Multi-faceted boundary relations in pharmacy automation

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Abstract

The robotization of pharmacies has been a comprehensive and yet subtle development proceeding over the past two decades. Pharmacies provide a novel and relevant framework for the study of automation where multiple factors, including professional interests, governmental regulation, and private business interests all determine how robots are integrated into work. Applying a mixed methods approach including interviews with automation manufacturers and pharmacy workers as well as a comprehensive survey (N = 573), we investigated how pharmacy automation is produced and implemented. Our research shows that pharmacy automation is deemed more useful by the pharmaceutical staff compared to technical assistants. Autonomous machines may deteriorate workers' own autonomy. Significant factors in evaluating the usefulness of automation were primarily autonomy and time pressure. The findings further reveal that pharmacy robots facilitate a new spatial design where the effectiveness of automation can also be harnessed to increase over-the-counter product sales amplifying the societal use of medication, also known as pharmaceuticalization.

Keywords: Automation, robots, pharmacy, medication, pharmaceuticalization, professional relations, boundary relations, healthcare, medical care

INTRODUCTION

As already noted by Angelo et al. (2005), "(i)ncreases in pharmacist productivity have occurred largely through the use of technicians and technology in today's pharmacies." 15 years ago the development of automated dispensing systems – pharmacy robots, as we also call them today – was in its infancy. The first automated dispensers were developed in Europe in the mid 1990's by Rowa and Willach (Nemutanzhela and Sekgweleo 2019). After that, Finnish hospital and retail pharmacies have adopted this type of robotics quite extensively. Indeed, Finland makes an appropriate context to study robotization for several reasons. In the world-scale statistics of the International Federation of Robotics (IFR), Finland's industrial robot density is somewhat behind the leading countries like China and the US but has been consistently above the average. There were 161 robots per 10.000 employees in the Finnish manufacturing industry in 2021 when the world average figure was 141 (IFR 2022). The relevance lies in how the use of industrial robotics creates a favorable launch pad for automated applications in many non-industrial services, as well, such as pharmacy logistics. In addition, Finland's national innovation system is quite well developed (e.g. Kapetaniou and Pissarides 2022) which creates favourable conditions for technological innovations in health technology products and solutions. On the other hand, there are special factors like strong regulational needs and occupational terms that bring challenges for health innovations and health startups (Chernova and Konina 2022; Niskasaari et al. 2022). In fact, the regulation of pharmacy systems is high, and Finland stands out as one of the most regulated pharmacy ecosystems in Europe (Vogler et al. 2012).

Approximately every third pharmacy in Finland currently utilizes automation for their drug stock management. The high rate suggest a kind of a *bandwagon effect* under its way. Automated dispensing systems are becoming the norm in modern pharmacies. However, the effectiveness and user acceptance of pharmacy automation has been assessed mostly from the *insiders'* point of view. Existing research has focused on the medical and pharmaceuticals industry and the professional field of pharmacists with an emphasis on hospital, rather than retail pharmacies (e.g., James et al. 2013; Hogan et al. 2020).

Benefits of robotic solutions in pharmacies include avoiding human error in dispensing medication, and reorganizing professionals' time from routine tasks to personal customer services. It has long been acknowledged that digitalization and (intelligent) automation increase medication safety as well as efficiency in dispensing drugs (Mehta and Shukla 2022). An early example of this, is the implementation of bar code technology in hospital pharmacies (Poon et al. 2006). The trend has been confirmed in many later case studies, such as studies on electronic prescribing and robotic labelling (Beard and Smith 2013), as well as using robotic dispensing systems in hospital pharmacies (Rodriguez-Gonzalez et al. 2018).

If the automation of pharmacies is considered from a more systemic perspective, that is, how automation works within organizations and how occupational groups adopt new technologies, the lack of research is furthermore evident (Wise et al. 2015; Boyd and Chaffee 2020; cf. Qureshi and Syed 2014). In order to decrease pharmacists' workload while maintaining or increasing efficiency and productivity, the inputs of information technology and automation for dispensing, logistics and management processes have been found promising (e.g., Westerling et al. 2010). However, even some robot manufacturers have found that while their automation technologies increase the efficiency, accuracy, and safety of medical dispensing, they may also have an impact on the space requirements and even slow down pharmacy workflows (Swisslog, according to Grosch 2015). From the perspective of changing workflows, change management and achieving profitability with automated dispensing systems have not been an entirely straightforward processes (see e.g., Ruhle et al. 2008; Berdot et al. 2016). This leads us to believe that a qualitative and complex change is followed by the implementation of this relatively straightforward technology. This change is the basis of our research, and the goal to ascertain which factors fundamentally change how automation affects work in pharmacies.

