satisfaction survey (MBO)	Work enjoyment	0.766	<0.001
	Autonomy	0.487	0.021
	Development	0.640	0.001
	Challenge	0.641	0.001
	Team	0.515	0.014
	Appreciation	0.515	0.014
	Supervisor	0.242	0.278
	Acceptable work load	0.574	0.005
	Health	0.766	<0.001
Reten-tion	Inflow compared to capacity	-0.370	0.090
	Outflow compared to capacity	-0.452	0.035
	Ratio inflow vs outflow	-0.010	0.967
	Sick leave	-0.227	0.310
Quality of Care	HSMR (mortality)	-0.336	0.160
	OLO (stay)	0.216	0.347
	Readmission ratio	-0.383	0.106
	Pain in rest (%)	0.136	0.568
	Decubitus score	0.574	0.008
	Delirium score	0.021	0.931
	Patient incidents	-0.268	0.228
	Patient calamities	-0.458	0.032
	Occupational incidents	-0.024	0.922
Patient Experience Monitor (PEM)	Time om waiting list	-0.016	0.954
	Trust in doctor	-0.143	0.572
	Trust in nurse	-0.284	0.253
	Available time for patient	-0.051	0.830
	Nurse's time	-0.053	0.835
	Shared decision making clinic	-0.016	0.952
	Shared decision making outpatient	0.270	0.249
	Contradictory information	0.009	0.972
	Treatment with respect	-0.207	0.409

SUPPLEMENTARY FILE 4

In addition to the regression models presented in our Results section, we also performed a regression analyses with an entry of p < .2 and removal set at p < .3, for explorative purposes. Below, an overview of independent predictors of sick leave, with an entry of p < .2 and removal set at p < .3.

	Tested variables input	**Tested variables output**
Model 1 **Energy sources** 6 models		***Constant*** *(B = 23.287, p = .010)*
	MBO - Autonomy	-
	MBO - Supervisor	-
	MBO - Team	MBO - Team (B = -4.029, p = .050)
	MBO - Development	-
	MBO - Appreciation	-
	MBO - Challenge	-
Model 2 **Stressors** 5 models		***Constant*** *(B = 5.504, p = .000)*
	MBO - Workload	-
	Patients per FTE	-
	Casemix	-
	Secondary diagnoses	-
	Occupational incidents	Occupational incidents (B = .536, p = .171)
Model 3 **Well-being** 4 models		***Constant*** *(B=3.051, p = .323)*
	MBO - Health	-
	MBO - Vitality	MBO – Vitality (B = -.177, p = .012)
	MBO - Connectedness	-
	MBO - Involvement	-
	MBO – Job satisfaction	MBO – Job satisfaction (B = .670, p = .038)
Model 4 **Organisation** 3 models		***Constant*** *(B =-17.710, p = .323)*
	Inflow compared to capacity	Inflow compared to capacity (B = .711, p = .107)
	Outflow compared to capacity	-
	Unique patients	-
	Capacity (B=1.381, p=0.003)	Capacity (B = 1.391, p = .006)
	Age of HCP	Age of HCP (B = .399, p = .077)
Model 5 **Quality of care** 4 models		***Constant*** *(B = .610, p = .820)*
	Patient incidents	Patient incidents (B = 1.393, p = .047)
	Calamities	Calamities (B = -.878, p = .209)
	HSMR	-
	OLO	-
	Readmission ratio	-
Model 6 **Patient experience** 4 models		***Constant*** *(B = 12.250, p = .060)*
	Waiting list	Waiting list (B = .118, p = .005)
	Trust physician	-
	Trust nurse	Trust nurse (B = .002, p = .069)
	Time physician	-
	Time nurse (B=-0.330, p= 0.010)	Time nurse (B = -.330, p = .010)
	Shared decision making	-

SUPPLEMENTARY FILE 5

In addition to the regression models presented in our Results section, we also performed a regression analyses with an entry of $p < .2$ and removal set at $p < .3$, for explorative purposes. Below, an overview of independent predictors of engagement, with an entry of $p < .2$ and removal set at $p < .3$.

	Tested variables input	**Tested variables output**
Model 1 **Energy sources** 5 models		***Constant*** *(B = -10.532, p < .001)*
	MBO - Autonomy	-
	MBO - Supervisor	-
	MBO - Team	MBO - Team (B = 2.249, p < .001)
	MBO - Development	-
	MBO - Appreciation	-
	MBO - Challenge	MBO – Challenge (B = 3.606, p < .001)
Model 2 **Stressors** 4 models		***Constant*** *(B = -.884, p = .647)*
	MBO - Workload	MBO – Workload (B = 4.503, p < .001)
	Patients per FTE	Patients per FTE (B = .414, p = .010)
	Casemix	-
	Secondary diagnoses	-
	Occupational incidents	-
Model 3 **Well-being** 2 models		***Constant*** *(B = 1.866, p =.030)*
	MBO - Health	MBO – Health (B = 1.002, p = .002)
	MBO - Involvement	-
	MBO – Job satisfaction	MBO – Job satisfaction (B = .524, p < .001)
Model 4 **Organisation** 3 models		***Constant*** *(B =-5.798, p = .439)*
	Inflow compared to capacity	Inflow compared to capacity (B = .918, p = .037)
	Outflow compared to capacity	Outflow compared to capacity (B = -1.357, p = .001)
	Unique patients	-
	Capacity (B=1.381, p=0.003)	Capacity (B = .475, p = .013)
	Age of HCP	-
Model 5 **Quality of care** 6 models		***Constant*** *(B = 13.021, p < .001)*
	Patient incidents	-
	Calamities	-
	HSMR	-
	OLO	-
	Readmission ratio	-
Model 6 **Patient experience** 4 models		***Constant*** *(B = 13.545, p = .208)*
	Waiting list	-
	Trust physician	Trust physician (B = -.252, p = .216)
	Trust nurse	-
	Time physician	-
	Time nurse	Time nurse (B = .162, p = .164)
	Shared decision making	Shared decision making (B = .128, p = .291)

NEDERLANDSE FEDERATIE VAN UNIVERSITAIR MEDISCHE CENTRA

Zorginstituut Nederland

The impact of medical technology on the hospital physician's and nurse's work and well-being: a scoping review

28 december 2023.

Rapport opgesteld in het kader van de Academische Werkplaats 'Geef bevlogenheid vleugels: de basis van gewoon goede zorg' door Saskia Bontjer (UMCG), onder dagelijkse begeleiding van Michiel Oerbekke (Cochrane) en stuurgroepleden Maarten van der Laan (UMCG), Lotty Hooft (Cochrane), Arie Franx (Erasmus MC), Dave Dongelmans (Amsterdam UMC), Annelies Visser (Amsterdam UMC), Leontien Sturms (NFU), Diana Delnoij (ZINL), Marieke Visser (ZINL).

Abstract

Introduction: Medical technologies are currently reshaping the delivery of healthcare worldwide. While these technologies hold promise for improving safety, efficiency, accessibility, and patient outcomes in healthcare, there seems to be less emphasis on evaluating the effect of technology use on healthcare professional well-being. The aim of this scoping review was therefore to examine the impact of electronic medical technologies on the workflow and well-being of physicians and nurses in hospital settings.

Method: To narrow the focus, this scoping review specifically examined various medical technologies, including continuous glucose telemonitoring, clinical decision support systems in radiology, 3D laparoscopy, robot-assisted surgery and electronic health records. A literature search was performed in Epistemonikos on the 5th of July 2023. Inclusion criteria encompassed review studies published in English or Dutch after 01-01-2003, focusing on hospital-based nurses and physicians and evaluating the medical technologies of interest. Outcomes within the domains of workflow or well-being were not specified a priori, but were inductively determined. All titles and abstracts and all full-text articles were reviewed by three reviewers. Any conflicts were addressed and resolved through discussion. The data extraction and analysis involved a standardized form.

Results/conclusions: The search identified 2004 articles with 1898 remaining after duplicate removal. The screening of title and abstracts led to 185 studies available for full-text assessment, resulting in 63 included in this scoping review. It appeared that the main focus of literature lies on examining the influence of technology use on workflow related outcomes. The impact of medical technologies on hospital nurses and physicians workflow and well-being is to a high extent heterogenous and multifaceted. While some results showed potential benefits for workflow efficiency and well-being related outcomes, others posed challenges and potential risks. The direction of these effects on studied concepts did not necessarily align and could be contradicting. Furthermore, this scoping review highlights the fact that there exist great diversity in evaluation measurement units with a lack of uniformity in results for both workflow- and well-being related outcomes, within and between technologies.

Implications: The absence of well-being-related outcomes in literature with also highly contradicting results underscores the need for a more holistic and consistent approach to evaluating the introduction of medical technologies. Providing this current state of knowledge could lay the foundation for more focused systematic reviews or primary research. Future research should delve deeper into understanding the interplay between technology adoption, workflow optimization, and the well-being of HCP to inform evidence-based strategies for improving healthcare delivery and to retain HCP in the field.

Introduction

Medical technologies are currently reshaping the delivery of healthcare worldwide. A combination of advanced medical science, market demand, governmental policies and financial and societal pressures drive the rapid development and implementation of these technologies in daily clinical practice[1,2]. A widely accepted definition of medical technologies has not yet been established. In this study, various sources were consulted to define medical technology as 'any electronic or digital tool, including medical devices, IT/software-systems, telemedicine and artificial intelligence, that is designed to improve health and support healthcare', as per the definitions found in selected literature[3–5].

It is assumed that medical technologies have the potential to enhance the safety and efficiency of healthcare services, improve accessibility and patient outcomes and promote self-management[6]. However, effective implementation and application of medical technologies in healthcare delivery faces numerous challenges. These challenges include oversight and regulation, workforce education and adoption, data quality and storage, workflow integration and stakeholder engagement[7,8]. It is essential that the development of innovative, reliable, and accurate technologies is balanced with thoughtful consideration of their practical application within healthcare work environments[9]. This concept aligns with the sociotechnical systems (STS) approach, which recognizes the intertwined nature of social and technical systems in the workplace, emphasizing that they cannot be separated. Effective integration of technology into existing workflows could, in theory, yield positive outcomes, such as reduced task completion time and decreased workload. Consequently, to enhance and support healthcare processes, medical technologies should be specifically designed to align with and integrate into existing workflows[9].

Current evaluations on the impact of medical technologies on healthcare professionals (HCP) predominantly seem to focus on measuring user compliance, satisfaction, or usability[10,11]. However, as also described by the STS approach, introducing new technologies into already complex healthcare systems substantially affects HCP work and workflows, interpersonal interactions and the delivery of patient care[9,11,12]. Importantly, new technologies may introduce efficiencies on the healthcare delivery process side but may have an unclear trade-off on the HCPs' well-being side. Currently, it seems that there might be less emphasis on evaluating this impact on work and well-being compared to the technology's impact on efficiency, compliance, satisfaction, and usability[11,12]

With a rapidly aging population and the growing chronic disease burden in mind, the pressure on the healthcare system and healthcare workforce is increasing. Because of this, HCP health and well-being is currently under pressure, with markedly high rates of sickness absence, burnout and distress compared to other sectors[13]. Well-being at work is defined as 'creating an environment to promote a state of contentment which allows an employee to flourish and achieve their full potential for the benefit of themselves and their organization'[14] . Well-being includes psychological, physical and social well-being[15,16]. A healthy care workforce is positively associated with work satisfaction, productivity and patient safety[17]. On the other hand, poor work satisfaction is an important factor in causing HCP leaving the field and contributes to negative psychosocial, physical and financial consequences for the workforce, patients and healthcare organizations[18,19]. In summary, the well-being of HCP is not only a moral and ethical consideration, but also a strategic imperative for healthcare organizations.

There appears to be a gap in knowledge on how the integration of medical technology in the care process affects both HCP workflow and well-being. The aim of this scoping review is therefore to examine the impact of electronic medical technologies on the workflow and well-being of physicians and nurses in hospital settings.

Methods

Due to the fact that this study examines the broad topic of medical technologies with an extensive literature base, a scoping review methodology was conducted. This review methodology is inclusive, flexible and iterative of nature[20]. It requires analytical (re)interpretation of literature and search strategy, and allows for evolution in PICO elements under study[20].

Considering the broad definition of medical technologies, the current scoping review was limited by including studies concerning specific technologies as examples of different categories within a medical technology (table 1).

Table 1. *Included medical technologies in scoping review*

Technology category	**Type of technology**	**Technology of interest**
Medical devices	Robotic surgery	●Robot assistance in surgery (RAS) ●3D Laparoscopy in surgery
Mobile communication & telehealth	Telemonitoring	Continuous glucose telemonitoring (CGM)
Artificial Intelligence	Clinical Decision Support Systems (CDSS)	Assessment of radiological images with use of CDSS
Registration of information	Electronic Health Records (EHR)	EHR

Search strategy and information sources

Literature was searched in June 2023 through Epistemonikos. A comprehensive search strategy was developed by an information specialist. Two search strings were developed (Appendix 1), combining search terms for technology with either the outcomes of interest or with the setting to increase the potential relevant yield of the search strategy (search set 1: type of technology with outcomes of interest, search set 2: type of technology with setting). Both sub-searches were conducted in July 2023.

Study selection

Eligible review studies for inclusion were those that focussed on nurses and/or physicians in a hospital setting, where the medical technologies of interest were implemented or assessed, and reported at least one of the outcomes of interest (workflow- or well-being related). Outcomes within the domains of workflow or well-being were not specified a priori, but were inductively determined. Studies that concerned care outside hospital settings (e.g. primary care, elderly care, educational settings) and articles published before 01-01-2003 were excluded. Furthermore, studies concerning conventional imaging techniques, medicines, or vaccines were excluded as well as conference abstracts, study protocols, posters, opinion papers, narrative reviews, primary studies, simulation studies, animal studies or studies not published in English or Dutch were excluded. Ten percent of the titles and abstracts were independently screened on their potential relevance by three different researchers (SB, MO, MK), whereafter discrepancies were resolved to calibrate the judgement for potential relevance among screeners. Selected review studies were read full text by two reviewers (SB and MO) blinded from each other's decisions for final inclusion. Discrepancies were discussed until consensus was reached.

Data extraction and analysis

Three researchers (SB, LH, DI) extracted the data of the included reviews by using a standardized extraction form developed in Microsoft Excel. The extraction form was developed a priori, pilot tested (on 15 reviews), and updated accordingly before data extraction continued. The following data from the included reviews was extracted: general characteristics (year, author names, review design, study aim, nr. Included primary studies), population characteristics (setting, type of HCP), medical technology (type of technology and category, comparator), outcomes of interest (outcome category). The following data from the primary studies reported in the reviews was extracted: general characteristics (year, author names, study design), population characteristics (setting, type of HCP), medical technology

(type of technology and category, comparator), outcomes of interest (outcome category, measurement method, outcome data). Relevant data from primary studies reported in the review studies were extracted as reported in the review. Extracted data was checked for a random 20% of included studies by three researchers (SB, LHV, DI). The quality of the included review studies was not assessed for risk of bias due to the scoping nature of this study.

Synthesis of results

The data were narratively synthesized since a scoping review aims to map the literature and provide an overview rather than assessing the effectiveness of interventions. The data was cleaned and organized in Excell by main researcher (SB) to identify trends, gaps and patterns. Data was charted per medical technology and type of outcome by applying filter button in Excell.

Results

The electronic search strategy yielded a total of 2004 review articles. Duplicates (n=106) were removed before title and abstract screening. Overall, 1716 review studies were excluded and 185 articles were ultimately selected for full text reading. Overall, 122 studies were excluded and labelled following examination of full text manuscripts. Most review articles were excluded based on wrong intervention type or wrong type of outcome. Other articles were excluded due to mismatches in type of comparator, population, study design, publication type or language. Finally, 63 reviews were eligible for inclusion for all the five technologies of interest. Results of the study selection process are summarized in figure 1.

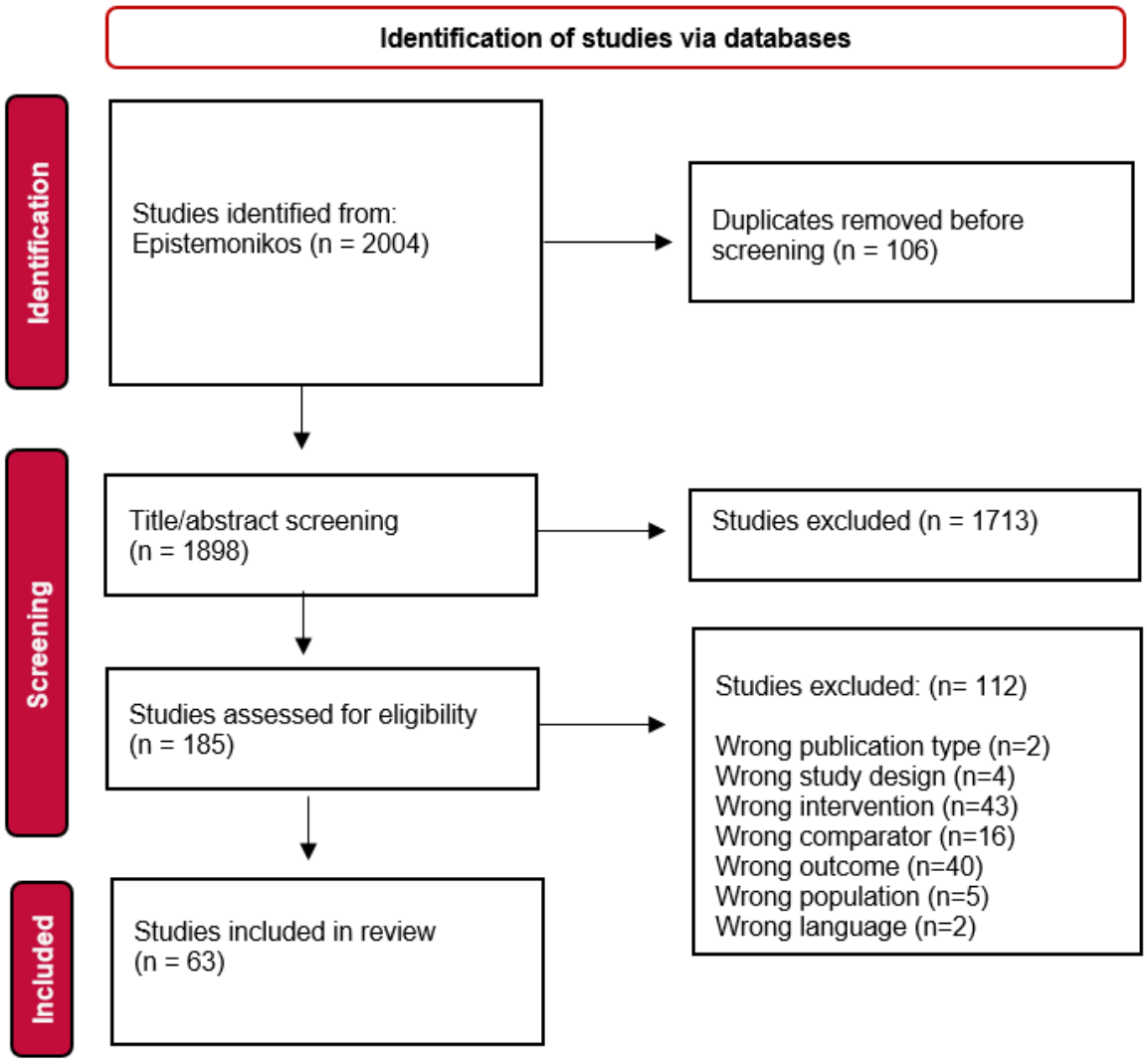

Figure 1 – PRISMA flow diagram

An overview of study characteristics can be found in table 2. The majority of reviews were published between 2011 and 2020 (59%). 38% of included reviews were published in the last 1.5 years between 2021 and 2023, 3% were published before 2010. More than half of the studies were systematic reviews (55%) and 30% were systematic reviews with meta-analysis. There were a couple of scoping and integrative reviews. 81% of the review studies were focused completely on the hospital environment and physicians were the most studied population (67%). Looking at the outcomes of interest, two third of review studies focused on workflow related outcomes. 19% investigated both type of outcomes and 14% on well-being related outcomes.

Table 2 – *Overview of review characteristics*

	Total	**CGM**	**CDSS in radiology**	**3D laparoscopy**	**RAS**	**EHR**
Nr. included reviews	63	3 (5%)	3 (5%)	7 (11%)	29 (46%)	21 (33%)
Nr. Relevant primary studies	138	2	14	24	57	41
Publication year						
2003-2010	2 (3%)	0 (0%)	0 (0%)	0 (0%)	1 (3%)	1 (5%)
2011-2020	37 (59%)	2 (67%)	0 (0%)	5 (71%)	18 (62%)	12 (57%)
2021-2023 (July)	24 (38%)	1 (33%)	3 (100%)	2 (29%)	10 (35%)	8 (38%)
Type of review design						
Nr. systematic reviews	35 (55%)	2 (67%)	3 (100%)	4 (57%)	14 (48%)	12 (57%)
Nr. systematic reviews with meta-analysis	18 (30%)	0 (0%)	0 (%)	3 (43%)	15 (52%)	0 (0%)
Nr. scoping reviews	4 (6%)	1 (33%)	0 (%)	0 (%)	0 (%)	3 (14%)
Nr. Integrative reviews	4 (6%)	0 (%)	0 (%)	0 (%)	0 (%)	4 (19%)
Other reviews	2 (3%)	0 (%)	0 (%)	0 (%)	0 (%)	2 (10%)
Type of review setting						
Hospital environment	51 (81%)	2 (67%)	3 (100%)	7 (100%)	29 (100%)	10 (48%)
Partly hospital environment	12 (19%)	1 (33%)	0 (0%)	0 (0%)	0 (%)	11 (52%)
Type of review population						
Physicians	43 (69%)	0 (0%)	3 (100%)	7 (100%)	29 (100%)	4 (19%)
Nurses	9 (14%)	1 (33%)	0 (%)	0 (0%)	0 (%)	8 (38%)
Both	11 (17%)	2 (67%)	0 (%)	0 (0%)	0 (%)	9 (43%)
Type of review outcome						
Workflow	42 (67%)	3 (100%)	3 (100%)	3 (43%)	24 (83%)	9 (43%)
Well-being	9 (14%)	0 (0%)	0 (%)	0 (%)	3 (10%)	6 (29%)
Both	12 (19%)	0 (0%)	0 (%)	4 (57%)	2 (7%)	6 (29%)

Continuous glucose telemonitoring (CGM)

Overall results

Three eligible reviews (5%) about the impact of continuous glucose telemonitoring were found (table 3). Two third of included studies were published between 2011 and 2020, one third between 2021 and July 2023. There were two systematic reviews and one scoping review. Two reviews focused completely on the hospital setting, one review had also included primary studies focusing both on hospital and other healthcare settings. Flodgren et al. (2015) investigated the use of continuous glucose telemonitoring in direct patient care with a comparison to face-to-face consultation or telephone consultation[21]. Van Steen et al. (2017) and Yao et al. (2022) studied the use of continuous glucose

telemonitoring in critically ill patients in the ICU[22,23]. In total, reported data from two primary studies were extracted from the three review studies. An overview of review characteristics can be found in table 3.