In the present study we investigated how robotic dispensing systems in pharmacies reorganize the material and information flows, how new technology is accepted by the pharmacy staff, and how automation rearranges the spatial and temporal configurations of pharmaceutical processes and operations. In our mixed methods approach, we utilize both qualitative and quantitative data. Sociologically, it is rational to think that the results of robot implementations depend on many other factors than just logistical effectiveness or professional interests of delivering the right medication doses at the right time to patients and clients. First, we will focus on how the implementation of a robot modifies the organization of work in retail pharmacies in Finland. Next, we ask how the practical solutions in pharmacy automation reflect the changing pharmaceuticals markets and increased pressure to sell non-prescription drugs. The usefulness of pharmacy automation and other context-dependent healthcare technologies has not been thoroughly studied, and it has been argued that the studies should address the probable and even considerable number of unintended consequences when it comes to issues of healthcare services (Boyd and Chaffee 2018:8).

Our research acknowledges how pharmacy automation changes retail pharmacies from the perspective of occupational relationships within the pharmacies, and also shows how the implementation of automation is affected by outside factors, such as regulation, automation, and pharmaceuticals industries, and quite importantly, the role of pharmacies as private businesses. The quantitative part of the study draws from a survey data which we use to analyze the variance in the perceived usefulness of technology and how it correlates with value-congruence, employee autonomy and time pressure among the various occupational groups. The qualitative aspects of the research consist of interview data from both inside and outside the pharmacy. The multiple interviews cover qualitative changes in retail pharmacies, provide supplementary information for the quantitative analysis, and provide a case study for the spatial changes occurring alongside automation.

BACKGROUND

Where the seminal study by Barrett et al. (2012) focuses on professional boundaries in hospital pharmacies, our study concentrates on retail pharmacies and compares the relations between the two. Regardless of many functional and organizational similarities in hospital and retail pharmacies, there are also crucial differences. Hospital pharmacies serve highly specific *clientele* of professionals, whereas retail pharmacies are in direct contact with customers, patients, and other private persons. The retail pharmacies are also privately owned businesses, regularly aiming to improve their turnover by marketing over-the-counter (OTC) medicine and products, which include non-prescription drugs, medical equipment and cosmetics. This connects the introduction of pharmacy automation and discussions of productivity to current trends in Europe. There has been debate, for example in Sweden and Estonia, on how pharmacies should be owned and, importantly, whether non-prescription drugs could be sold in other outlets as well (Wisell 2019; Gross and Volmer 2016).

Automated dispensing systems in pharmacies can be viewed as mechanizing and robotizing human tasks such as shelving medicine packages. In principle, automated dispensing and shelving does not differ from the industrial solutions of warehouse logistics. From an engineering perspective, automatic dispensers are logistical devices rendering stores management more effective, and optimizing the use of space needed for handling, picking, and delivering the products. The typical packaging of pharmaceutical goods is well standardized, which also favors applying robotic technologies in pharmacy logistics (cf. Rodriguez-Gonzales et al. 2018).

The widespread general interest in automated dispensing systems (ADS), automated dispensing cabinets (ADC) and automated dose dispensing (ADD) devices in recent years (e.g., Sinnemäki et al. 2014) can be taken as a sign of pressures to make the healthcare sector more cost-efficient and productive. Yet, robots have not so far become the healthcare breakthrough that they were imagined to be, and the usage of care robots is globally still very marginal (Van Aerschot and Parviainen 2020). Logistic robots, including pharmacy automation, seem to show the most promise in automating healthcare (Niemelä et al. 2021).

At the same time, automation has potential to achieve many qualitative changes in how organizations and groups of people work and interact. Critical voices in discussions about technological unemployment even argue that automation does not only cause job loss but also impairs the quality of existing jobs by subjecting work to the control and pace of the machine and decreases autonomy (Wajcman 2017:124; Vidal 2013). Examples of this have been found in the hospital pharmacy setting as automation decreased the autonomy for auxiliary workers (Barrett et al. 2011).

If technology like pharmacy automation is studied from a purely technical point of view, it comes to neglect how the new technology fits into the organizational environment with dynamic occupational and power-related relationships (cf. Barrett et al. 2011). Instead, it is important to identify various relevant boundaries that will have an affect on how automation is adopted in workplaces, such as pharmacies. In addition to professional relationships, external ecosystem of legislation, regulation and technology companies play key roles in shaping pharmacy automation.

Automation, pharmaceuticalization, and professional adaptation

New technologies shift the boundaries and power among occupational groups. Pharmacy organizations engage both professionally and occupationally trained employees. The first being pharmacists and the latter being technical assistants performing a variety of auxiliary tasks within pharmacies. Traditionally healthcare professions and practices have been legitimized and defined by law (Lindsay et al. 2014:2945), which is also the case with the profession of pharmacists. In Finland, pharmacists have the exclusive right and license to distribute prescription drugs (Fimea 2016). This has in fact made it impossible to fully automate the pharmacy process.

Pharmacy work is highly gendered (Goldin and Katz 2016), and for example in the Finnish retail pharmacies, more than two thirds of head pharmacists (the licensed pharmacy owners) are reportedly female (Apteekkari 2021). The fact that female workers in pharmacies are a majority has been explored previously and also connected to the information technology use (see Goldin and Katz 2016.). Goldin and Katz (ibid.) note interestingly how information technology and standardized products and services have enabled greater substitutability between pharmacists. This means that one pharmacist can take over the tasks of a colleague without specified knowledge about it, beyond the general professional knowledge. According to Goldin and Katz (2016), this enabled a smaller wage penalty when working part-time, which is generally more common among women with children (ibid.). Goldin and Katz note how pharmacies are female-dominated in number, but the managers and owners are still predominantly male, making the Finnish system unique in comparison.