Table 3 *– Descriptive characteristics of reviews for CGM*

Review reference & design	Nr. Primary studies	Setting & population in review	Intervention in review	Comparator in review	Type of outcome in review
Flodgren et al. (2015)[21] Systematic review	●93 included ●1 relevant	●Partly hospital environment ●Nurses and physicians	CGM in direct diabetic patient care for moni-toring of the treatment response	Face-to-face consultation or telephone consultation	● Workflow
Van Steen et al. (2017)[22] Scoping review	●37 included ●1 relevant	●Hospital environment ●ICU nurses	CGM (subcutaneous or intravascular) with automated insulin infusion in critically ill patients	Standard care or head-to-head with another CGM system	●Workflow
Yao et al. (2022)[23] Systematic review	●19 included ●1 relevant	●Hospital environment ●ICU physicians and nurses	CGM (subcutaneous) in critically ill patients	Point of care measurement	●Workflow

Workflow related outcomes

All three review studies investigated workflow related outcomes (table 4). The three reviews all included one relevant primary study for this scoping review, of which one primary study was the same in two reviews. Flodgren et al. (2015) reported that total consultation time was decreased for telemonitoring patients compared to control, but that the communication time between the patient and physician was increased[21]. All three reviews reported data on workload, measured in time expenditure. Flodgren et al. (2015) reported an increased workload for physicians in managing patients using continuous glucose telemonitoring, whereas Van Steen et al. (2017) and Yao et al. (2022) reported a significant decrease in workload for nurses[21–23].

Well-being related outcomes

There were no well-being related outcomes reported in the three reviews.

Table 4 – *Overview of workflow related outcomes for CGM*

Domain	Outcome	Finding in review	Direction of effect	Nr. of primary studies	Review reference
Workflow	**Time efficiency**				
	Consultation time	Decreased for TM patients compared to control	↑	1 [1]	Flodgren et al. (2015)[21]
	Communication time	Increased contact with physician for TM patients compared to control	↓		
	Workload	Increased for physicians with TM patients compared to control (50 vs. 42 min per month)	↓		
		Decreased* for nurses with continuous compared to intermitted glucose control (17 vs 36 min. p<0.001)	↑	1 [2]	Van Steen et al. 2017[22]
					Yao et al. 2022[23]

*: significant, ↑: positive direction of effect, ↓: negative direction of effect, [...] : reference primary study
TM: Telemonitoring
Note 1: Findings as reported in reviews
Note 2: see Appendix 2 for references primary studies

Clinical Decision Support Systems (CDSS) in radiology

Overall results

Three eligible reviews (5%) were found about the use of clinical decision support systems in the assessment of radiological images (table 5). All three studies were systematic reviews, published between 2021 and July 2023 and focused on the hospital setting. The machine learning interventions in the review studies examined the interpretation of images from chest x-rays, mammography and CT's and compared this to radiologists manual image reading. In total, reported data from fourteen primary studies was extracted from the three review studies. An overview of review characteristics can be found in table 5.

Table 5 – *Descriptive characteristics of reviews for CDSS in radiology*

Review reference & design	Nr. Primary studies	Setting & population in review	Intervention in review	Comparator in review	Type of outcome in review
Ahmad et al. (2023)[24] Systematic review	●46 included ●1 relevant	●Hospital environment ●Radiologists	Use of machine learning software in the inter-pretation of chest x-rays	Baseline models or manual reading by physician	●Workflow
Batchu et al. (2021)[25] Systematic review	●60 included ●3 relevant	●Hospital environment ●Radiologists	Use of machine learning software in the inter-pretation of mammography	Manual reading by physician	● Workflow
Li et al. (2021) [26] Systematic review	●38 included ●10 relevant	●Hospital environment ●Radiologists	Use of AI software in the inter-pretation of chest x-rays and CT	Manual reading by physician	●Workflow

Workflow related outcomes

All three reviews investigated workflow related outcomes (table 6). In total, reported data from fourteen primary studies was extracted from the three reviews. All three reviews reported workflow data on the image reading time. The study of Ahmad et al. (2023) reported a significant increase in time necessary for reading images aided with machine learning software compared to unaided[24]. This was in contrast with the review study of Batchu et al. (2021), which reported no significant difference in reading time when radiologists were supported with machine learning in the interpretation of mammographic images[25]. Li et al. (2021) presented primary studies which found an increase in reading time as well as a decrease[27]. Batchu et al. (2021) was the only review study which also emphasized on the impact on workload of radiologists when machine learning was used for the interpretation of images[25]. Data from two primary studies were extracted and displayed a decrease in workload by optimalization of the triage and double reading process.

Well-being related outcomes

There were no well-being related outcomes reported in the three reviews.

Table 6 - *Overview of workflow related outcomes for CDSS in radiology*

Domain	Outcome	Finding in review	Direction of effect	Nr. of primary studies	Review reference
Workflow	**Time efficiency**				
	Reading time	Increased* in radiologists aided with machine learning software compared to unaided (19s vs. 14s, p<0.001)	↓	1 [3]	Ahmad et al. (2023)[24]
		ND* in radiologists aided with machine learning software compared to unaided (149s vs. 146s, p=0.15)	-	1 [4]	Batchu et al. (2021)[25]
		Decreased in radiologists aided with AI software compared to unaided	↑	9 [5-13]	Li et al. (2021)[26]
		Increased in radiologists aided with AI software compared to unaided	↓	2 [5,14]	
	Workload				
	Workload	Decreased for second reader radiologist through optimalization of double-reading process with machine learning software.	↑	1 [15]	Batchu et al. (2021)[25]
		Decreased with 19.3% in radiologists aided with machine learning software in triaging process	↑	1 [16]	

*: significant difference, ↑: positive direction of effect, ↓: negative direction of effect, - : neutral direction of effect, [...] : reference primary study
ND: no difference, AI: Artificial Intelligence
Note 1: Findings as reported in review
Note 2: See Appendix 2 for references primary studies

3D Laparoscopy

Overall results

Seven eligible reviews (11%) were found for examining the impact of 3D laparoscopy on workflow and/or well-being outcomes (table 7). The majority of reviews (71%) were published between 2011 and 2020, the remaining part was published in or after 2021. Four studies had an systematic review design (57%), three were systematic reviews with a meta-analysis (43%). No scoping reviews, integrative or other type of reviews were included. All seven reviews focused on surgeons operating in the hospital setting and compared the use of 3D laparoscopy to the use of 2D laparoscopy in different surgical fields. An overview of review characteristics can be found in table 7. In total, reported data from twenty-four primary studies was extracted from the seven review studies.

Table 7 – *Descriptive characteristics of reviews for 3D laparoscopy*

Review reference & design	Nr. Primary studies	Setting & population in review	Intervention in review	Comparator in review	Type of outcome in review
Fergo et al. (2017)[28] Systematic review	●13 included ●2 relevant	● Hospital ● Surgeons	3D laparoscopy in abdominal, gynecological and urological surgery	2D laparoscopy in abdominal, gynecological and urological surgery	● Workflow ● Well-being
Li et al. (2019)[29] Systematic review with meta-analysis	●23 included	● Hospital ● Surgeons	3D laparoscopy in gastrointestinal surgery	2D laparoscopy in gastrointestinal surgery	●Workflow
Restaino et al. (2023)[30] Systematic review with meta-analysis	●24 included	●Hospital ●Trainee surgeons	3D laparoscopy in gynecological surgery	2D laparoscopy in gynecological surgery	●Workflow
Sánchez-Margallo et al. (2021)[31] Systematic review with meta-analysis	●25 included ●4 relevant	●Hospital ●Surgeons	3D laparoscopy in urological surgery	2D laparoscopy in urological surgery	● Workflow ● Well-being
Sørensen et al. (2016)[32] Systematic review	●31 included ●3 relevant	● Hospital ● Surgeons	3D laparoscopy in gastrointestinal and gynecological surgery	2D laparoscopy in gastrointestinal and gynecological surgery	● Workflow ● Well-being
Vettoretto et al. (2018)[33] HTA report with systematic literature search	●142 included ● 11 relevant	● Hospital ● Surgeons	3D laparoscopy in general, gynecological and urological surgery	2D laparoscopy in general, gynecological and urological surgery	● Workflow ● Well-being
Wang et al. (2022)[34] Systematic review	●5 included ●4 relevant	● Hospital ● Surgeons	3D laparoscopy in gastrointestinal surgery	2D laparoscopy in gastrointestinal surgery	● Workflow

Workflow related outcomes

The impact of the use of 3D laparoscopy on time efficiency was in all seven included reviews presented through operation time (table 8). Some reviews, but not all, examined the use of 3D laparoscopy for specific type of surgeries, which were at least six different types. Six reviews reported a decrease in operation time when using 3D laparoscopy compared to 2D laparoscopy[28,31–35]. In contrast, three reviews reported no difference in operation time when 3D laparoscopy was used compared to 2D laparoscopy [28,32,36]. None of the reviews reported an increase in operation time for 3D laparoscopy.

Well-being related outcomes

The impact of using 3D laparoscopy compared to 2D laparoscopy on surgeon well-being was reported by four reviews (table 8). Fergo et al. (2017) reported a decrease in neck strain and Vettoretto et al. (2018) reported a significant decrease in neck pain[28,33]. Eye strain was reported by three reviews conflicting outcomes[28,31,32]. A significant increase in visual distress using 3D laparoscopy was reported by Sánchez Margallo et al. (2020) (Sánchez-Margallo et al., 2021). The impact on eye fatigue was reported by Fergo et al. (2017) and Vettoretto et al. (2018)[28,33]. Sánchez-Margallo et al. (2020) and Sørensen et al. (2016) both reported an increase in headache in surgeons using 3D laparoscopy[31,32]. There were no differences reported in nausea levels, hand or wrist strain and overall fatigue levels of surgeons using 3D laparoscopy[28,31,33].

Robot assisted surgery (RAS)

Overall results

Twenty-nine reviews (46%) provided relevant data for examining the impact of robot assistant surgery (RAS) compared to conventional surgery on workflow and/or well-being outcomes (table 9). Eighteen reviews were published between 2011 and 2020, 10 reviews between 2021 and July 2023 and only one study before 2010. Approximately half of the reviewed studies were systematic reviews and the other half were systematic reviews including a meta-analysis. There were no scoping, integrative or other reviews included. All twenty-nine reviews focused on surgeons operating in the hospital setting and compared the use of robot assistant surgery to conventional surgical methods in different surgical fields. Conventional surgical methods consisted of open-, laparoscopic assisted- (LAS) or endoscopic assisted surgery (EAS). The majority of reviews focused on workflow related outcomes (83%). 3 review studies focused on well-being related outcomes (10%) and 2 focused on both categories (7%). An overview of review characteristics can be found in table 9. In total, reported data from fifty-seven primary studies was extracted from the seven review studies.

Workflow related outcomes

The impact of robot assistance during surgery on time efficiency was presented through surgical operation time in twenty-four reviews (table 10). Nineteen reviews reported an increase in surgical operation time, five studies reported a decrease and two studies reported no difference in operation time when RAS was compared to conventional surgery (CS) for different type of surgeries. Some reviews found mixed results. Other workflow related outcomes were in the domain of task efficiency and team efficiency. Gillespie et al. (2020) reported that RAS increased the level of multitasking in surgeons[37]. Moreover, nurses experienced an increase in the task complexity[37]. Considering team efficiency, two primary studies included in the review of Gillespie et al. (2020) found an increase in the communication load experienced by the OR-team and operating assistants [37].

Table 8 – *Overview of workflow & well-being related outcomes for 3D laparoscopy*

Domain	Outcome	Finding in review	Direction of effect	Nr. of primary studies	Review reference
Workflow	**Time efficiency**				
	Operation time (not specified)	Decreased in 3D laparoscopy	↑	2 [17,18]	Sørensen et al. (2016)
		ND in 3D laparoscopy	-	1 [19]	
		Decreased in 3D laparoscopy	↑	8 [17,20-26]	Vettoretto et al. (2018)
	Operation time in nephrectomy	Decreased* in 3D laparoscopy	↑	Meta-analysis	Sánchez-Margallo et al. (2021)[31–33]
	Operation time in prostatectomy	ND in 3D laparoscopy	-	1 [27]	Fergo et al. (2017)[28]
	Operation time in gastric bypass	Decreased in 3D laparoscopy	↑	1 [28]	
		Decreased in 3D laparoscopy	↑	4 [28-31]	Wang et al. (2022)[34]
	Operation time in sleeve gastrectomy	ND in 3D laparoscopy	-	1 [28]	Fergo et al. (2017)[28]
	Operation time in rectal cancer	Decreased* in 3D laparoscopy (WMD 11.33 min, 95%CI: -14.53 to -8.13)	↑	Meta analysis	Li et al. (2019)[35]
	Operation time in hysterectomy	ND* in 3D laparoscopy (MD 8.71s, 95% CI: -13.55 to 30.98, p=0.44)	-	Meta analysis	Restaino et al. (2023)[30]
Well-being	**Physical strain**				
	Neck strain	Decreased in 3D laparoscopy	↑	1 [28]	Fergo et al. (2017)[28]
	Hand and/or wrist strain	ND in 3D laparoscopy	-	1 [28]	
	Eye strain	Decreased in 3D laparoscopy	↑	1 [28]	
		ND in 3D laparoscopy	-	2 [32,33]	Sánchez-Margallo et al. (2021)[31]

Well-being		Increased in 3D laparoscopy	↓	2 [17,19]	Sørensen et al. (2016)[32]
	Physical discomfort				
	Headache	Increased* in 3D laparoscopy	↓	1 [22]	Sánchez-Margallo et al. (2021)[31]
		Increased in 3D laparoscopy	↓	2 [19]	Sørensen et al. (2016)[32]
	Nausea	ND in 3D laparoscopy	-	2 [22,23]	Sánchez-Margallo et al. (2021)[31]
	Visual distress	Increased* in 3D laparoscopy	↓	1 [22]	
	Physical fatigue				
	Overall fatigue	ND in 3D laparoscopy	-	1 [27]	Fergo et al. (2017)[28]
	Eye fatigue	ND in 3D laparoscopy	-	1 [27]	
		Decreased* in 3D laparoscopy	↑	3 [28, 34, 35]	Vettoretto et al. (2018)[33]
	Physical pain				
	Neck pain	Decreased* in 3D laparoscopy	↑	3 [28, 34, 35]	Vettoretto et al. (2018)[33]

* : significant difference, ↑: positive direction of effect, ↓: negative direction of effect, - : no direction of effect, [...] : reference primary study
ND: no difference
Note 1: Findings as reported in review
Note 2: See Appendix 2 for references primary studies

Table 9 *– Descriptive characteristics of reviews for RAS*

Review reference & design	Nr. Primary studies	Setting & population in review	Intervention in review	Comparator in review	Type of outcome in review
Ahmed et al. (2012)[38] Systematic review	●13 included ●3 relevant	●Hospital environment ●Surgeons	RA in urological surgery	LA and open urological surgery	●Workflow
Chandrasekharam and Babu (2020)[39] Systematic review with meta- analysis	●28 included	●Hospital environment ●Surgeons	RA in urological surgery	LA in urological surgery	●Workflow
Chang et al. (2021)[40] Systematic review with meta- analysis	●13 included	●Hospital environment ●Surgeons	RA in gynaecological surgery	LA in gynaecological surgery	●Workflow
Chen et al. (2018)[41] Systematic review with meta -analysis	●7 included	●Hospital environment ●Surgeons	RA in orthopedic surgery	Open orthopaedic surgery	●Workflow
Dalager et al. (2017)[42] Systematic review	●15 included ● 1 relevant	●Hospital environment ●Surgeons	RA in different surgical fields	LA in different surgical fields	●Well-being
Gillespie et al. (2020)[43] Systematic review	●19 included ●5 relevant	●Hospital environment ●Surgeons	RA in different surgical fields	LA or open surgery in different fields	●Workflow ●Well-being
Health Quality (2010)[44] Systematic review with meta-analysis	●2 included	●Hospital environment ●Surgeons	RA in urological and gynaecological oncology surgery	LA in urological and gynaecological oncology surgery	●Workflow
Jackson et al. (2014)[45] Systematic review with meta-analysis	●9 included	●Hospital environment ●Surgeons	RA in endocrine surgery	EA in endocrine surgery	●Workflow
Kang et al. (2022)[45] Systematic review	●10 included ●3 relevant	●Hospital environment ●Surgeons	RA in endocrine surgery	Open endocrine surgery	●Workflow
Khetrapal et al. (2023) [46] Systematic review with meta-analysis	●17 included	●Hospital environment ●Surgeons	RA in urological surgery	Open urological surgery	●Workflow
Kim et al. (2023)[47]	●72 included	●Hospital environment ●Surgeons	RA in endocrine surgery	EA in endocrine surgery	●Workflow

Network meta-analysis					
Kowalewski et al. (2022)[48] Systematic review with meta-analysis	●4 included	●Hospital environment ●Surgeons	RA in urological surgery	EA in urological surgery	●Workflow
Lee et al. (2014)[49] Systematic review	●22 included ●2 relevant	●Hospital environment ●Surgeons	RA in gynaecological surgery	LA in gynaecological surgery	●Workflow
Liu et al. (2020)[50] Systematic review with meta-analysis	●59 included	●Hospital environment ●Surgeons	RA in endocrine surgery	Open endocrine surgery	●Workflow
Mancino et al. (2020)[51] Systematic review	●9 included ●1 relevant	●Hospital environment ●Surgeons	RA in orthopedic surgery	Open orthopaedic surgery	●Workflow
Möckelmann et al. (2016)[52] Systematic review	●18 included ●8 relevant	●Hospital environment ●Surgeons	RA in neurological surgery	Open neurological surgery	●Workflow
Mullaji et al. (2022)[53] Systematic review	●13 included ●4 relevant	●Hospital environment ●Surgeons	RA in orthopedic surgery	Open orthopaedic surgery	●Workflow
Park et al. (2021)[54] Systematic review	●30 included ●3 relevant	●Hospital environment ●Surgeons	RA in gastrointestinal, urological and gynaecological surgery	LA and open gastrointestinal, urological and gynaecological surgery	●Well-being
Ravendran et al. (2023)[55] Systematic review	●17 included ●16 relevant	●Hospital environment ●Surgeons	RA in gastrointestinal surgery	LA in gastrointestinal surgery	●Workflow
Safiejko et al. (2021)[56] Systematic review with meta-analysis	●41 included	●Hospital environment ●Surgeons	RA in gastrointestinal surgery	LA in gastrointestinal surgery	●Workflow
Scandola et al. (2011)[57] Systematic review with meta-analysis	●21 included	●Hospital environment ●Surgeons	RA in gynaecological surgery	LA in gynaecological surgery	●Workflow
Shugaba et al. (2022)[58] Systematic review	●10 included ●3 relevant	●Hospital environment ●Surgeons	RA in different surgical fields	Conventional surgery in different surgical field	●Well-being
Son et al. (2015)[59]	●14 included	●Hospital environment ●Surgeons	RA in endocrine surgery	Open endocrine surgery	●Workflow

Systematic review with meta-analysis					
Stonier et al. (2017)[60] Systematic review	●14 included ●3 relevant	●Hospital environment ●Surgeons	RA in urological surgery	LA in urological surgery	●Workflow
Sun et al. (2014)[61] Systematic review with meta-analysis	●12 included	●Hospital environment ●Surgeons	RA in endocrine surgery	Conventional endocrine surgery (a.o. open surgery)	●Workflow
Tan et al. (2018)[62] Systematic review	●38 included ●1 relevant	●Hospital environment ●Surgeons	RA in plastic surgery	Conventional plastic surgery (N.R.)	●Workflow
Tang et al. (2015)[63] Systematic review with meta- analysis	●8 included	●Hospital environment ●Surgeons	RA in endocrine surgery	LA in endocrine surgery	●Workflow
Wang et al. (2012)[64] Systematic review with meta-analysis	●6 included	●Hospital environment ●Surgeons	RA in gastrointestinal surgery	LA in gastrointestinal surgery	●Workflow
Wee et al. (2020)[65] Systematic review	●29 included ●4 relevant	●Hospital environment ●Surgeons	RA in different surgical fields	LA or open surgery in different surgical fields	●Workflow ●Well-being

Well-being related outcomes

The impact of using RAS on surgeon well-being was reported in five reviews in various manners (table 10). Considering physical discomfort and pain, four different reviews reported data. Shugaba et al. (2022) reported a decrease in overall discomfort in surgeons using RAS compared to LAS[58]. Park et al. (2021) displayed the impact on different body parts and reported a decrease in neck discomfort, a significant increase in upper back discomfort and no difference in hand or wrist and shoulder discomfort in case of RAS[54]. Wee et al. (2020) reported a significant increase in surgeon neck pain in RAS compared to LAS, whereas Dalager et al. (2017) reported a decrease in musculoskeletal pain in RAS compared to LAS and/or open surgery[42,66]. Physical fatigue levels in surgeons were decreased in RAS compared to LAS and/or open surgery in two reviews[37,42]. There were conflicting results reported on mental fatigue levels by surgeons[37,54,58,66] For the impact of RAS on mental demand and stress outcomes, Gillespie et al. (2020) reported increased stress and concentration in surgeons using RAS compared to LAS in the learning phase[37]. Park et al. (2021) reported a decreased amount of anxiety in assistant surgeons using RAS compared to LAS[54]. Two primary studies included in the review by Park et al. (2021) examined the cognitive demand of surgeons[54]. One of the primary studies reported no difference in cognitive demand for RAS compared to CS, the other reported a significant decrease in cognitive demand in RAS compared to LAS. This was in line with the data reported by Shugaba et al. (2012) on cognitive demand of surgeons in RAS compared to LAS [58]. Wee et al. (2020) referred to a primary study on surgeon workload, measured with the NASA-TLX score, using RAS compared to LAS and found a significant decrease[66]. Lastly, Gillespie et al. (2020) reported data in the domain of team demand, and stated that the collaboration effort of the OR team was increased in RAS compared to LAS[37].

Table 10 *– Overview of workflow and well-being related outcomes for RAS*

Domain	Outcome	Finding in review	Direction of effect	Nr. of primary studies	Review reference
Workflow	**Time efficiency**				
	Operation time in prostatectomy	Increased in RAS compared to OS and/or LAS	↓	3 [36-38]	Ahmed et al. (2012)
		Decreased in RAS compared to OS and/or LAS	↑	2 [39,40]	
		Increased in RAS compared to EAS (MD 68.32 min, 95% CI: -8.03 to 144.67, p=0.08)	↓	Meta analysis with 4 studies	Kowalewski et al. (2022)
	Operation time in uretric reimplantation	Increased* in RAS compared to LAS for unilateral procedure (171 ± 30.7 min. vs 107 ± 30.1min, p<0.001)	↓	Meta-analysis of 28 studies	Chandrasekharam and Babu (2020)
		Increased* in RAS compared to LAS for bilateral procedure (223 ± 38.1 min vs. 161 ± 35.8min, p<0.001)	↓	Meta-analysis of 28 studies	
	Operation time in sacrocolpopexy	Increased* in RAS compared to LAS (WMD 29.53 min, 95% CI: 12.88 to 46.18 min, p= 0.0005)	↓	Meta-analysis of 13 studies	Chang et al. (2021)
		Increased in RAS compared to OS	↓	2 [41,42]	Lee et al. (2014)
		Increased in RAS compared to LAS	↓	2 [43,44]	
		Decreased in RAS compared to LAS	↑	1 [45]	
	Operation time in total hip arthroplasty	ND* in RAS compared to LAS (WMD 23.21 min, 95% CI: -3.76 to 50.09 min)	-	Meta analysis of 3 studies	Chen et al. (2018)
	Operation time in thyroidectomy	Increased in RAS compared to OS (WMD 42.05 min, 95% CI 29.23 to 54.87)	↓	Meta analysis with 9 studies	Jackson et al. (2014)

Workflow		Decreased in RAS compared to EAS (WMD 20.99 min, 95% CI -59.03 to 17.05)	↓	Meta analysis with 9 studies	Jackson et al. (2014)
		Increased in RAS compared to OS	↓	3 [46-48]	Kang et al. (2022)
		Increased in RAS compared to EAS	↓	2 [49,50]	
		Increased in RAS compared to CS (NS) for different approaches Transaxillary (SMD 1.651, 95% CI 0.859 to 2.443) Bilateral axillo breast: (SMD 5.975, 95% CI 4.698 to 7.252) Transoral (SMD 3.016, 95% CI 1.734 to 4.298) Retro-auricular (SMD 2.571, 95% CI 0.077 to 5.065)	↓	Meta analysis	Kim et al. (2023)
		Increased* in RAS compared to OS for different approaches Transaxillary (MD 44.96, 95% CI 34.24 to 55.68) Bilateral axillo breast (MD 81.07, 95% CI 48.73 to 113.40)	↓	Meta analysis with 26 studies	Liu et al. (2020)
		Increased* in RAS compared to OS (WMD 39.77 min, 95% CI: 26.66 to 52.89, p<0.00001, I2=84%)	↓	Meta analysis with 14 studies	Son et al. (2015)
		Increased in RAS compared to OS (MD 76.7 min, 95%-CI 47.3 to 106.1)	↓	Meta analysis with 12 studies	Sun et al. (2014)
	Operation time cystectomy	Increased in RAS compared to OS (MD 75.00 min, 95% CI: 112.08 to 39.34)	↓	Meta analysis with 8 studies	Khetrapal et al. (2023)

Workflow	Operation time total knee arthroplasty	Increased* in RAS compared to OS (25 min. longer, p<0.001)	↓	1 [51]	Mancino et al. (2020)
		Increased* in RAS compared to OS	↓	4 [52-55]	Mullaji et al. (2022)
	Operation time neck dissection surgery	Increased* in RAS compared to OS	↓	8 [56-63]	Möckelmann et al. (2016)
	Operation time in colectomy	Decreased in RAS compared to LAS (MD = 43.49; 95% CI 25.26 to 61.51; p < 0.001; I2=98%)	↑	Meta analysis 34 studies	Safiekjko et al. (2021)
		Increased in RAS compared to LAS	↓	11 [64-74]	Ravendran et al. (2023)
		Decreased in RAS compared to LAS	↑	5 [69, 75-78]	
	Operation time in hysterectomy	ND* in RAS compared to LAS	-	Meta analysis of 20 studies	Scandola et al. (2011)
	Operation time nephroureterectomy	Increased* in RA compared to LAS	↓	3 [79-81]	Stonier et al. (2017)
	Operation time adrenalectomy	Increased* in RAS compared to LAS (WMD=17.52 minutes; 95-CI% 3.48 to 31.56)	↓	Meta analysis of 8 studies	Tang et al. (2015)
	Operation time nissen fundoplication	Increased in RAS compared to LAS	↓	Meta analysis of 3 studies	Want et al. (2012)
		Decreased in RAS compared to LAS (65 min. vs 82 min. p=0.006)	↑	1 [82]	Gillespie et al. (2020)
	Operation time palatoplasty	Increased in RAS compared to CS (NS) (122± 8 min to 87± 6 min)	↓	1 [83]	Tan et al. (2018)
	Task efficiency				
	Multitasking	Increased in RAS compared to CS as reported by surgeons	↓	1 [84]	Gillespie et al. (2020)
	Task complexity	Increased in RAS compared to CS as reported by nurses	↓	1 [85]	
	Team efficiency				
	Communication load	Increased* in RAS compared to LAS and/or OS (p=0.02) as reported by operating assistants	↓	1 [86]	Gillespie et al. (2020)

		Increased in RAS compared to LAS as reported by OR team	↓	1 [84]	
Well being	**Physical strain**				
	Overall strain	Decreased in all body areas for RAS compared to LAS	↑	1 [87]	Wee et al. (2020)
	Muscle activity	Decreased in RAS compared to LAS	↑	1 [88]	Shugaba et al. (2022)
	Physical discomfort				
	Overall discomfort	Decreased in RAS compared to LAS	↑	1 [89]	Shugaba et al. (2022)
	Neck discomfort	Decreased* in surgeons for RAS compared to CS ($p<0.05$)	↑	1 [90]	Park et al. (2021)
	Upper back	Increased* in surgeons for RAS compared to CS ($p>0.05$)	↓		
	Hands and/or wrists	ND in surgeons for RAS compared to CS	-		
	Shoulders	ND in surgeons for RAS compared to CS	-		
	Physical pain				
	Musculoskeletal pain	Decreased in surgeons for RAS compared to LAS and/or OS	↑	1 [91]	Dalager et al. (2017)
	Neck pain	Increased* in RAS compared to LAS ($p=0.028$)	↓	1 [90]	Wee et al. (2020)
	Fatigue				
	Physical fatigue	Decreased in surgeons for RAS compared to LAS	↑	1 [91]	Dalager et al. (2017)
		Decreased in surgeons for RAS compared to LAS and/or OS	↑	1 [92]	Gillespie et al. (2020)
	Mental fatigue	Increased in surgeons for RAS compared to LAS and/or OS	↓		
		ND in chief surgeons in RAS compared to LAS	-	1 [93]	Park et al. (2021)
		Decreased in assistant surgeons in RAS compared to LAS	↑		

Well being		ND in RAS compared to LAS	-	1 [94]	Shugaba et al. (2022)
		ND in RAS compared to LAS	-	1 [88]	
		ND in RAS compared to LAS	-	1 [88]	Wee et al. (2020)
	Mental demand				
	Concentration	Increased in surgeons for RAS compared to LAS and/or OS due to less experience	↑	1 [92]	Gillespie et al. (2020)
	Cognitive demand	ND in RAS compared to CS	-	1 [89]	Park et al. (2021)
		Decreased* in RAS compared to LAS ($p<0.05$)	↑	1 [95]	
		Decreased in RAS compared to LAS	↑	1 [89]	Shugaba et al. (2022)
	Mental stress				
	Anxiety	Decreased in assistant surgeons in RAS compared to LAS	↑	1 [93]	Park et al. (2021)
	Stress	Increased for surgeons in RAS compared to LAS in learning phase	↓	1 [92]	Gillespie et al. (2020)
	Workload				
	Workload	Decreased* in RAS compared to LAS (NASA-TLX score 13 ± 5 vs 10 ± 5, respectively; $p <0.001$)	↑	1 [96]	Wee et al. (2020)
	Team demand				
	Collaboration	Increased in OR team for RAS compared to LAS	↓	1 [85]	Gillespie et al. (2020)

* : significant difference, ↑: positive direction of effect, ↓: negative direction of effect, -: no direction of effect, [...] : reference primary study
ND: no difference, RAS: Robot assisted surgery, LAS: Laparoscopic assisted surgery, OS: Open surgery, EAS: Endoscopic assisted surgery, CS: Conventional surgery (can be laparoscopic, endoscopic or open surgery)
Note 1: Findings as reported in review
Note 2: See appendix 2 for references of primary studies

Electronic health record (EHR)

Twenty-one reviews (33%) were included for examining the impact of the use of the HER on workflow and/or well-being related outcomes (table 11). More than half of the reviews were published between 2011 and 2020. 8 Reviews were published in the last two years (38%) and only one study was published between 2003 and 2010. 12 Reviews (57%) had a systematic review design. 14% had a scoping design, 19% had an integrative design and 10% had another review design. The majority of reviews focused completely on the hospital setting, whereas 19% focused on both hospital and other healthcare settings such as primary care and elderly care. Considering the population of interest, physicians were studied in 69% of the reviews, 17% focused on both physicians and nurses and 14% only on nurses. The use of an EHR was in most reviews compared between pre- and post- EHR implementation. Sometimes the comparator was not clearly documented. In this case an implicit comparison between a pre- and post EHR implementation was assumed. Two third of included reviews focused on workflow-related outcomes. 9 review studies (14%) focused on well-being related outcomes and 12 reviews (19%) focused on both categories. An overview of review characteristics can be found in table 11. In total, reported data from fourty-one primary studies was extracted from the twenty-one review studies.

Workflow related outcomes

Workflow related outcomes were categorized in the domains of time efficiency, task efficiency and team efficiency (table 12). Considering time efficiency, Al Ani et al. (2022) and Eden et al. (2018) reported a decrease in overall productivity among physicians when using an EHR[67,68]. Documentation time was the most reported outcome in the time efficiency domain. Seven reviews reported an increase in health record documentation time for both physicians and nurses[68–74]. A couple of studies reported that this was especially the case during the implementation phase. Two reviews reported a decrease in documentation time among physicians and nurses using an EHR[71,73]. One review study also reported data on the completion time of health record documents, which was increased among physicians post EHR implementation[73] When looking at the impact of EHR use on direct patient care, different reviews reported an impact on patient (transfer) time[67,69,72–74]. Outcomes of the different primary studies were however conflicting. Considering the category of task efficiency, Tsai et al. (2020) reported a significant decrease in task occurrences among attending physicians in an ICU post EHR implementation from 2.30 to 1.76 activities per minute[73]. This was in line with findings of Baumann et al. (2018) which reported a 12% decrease in multitasking among physicians post EHR implementation[69]. The impact of EHR use on HCP workarounds was reported in 4 different reviews[67,74–76]. All reviews stated that the presence of an EHR led to more workarounds in both physicians and nurses, often in the form of using more paper artifacts. Tolentino & Gephart. (2020) looked into the amount of task interruptions and completed tasks, which were all increased for nurses in different settings when an EHR was in place[74]. Mouse clicking activity was also measured in primary studies reported by Al ani et al. (2022) and Tolentino et al (2020) and was increased in physicians but decreased in expert nurses[68,74]. Considering the domain of team efficiency, Forde Johnston et al (2022) and Gephart et al. (2015) both reported an increase in communication effort of nurses in case of EHR presence[70,77].

Table 11 – *Descriptive characteristics of reviews for EHR*

Review reference & design	Nr. Primary studies	Setting & population in review	Intervention in review	Comparator in review	Type of outcome in review
Al Ani et al. (2022)[68] Systematic review	●40 included ● 4 relevant	●Hospital environment ●Physicians and nurses	Use of EHR	Comparison of different EHR systems	●Workflow ●Well-being
Baumann et al. (2018)[69] Systematic review with pooled data	●28 included	●Hospital environment ●Physicians, nurses and interns	Use of EHR	Pre/post implementation of EHR (implicit)	●Workflow
Dechant et al. (2019)[78] Systematic review	●50 included ●3 relevant	●Partly hospital environment ●Physicians and residents	Use of EHR	Pre/post implementation of EHR (implicit)	●Well-being
Eden et al. (2018)[67] Narrative review	●7 included ●1 relevant	●Hospital environment ●Physicians and nurses	Use of a.o. EHR	Pre/post implementation of EHR (implicit)	●Workflow
Forde-Johnston et al. (2022)[70] Integrative review	●8 included ●3 relevant	●Partly hospital environment ●Nurses	Use of EHR	Pre/post implementation of EHR (implicit)	●Workflow
Fraczkowski et al. (2020)[75] Integrative review	●33 included ●4 relevant	●Partly hospital environment ●Nurses	USE of EHR	Pre/post implementation of EHR (implicit)	●Workflow
Gephart et al. (2015)[77] Systematic review	●5 included ●1 relevant	●Hospital environment ●Registered nurses	Use of EHR	Pre/post implementation of EHR (implicit)	●Workflow
Hawley et al. (2014)[79] Systematic review	●43 included	●Partly hospital environment ●Maternity care physicians	Use of EHR	Paper based records	●Workflow
Kruse et al. (2022)[80] Systematic review	●25 included	●Partly hospital environment ●Physicians	Use of EHR during Covid-19	Pre/post implementation of EHR (implicit)	●Workflow ●Well-being
Li et al. (2022)[81] Scoping review	●25 included ●2 relevant	●Partly hospital environment ●Physicians, nurse practitioners and registered nurses	Use of EHR	Pre/post implementation of EHR (implicit)	●Well-being
Moore et al. (2020)[71] Systematic review	●33 included ●1 relevant	●Partly hospital environment ●Nurses	Use of EHR	Paper based records	●Workflow

Nguyen et al. (2021)[10] Systematic review	●12 included ●1 relevant	●Partly hospital environment ●Licensed vocational nurse, registered nurse, nurses	Use of EHR	Pre/post implementation of EHR (implicit)	●Well-being
Nguyen et al. (2020)[82] Systematic review	●35 included ●3 relevant	●Partly hospital environment ●Physicians and residents	Use of EHR	Pre/post implementation of EHR (implicit)	●Well-being
Robertston et al. (2022)[83] Systematic review	●17 included	●Hospital environment ●Physicians, nurses and allied care professionals	Implementation of inpatient EHR or EHR enhancement	Before-after EHR implementation or enhancement of paper based records	●Workflow
Sipanoun et al. (2022)[72] Systematic review	●36 included ●3 relevant	●Hospital environment, ●Paediatric Physicians, nurses and administrative staff	Use of EHR with/without EHR linked patient portal	Before/after implementation of EPR (implicit)	●Workflow ●Well-being
Stevenson et al. (2010) Other review	●5 included ●1 relevant	●Hospital environment ●Acute care nurses	Use of EHR in inpatient care settings	Pre/post implementation of EHR (implicit)	●Workflow
Tolentino et al. (2020)[74] Integrative review	●26 included	●Hospital environment ●Nurses	Use of EHR	Pre/post implementation of EHR (implicit)	●Workflow ●Well-being
Tsai et al. (2020)[73] Scoping review	●141 included ●6 relevant	●Hospital environment ●Physicians, registered nurses and nurse practitioners	Use of EHR	Pre/post implementation of EHR (implicit)	●Workflow ●Well-being
Wisner et al. (2019)[76] Integrative review	●18 included ●4 relevant	●Hospital environment ●Nurses	Use of EHR	Pre/post implementation of EHR (implicit)	●Workflow ●Well-being
Wu et al. (2019)[84] Scoping review	●36 included ●2 relevant	●Partly hospital environment ●Physicians, residents, nurse practitioners, physician assistants, nurses	Use of a.o. EHR	Pre/post implementation of EHR (implicit)	●Well-being

Yan et al. (2021)[85] Systematic review	●26 included ●2 relevant	●Partly hospital environment ●Physicians, physician assistants, nurse practitioners, nurses, allied care professionals	Use of EHR	Pre/post implementation of EHR (implicit)	●Well-being

Well-being related outcomes

The impact of EHR use on HCP well-being was reported in twelve reviews in various manners (table 12). Tolentino & Gephart (2020) reported a negative impact of EHR use on nurses physical strain[74]. No other physical effects were reported in the reviews. Considering mental demand, four reviews reported data on the impact of EHR use on the cognitive workload of both nurses and physicians[72–74,76]. Almost all primary studies reported in these four reviews found an (significant) increased amount of cognitive workload, most shortly after EHR implementation. Only one primary study reported a decrease in cognitive workload with EHR use compared to paper records. Looking into mental stress, frustration was often reported and increased in physicians when an EHR was in place with different influencing factors[68,82,84,85]. Nguyen et al. (2021) also reported that increased time spent in an EHR was associated with depersonalization in HCP[82]. Wisner et al. (2019) stated that nurses levels of confidence about accessing the right information and ability to make well informed decisions was decreased with the use of an EHR[76]. Li et al. (2022) reported that high amounts of time spent in an EHR at home were significantly associated with depressive symptoms in critical care physicians[81]. Five different reviews reported data on HCP burn-out, which was often increased with EHR use or associated with factors such as EHR user dissatisfaction[81], documentation burden and mouse clicking activity[82], amount of EHR messages[84] and insufficient documentation time[85]. Three studies furthermore also reported a significant increase in stress levels among physicians and nurses[10,68,78]. There were conflicting results considering the impact of the EHR on HCP job satisfaction. Al Ani et al. (2022) reported a significant increase in job satisfaction among female physicians with using EHR compared to male physicians[68]. Dechant et al. (2019) however reported a decrease or no difference in job satisfaction among physicians [78]. Kruse et al. (2022) reported a decrease in level of autonomy of HCP, an increase in total working hours and a decrease in work-life balance of HCP when a EHR was in place[80]. Finally, Wisner et al. (2019). Stated that nurses had an increased need for team support[76].

Table 12 – *Workflow and well-being related outcomes for EHR*

Domain	Outcome	Finding in review	Direction of effect	Primary studies	Review reference
Workflow	**Time efficiency**				
	Overall productivity	Decreased among American Neurotology Society members	↓	1 [97]	Al Ani et al. (2022)
		Decreased among physicians using EHR	↓	1 [98]	Eden et al. (2018)
	Documentation time	Increased* among nurses during implementation phase, returning to baseline within 3 months	↓	1 [99]	Al Ani et al. (2022)
		Increased in physicians with use of EHR (MD 7.1 min, p=0.207)	↓	1 [100]	
		Increased with 12% among physicians post EHR implementation	↓	Pooled data	Baumann et al. (2018)
		Increased* with 14% among nurses post EHR implementation (p<0.05)	↓		
		Increased with 6% among interns post EHR implementation	↓		
		Increased* among nurses post EHR implementation (p<0.001)	↓	1 [101]	Forde-Johnston et al. (2022)
		Increased with 5% among nurses post EHR implementation	↓	1 [102]	
		Decreased among nurses with use of EHR	↑	1 [102]	Moore et al. (2020)
		Increased among nurses with use of EHR	↓	3 [101,103,104]	
		Increased* with use of EHR (10.25 min. ±0.38 vs. 23.9 min. ±0.43; p < 0.001)	↓	1 [105]	Sipanoun et al. (2022)

		Decreased among physicians with use of EHR	↑	2 [106,107]	Tsai et al. (2020)
		Increased* among nurses post EHR implementation (p<0.05)	↓	1 [108]	
		Increased* among physicians in settings with EHR compared to non EHR settings (p<0.001)	↓		
		Increased among physicians and nurses in settings with EHR compared to non-EHR settings	↓	1 [109]	
		Increased* for vital signs in EHR compared to paper (116(89) min. vs. 79(39)min, p=0.02)	↓	1 [110]	Tolentino et al. (2020)
	Completion time	Increased for notes among physicians post EHR implementation (pre: 600-1200hours, post: 10-24 hours)	↑	1 [111]	Tsai et al. (2020)
	Patient time	Decreased among nurses and physicians	↓	1 [112]	Baumann et al. (2018)
		Increased among nurses post EHR implementation	↑	1 [113]	
		Decreased among physicians with use of EHR	↓	1 [114]	Sipanoun et al. (2022)
		ND pre- and post- EHR implementation	-	1 [110]	Tolentino et al. (2020)
		ND* among physicians post EHR adoption	-	1 [115]	Tsai et al. (2020)
	Patient transfer time	Increased with use of EHR	↓	1 [98]	Eden et al. (2018)
	Task efficiency				
	Task occurrences	Decreased* among attending physicians in ICU post EHR	↓	1 [116]	Tsai et al. (2020)

		implementation (2.30 to 1.76 activities per minute, p<0.01)			
	Multitasking	Decreased with 12% among physicians post EHR implementation	↑	1 [117]	Baumann et al. (2018)
	Workarounds	Increased with use of EHR	↓	1 [98]	Eden et al. (2018)
		Increased with use of EHR	↓	4 (N.R.)	Fraczkowski et al. (2020)
		Increased among nurses with use of EHR (more paper artifacts and open text fields)	↓	2 [42,111]	Tolentino et al. (2020)
		Increased among nurses with use of EHR (more paper artifacts)	↓	1 [118]	Wisner et al. (2019)
		Increased among physicians post EHR implementation (more paper artifacts)	↓	1 [119]	
		Increased among nurses during patient handover (more paper artifacts)	↓	1 [120]	Wisner et al. (2019)
	Task interruptions	Increased among nurses at neonatal ICU with use of EHR	↓	1 [121]	Tolentino et al. (2020)
		Increased among nurses with use of EHR	↓	1 [122, 123]	
	Task completion	Increased among expert nurses in ED with use of EHR	↑	1 [124]	Tolentino et al. (2020)
	Mouse clicking activity	Increased among physicians with use of EHR (MD 0.54, p=0.13)	↓	1 [100]	Al Ani et al. (2022)
		Decreased among expert nurses in ED with use of EHR	↑	1 [124]	Tolentino et al. (2020)
		Increased with use of EHR	↓	1 [125]	
	Handwriting	Decreased among nurses with use of EHR	↑	1 [126]	Stevenson et al. (2010)
	Team efficiency				

	Communication effort	Decreased among nurses with use of EHR	↑	1 [127]	Forde-Johnston et al. (2022)
		Increased among nurses with use of EHR	↓	1 [42]	Gephart et al. (2015)
Well-being	**Physical strain**				
		Suboptimal physical function among nurses with use of EHR	↓	1 [125]	Tolentino et al. (2020)
	Mental demand				
	Cognitive workload	Increased* among nurses post EHR implementation	↓	1 [128]	Sipanoun et al. (2022)
		Increased with use of EHR	↓	1 [129]	
		Increased* among nurses post EHR-implementation until 10 shifts after	↓	1 [128]	Tolentino et al. (2020)
		Decreased* among physicians with use of EHR compared to paper records	↑	1 [130]	Tsai et al. (2020)
		Increased* among pediatric nurses during EHR implementation ($p<0.001$)	↓	1 [128]	
		Increased among physicians due to fragmented information	↓	2 [118, 129]	Wisner et al. (2019)
		Increased among nurses in early EHR implementation phase	↓	1 [128]	
	Mental stress				
	Frustration	Increased* among male physicians compared to female physicians with use of EHR (MD 33.15, $p < 0.001$)	↓	1 [100]	Al Ani et al. (2022)
		Increased with use of cumbersome EHR	↓	1 [131]	Nguyen et al. (2021)
		Increased among physicians correlating with time spent in EHR	↓	1 [132]	Wu et al. (2019)

		Increased* among burned out physicians compared to non-burned out physicians ($p<0.001$)	↓	1 [133]	Yan et al. (2021)
	Depersonalization	Increased time spent in EHR is associated with depersonalization	↓	1 [131, 134]	Nguyen et al. (2021)
	Confidence	Decreased among nurses for accessing right information and ability to make well informed decisions	↓	1 [135]	Wisner et al. (2019)
	Depression	High amounts of time spent in EHR at home are associated* with depressive symptoms in critical care physicians	↓	1 [136]	Li et al. (2022)
	Burnout	Amount of EHR work per patient associated with burnout in radiologists	↓	1 [137]	Li et al. (2022)
		>20 hours of EHR use is associated with burnout among orthopedic surgery residents	↓	1 [138]	
		Dissatisfaction with use of EHR is associated with burnout among rheumatologists	↓	1 [139]	
		Low satisfaction with use of EHR is not associated with burnout among internal residents	↓	1 [140]	
		Increased documentation burden and mouse clicking activity with use of EHR is associated with burnout	↓	1 [141]	Nguyen et al. (2021)
		Increased EHR usability is associated with lower reported burnout	↑	1 [131]	
		Increased* among physicians using EHR compared to non-EHR use	↓	1 [108]	Tsai et al. (2020)

		Increased (19.8%) among nurses with use of EHR	↓	1 [142]	
		Increased among physicians as a result of among other EHR use	↓	1 [128]	Wu et al. (2019)
		Increased among nurses as a result of among others EHR use	↓	1 [143]	
		Increased symptoms among physicians associated with amount of EHR messages	↓	1 [144]	
		ND with use of EHR in adjusted models	↓	1 [145]	
		Predictors for burnout are insufficient documentation time and frustration with use of EHR		1 [142]	
		Increased burnout among cardiologists was associated with insufficient documentation time	↓	1 [146]	Yan et al. (2021)
		Increased burnout rates among cardiologists with negative perceptions of EHR use	↓	1 [147]	
	Stress	Increased* among male physicians compared to female physicians with use of EHR (MD 17.5, $p < 0.001$)	↓	1 [100]	Al Ani et al. (2022)
		Increased* among physicians with EHR adoption ($p<0.05$)	↓	1 [148]	Dechant et al. (2019)
		Increased* stress among nurses with use of EHR is associated with frustration	↓	1 [149]	Nguyen et al. (2020)
	Other				
	Job satisfaction	Increased* among female physicians compared with male physicians with ease of use of EHR (MD 0.66, $p = 0.03$)	↑	1 [100]	Al Ani et al. (2022)

		Decreased among physicians with use of EHR	↓	1 [150]	Dechant et al. (2019)
		ND among physicians with use of EHR	↓		
	Autonomy	Decreased with use of EHR	↓	Kruse et al. (2022)	Kruse et al. (2022)
	Workload				
	Working hours	Increased with use of EHR	↓	Kruse et al. (2022)	Kruse et al. (2022)
	Work-life balance	Decreased with use of EHR	↓		
	Team				
	Support	Increased need for support among nurses	↓	1 [120]	Wisner et al. (2019)

* : significant difference, ↑: positive direction of effect, ↓: negative direction of effect, -: no direction of effect, [...] : reference primary study
ND: no difference, EHR: electronic health record.
Note 1: Findings as reported in reviews
Note 2: See appendix 2 for references primary studies

Discussion

This scoping review aimed to explore the impact of electronic medical technologies on the workflow and well-being of physicians and nurses in hospital settings. The analysis encompassed various technologies, including continuous glucose telemonitoring (CGM), the use of clinical decision support systems (CDSS) in radiology, 3D laparoscopy, robot-assisted surgery (RAS) and electronic health records (EHR). In summary, the impact of medical technologies on healthcare physicians and nurses work and well-being in hospital settings is to a high extent heterogenous and multifaceted. While some results showed potential benefits in workflow efficiency and well-being related outcomes, others posed challenges and potential risks. The direction of these effects on the concepts of workflow- and well-being do not necessarily align and could be contradicting. In other words, a higher degree of workflow efficiency did not always corresponds to increased well-being of healthcare professionals (HCP), and vice versa. The most remarkable results per type of technology will be discussed in the next paragraph.

The examination of CGM revealed a nuanced picture. Workflow-related outcomes showed variations in consultation time and workload, with an increase in patient communication time for physicians and a decrease in workload for nurses. However, well-being-related outcomes were not addressed in the examined reviews. For CDSS in radiology, the impact on workflow-related outcomes, particularly image reading time, exhibited conflicting results. While some studies reported a longer reading time for radiologists aided with machine learning software, others found no significant difference. Interestingly, well-being-related outcomes were not covered in the reviews, leaving a gap in understanding the potential effects on the radiologists' well-being and job satisfaction. The exploration of 3D laparoscopy compared to 2D laparoscopy demonstrated a mixed impact on workflow-related outcomes, specifically on surgical operation time. Some reviews reported a decrease, while others found no significant difference. Regarding the health of surgeons, the reviews highlighted both positive and negative aspects, such as a decrease in neck pain but an increase in visual distress. The extensive focus on RAS revealed divergent impacts on workflow-related outcomes, notably surgical operation time. While some reviews reported an increase, others found no significant difference. Well-being-related outcomes depicted a complex scenario, with varying effects on physical discomfort, mental fatigue, and team collaboration. Lastly, the assessment of EHR unveiled challenges in time efficiency, with often increased documentation time for physicians and nurses. Workarounds and task interruptions were also noted. The well-being-related outcomes painted a concerning picture, indicating increased cognitive workload, stress, and burnout among HCP using EHRs.

As displayed above, the main focus of literature lies on examining the effect of technology use on workflow related outcomes. To a much lesser extent there is attention to the actual impact of technology integration on the health and experiences of HCP. This was especially the case in review studies examining the effects of technologies in the field of telemonitoring, clinical decision support systems and robotic surgery. Regarding the field of EHRs, the available knowledge on either the impact on workflow or well-being was more in balance. Moreover, this scoping review highlighted the fact that there exist great diversity in measuring units with a lack of uniformity in results for both workflow- and well-being related outcomes, both within and between technologies. This makes it very difficult to compare and interpret the results. Lastly, the extent of available literature on current outcomes of interest appeared to be dependent on the type of technology. Most of the eligible studies were part of the technology domains of EHRs and robotic surgery. Literature about the relevant technologies in the field of telemonitoring and CDSS were however available to a much lesser extent.

There could be multiple reasons for the more extensive focus in literature on workflow-related outcomes instead of well-being related outcomes. First, workflow-related outcomes are often easier to quantify and measure objectively. Metrics such as time expenditure, efficiency gains and reduced errors can be more readily assessed. Well-being-related outcomes, on the other hand, involves subjective factors that are harder to measure and evaluate in concrete terms[86,87]. Moreover, the impact on workflow is often more immediate and visible, making it easier to assess in the short term. The influence of medical technologies on HCP well-being may take longer to manifest, and their effects might be expressed subtle and on the long-term[87]. Lastly, healthcare systems are under constant

pressure to improve efficiency, productivity, patient safety and cost savings. Assessing the impact of medical technologies on workflow directly align with these goals and is seen as a way to enhance overall system performance[88].

The finding that there exist great diversity in measuring units in the assessment of medical technology use could be explained by the multidimensional nature of the concepts of workflow and well-being. This makes it challenging to capture in a predefined set of outcome measures. The absence of standardized metrics or guidelines for measuring and evaluating the impact of medical technologies on workflow- or well-being related outcomes contributes to its variability in research outcomes. Researchers currently use different instruments based on for example the goal of the study, the specific healthcare setting, or preferences[87]. Sometimes a combination of quantitative and qualitative measures are applied, which provide a more comprehensive understanding. Efforts to establish common measurement units could enhance comparability across studies and contribute to a more effective and cohesive understanding[89].

As also described by the social-technical-system approach, introducing new technologies into already complex healthcare systems substantially affects HCP work and workflows, interpersonal interactions and the delivery of patient care[9,11]. Current assessment and evaluations of new medical technologies are often focused on patient safety, efficacy and effectiveness, workflow integration, financial aspects and usability[90]. A significant strength of this scoping review is highlighting the fact that the use of medical technologies also substantially affect the well-being and workload of HCP. The absence of well-being-related outcomes in literature with also highly contradicting results underscores the need for a more holistic and consistent approach to evaluating the introduction of medical technologies. Providing this current state of knowledge could lay the foundation for more focused systematic reviews or primary research. Future research should delve deeper into understanding the interplay between technology adoption, workflow optimization, and the well-being of HCP to inform evidence-based strategies for improving healthcare delivery and to retain HCP in the field.

Another great strength of this review is the inclusion and comparison of different type of medical technologies, which provides an extensive overview. The great variety in measuring and reporting of outcomes reinforces the need for a standardized assessment framework for each type of technology, which should include HCP health aspects and experiences. As the field evolves, assessment frameworks may evolve as well. Future research needs to thoroughly examine the specific measurement tools and units for each category of medical technology. Putting measures in place without sufficient thought and care may result in misdirection of resources, a false sense of the scope of the problem and a delay in improvements[86]. Since different technologies also affect different efficiency and well-being aspects, attention must be paid to tailor-made frameworks.

Several limitations should be considered when interpreting the results of this scoping review. First, included literature may not comprehensively cover all relevant studies, as scoping reviews prioritize breadth over depth. Second, this study merely included and extracted data from review studies instead of original primary studies. This leads to great heterogeneity in reporting, accuracy and depth of the data, which makes it more difficult synthesize and generalize results and draw firm conclusions. Moreover, eligible review studies were not assessed for risk of bias. Lastly, the contextual differences in healthcare settings, such as variations in technology implementation strategies and organizational structures, also introduces a layer of complexity in drawing overarching conclusions. Despite these limitations, this scoping review provides a valuable overview of the current state of literature, highlighting key themes and areas warranting further research for the integration of medical technologies in care practice.

Conclusion

This scoping review provides an overview of the impact of different medical technologies on the workflow and well-being of physicians and nurses in hospital settings. The findings indicate that the impact of medical technologies on HCP work and well-being in hospital settings is to a high extent heterogenous and multifaceted, which can both be positive and challenging. The direction of these

effects on the concepts of workflow- and well-being do not necessarily align and could be contradicting. For enforcing the potential of technologies in enhancing healthcare efficiency and HCP health, there are challenges that need careful consideration during development and integration of innovations in daily clinical practice. A comprehensive and standardized approach is needed for assessing the impact of medical technologies and should include both workflow considerations and an understanding of their effects on the well-being of HCP. Striking this balance between leveraging technology and preserving the human touch in healthcare is essential for ensuring the effectiveness of healthcare delivery and the sustainability of the healthcare workforce. Continuous training, support and a thoughtful approach to technology development, assessment and adoption are key elements in navigating the challenges successfully.

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Appendix 1 – Search string

Set	Search details	No. of papers
1: Robotic surgery + outcomes	(advanced_title_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety) OR advanced_abstract_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety)) AND (advanced_title_en:(((Three-dimension* OR 3D OR 3-D OR "3 dimension*" OR "3-dimension" OR Robot* OR Robot-*) AND (Surger* OR surgical* OR laparoscop* OR operat* OR resection*))) OR advanced_abstract_en:(((Three-dimension* OR 3D OR 3-D OR "3 dimension*" OR "3-dimension" OR Robot* OR Robot-*) AND (Surger* OR surgical* OR laparoscop* OR operat* OR resection*)	206
1: Telemonitoring + outcomes	(advanced_title_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety) OR advanced_abstract_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety)) AND (advanced_title_en:((((("Subcutaneous continuous" OR Computer-* OR computer* "data-filtering system" OR "Automatic response" OR Software OR Online OR tele* OR Tele-*) AND (glucose management OR glucose monitoring)) OR (CGM OR "Artificial pancreas"))) OR advanced_abstract_en:((((("Subcutaneous continuous" OR Computer-* OR computer* "data-filtering system" OR "Automatic response" OR Software OR Online OR tele* OR Tele-*) AND (glucose management OR glucose monitoring)) OR (CGM OR "Artificial pancreas")	45
1: CDSS + outcomes	(advanced_title_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR	117

	Burnout OR Stress OR distress OR Anxiety) OR advanced_abstract_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety)) AND (advanced_title_en:((("Artificial intelligence" OR "Neural network*" OR "Deep learning" OR algorithm*) AND ("Computed tomography" OR CT OR MRI OR "Magnetic resonance imaging" OR Radiomics OR radiolog*))) OR advanced_abstract_en:((("Artificial intelligence" OR "Neural network*" OR "Deep learning" OR algorithm*) AND ("Computed tomography" OR CT OR MRI OR "Magnetic resonance imaging" OR Radiomics OR radiolog*)	
1: EHR + outcomes	(advanced_title_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety) OR advanced_abstract_en:(Workflow OR Interruption* OR Workaround* OR Workload OR "Work load" OR ((Task OR Performance) AND (shift OR efficiency OR duration OR add* OR variety OR fragment* OR quantity OR switch* OR frequency OR time)) OR Barrier* OR Facilitator OR Autonomy OR engagement OR Dedication OR Satisfaction OR "Intention to stay" OR "Intention to leave" OR Turnover OR retention OR sick leave OR absenteeism OR "Work-life balance" OR well-being OR Wellbeing OR Burnout OR Stress OR distress OR Anxiety)) AND (advanced_title_en:((EHR* OR EHR-* EMR* OR EMR-* EPR* OR EPR-* "electronic health record*" OR "electronic health record-*" OR "electronic medical record*" OR "electronic medical record-*" OR "computerized medical record*" OR "computerized medical record-*" OR "electronic patient record*" OR "electronic patient record-*" OR "pajama time" OR "electronic point-of-care documentation systems" OR "clinical information system*" OR "clinical information system-*" OR "health information system*" OR "health information system-*" OR "medical information system*" OR "medical information system-*" OR "healthcare information system*" OR "healthcare information system-*" OR "hospital information system*" OR "hospital information system-*" OR "medical record system*" OR "medical record system-*" HIS OR CIS OR "health information technology")) OR advanced_abstract_en:((EHR* OR EHR-* EMR* OR EMR-* EPR* OR EPR-* "electronic health record*" OR "electronic health record-*" OR "electronic medical record*" OR "electronic medical record-*" OR "computerized medical record*" OR "computerized medical record-*" OR "electronic patient record*" OR "electronic patient record-*" OR "pajama time" OR "electronic point-of-care documentation systems" OR "clinical information system*" OR "clinical information system-*" OR "health information system*" OR "health information system-*" OR "medical information system*" OR "medical information system-*" OR "healthcare information system*" OR "healthcare information system-*" OR "hospital information system*" OR "hospital information system-*" OR "medical record system*" OR "medical record system-*" HIS OR CIS OR "health information technology")	1138

2: Robotic surgery + setting	(advanced_title_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center")) OR advanced_abstract_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center"))) AND (advanced_title_en:(((Three-dimension* OR 3D OR 3-D OR "3 dimension*" OR "3-dimension" OR Robot* OR Robot-*) AND (Surger* OR surgical* OR laparoscop* OR operat* OR resection*))) OR advanced_abstract_en:(((Three-dimension* OR 3D OR 3-D OR "3 dimension*" OR "3-dimension" OR Robot* OR Robot-*) AND (Surger* OR surgical* OR laparoscop* OR operat* OR resection*)	21
2: Telemonitoring + setting	(advanced_title_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center")) OR advanced_abstract_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center"))) AND (advanced_title_en:((((("Subcutaneous continuous" OR Computer-* OR computer* "data-filtering system" OR "Automatic response" OR Software OR Online OR tele* OR Tele-*) AND (glucose management OR glucose monitoring)) OR (CGM OR "Artificial pancreas"))) OR advanced_abstract_en:((((("Subcutaneous continuous" OR Computer-* OR computer* "data-filtering system" OR "Automatic response" OR Software OR Online OR tele* OR Tele-*) AND (glucose management OR glucose monitoring)) OR (CGM OR "Artificial pancreas")	7
2: CDSS + setting	(advanced_title_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center")) OR advanced_abstract_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center"))) AND (advanced_title_en:((("Artificial intelligence" OR "Neural network*" OR "Deep learning" OR algorithm*) AND ("Computed tomography" OR CT OR MRI OR "Magnetic resonance imaging" OR Radiomics OR radiolog*))) OR advanced_abstract_en:((("Artificial intelligence" OR "Neural network*" OR "Deep learning" OR algorithm*) AND ("Computed tomography" OR CT OR MRI OR "Magnetic resonance imaging" OR Radiomics OR radiolog*)	10
2: EHR + setting	(advanced_title_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center")) OR advanced_abstract_en:((professional* OR provider* OR Practitioner* OR Clinician OR Doctor* OR nurse* OR nursing OR physician* OR resident* OR "healthcare worker*" OR "health staff" OR physician* OR "medical staff") AND (inpatient* OR hospital* OR department* OR ward OR ICU OR "medical center"))) AND (advanced_title_en:((EHR* OR EHR-* EMR* OR EMR-* EPR* OR EPR-*	228

	"electronic health record*" OR "electronic health record-*" OR "electronic medical record*" OR "electronic medical record-*" OR "computerized medical record*" OR "computerized medical record-*" OR "electronic patient record*" OR "electronic patient record-*" OR "pajama time" OR "electronic point-of-care documentation systems" OR "clinical information system*" OR "clinical information system-*" OR "health information system*" OR "health information system-*" OR "medical information system*" OR "medical information system-*" OR "healthcare information system*" OR "healthcare information system-*" OR "hospital information system*" OR "hospital information system-*" OR "medical record system*" OR "medical record system-*" HIS OR CIS OR "health information technology")) OR advanced_abstract_en:((EHR* OR EHR-* EMR* OR EMR-* EPR* OR EPR-* "electronic health record*" OR "electronic health record-*" OR "electronic medical record*" OR "electronic medical record-*" OR "computerized medical record*" OR "computerized medical record-*" OR "electronic patient record*" OR "electronic patient record-*" OR "pajama time" OR "electronic point-of-care documentation systems" OR "clinical information system*" OR "clinical information system-*" OR "health information system*" OR "health information system-*" OR "medical information system*" OR "medical information system-*" OR "healthcare information system*" OR "healthcare information system-*" OR "hospital information system*" OR "hospital information system-*" OR "medical record system*" OR "medical record system-*" HIS OR CIS OR "health information technology")	

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1. Biermann E, Dietrich W, Rihl J, Standl E. Are there time and cost savings by using telemanagement for patients on intensified insulin therapy? Comput Methods Programs Biomed. 2002 Aug;69(2):137–46.

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