Examples of technology changing professional relationships have previously been found in a healthcare context, where new ways to render images (MRI and CT scans) made interpretations and diagnoses more accessible to others besides the individuals of established profession (Barrett et al., 2011). The loss of tasks or legitimacy of a profession can be seen as deskilling, which is a prominent theme in the discourse of automation and is sometimes even the goal of automation as it lowers the cost of labor (see Beard 2017:136). In the case of professionals, this deskilling would also refer to deprofessionalization or 'proletarianization' (Martin et al. 2009:1192).

Boyd and Chaffee (2019) point out that technology may have a poor fit with the workflow which makes people create workarounds to bypass some aspects of a system or the system entirely. Barrett et al. (2011:1459) note how workarounds, and who gets to make them, can be related to occupational or professional power. Their study found that the knowledge of workarounds and fixing the machine was not allowed to the group of assistants, as that knowledge was a form of legitimacy for the group of technicians only (ibid.).

Professions tend to defend their jurisdictions fiercely and shifts in the responsibilities of one profession impact others and the incursions are met with reassertions of existing boundaries (Martin et al. 2009). The profession in power can define the terms of reference for disputes that threaten this professional power (ibid.: 1192). This can be seen as boundary work that seeks to categorize objects, people, and practices to secure the autonomy, jurisdiction, and legitimacy of the group (Mäkinen 2018:353). This relates closely to the terms of discussion about pharmacy automation and how it has been mostly discussed in terms of medication errors and efficiency and almost exclusively from the point of view of pharmacists. This can be seen as boundary work, where pharmacists take control over the discourse surrounding automation.

Occupational/professional hierarchies of pharmacies in Finland consist of multiple working groups and whereas the ‘pharmacists’ are the largest working group, the second largest group is the ‘technical assistants’, who over the years have been referred to by varying titles (The Association of Finnish Pharmacies 2021). Regulation plays an important part in shaping professional relationships i.e. which responsibilities belong to which group and how they interact with each other. as well as the pharmacy institution as a whole. We expect regulation have an impact on automation as well. The pharmacies in Finland operate on the boundary of public and private sectors. Excluding the Helsinki University Pharmacy, pharmacies in Finland cannot be owned by companies *per se*, but rather by single graduated and accomplished pharmacists. The licenses for head pharmacists are granted by the Finnish Medicines Agency (Fimea). Particularly the regulated pharmacy countries Finland, Spain, Denmark, and Austria are implied to have higher usage of automation than the deregulated countries UK, Ireland, the Netherlands, Norway, and Sweden (see Vogler et al. 2012).

Pharmacy privatization has been studied from medical and economic perspectives. Productivity evaluations are favorable towards privatization largely due to OTC drugs increasing the profit margins (see Lluch and Kanavos 2010). Comparing regulated system to a privatized one, accessibility has been found higher in regulated pharmacies (ibid.). So far, however, there has been no evidence of health risks with the increased sale of drugs (ibid.). The increased sale and use of drugs ties pharmacy privatization and automation to the same trend of *pharmaceuticalisation*, the increased use of drugs.

Pharmaceuticalization can be called an expansion of medicalization to include the aspects of the pharmaceuticals industry, regulation, and the general increase in medication use. Medicalization refers to nonmedical problems becoming defined as medical ones (Conrad 1992) and has traditionally been focused on medical professionals and organizations, and their interaction with patients as the central driver of medicalization (Abraham 2010). Pharmaceuticalization shifts the focus to the pharmaceutical industry as another identified driver (ibid.). Pharmaceuticalization has also been defined as the general increase in medication use, which has several other grounds, such as aging population, new diagnoses, and mobilization of patient groups (Williams et al. 2011). Pharmaceuticalization can sometimes bypass medicalization and for example reclassify prescription drugs as OTC (Abraham 2010: 605), which is highly relevant to our research as well. An important reasoning that relates to automation are the effects of the pharmaceutical industry on pharmaceuticalization. Williams et al. (2011:712–720) describe that it is easier to get new medication onto the shelves than to get harmful ones out, and that medicines are used increasingly for enhancement rather than treatment (e.g., using ADHD medication to be able to work to a greater extent). With automation and robots, we may have an entirely new actor escalating the process. Automation increases the efficiency and the suggested mechanism here is that as medication, both prescription and OTC are dispensed more efficiently, the increased outflow of medications creates more demand for automation.

Although automation is used in both hospital and retail pharmacies, we expect them to have distinct effects from each other relating to the tasks, spaces, and professional relations of the respective organizations. The task of selling OTC and making a profit in retail pharmacies is expected to be the key factor in making pharmaceuticalization a part of the automation process of pharmacies.

Similarly, we can expect professional and occupational staff to adjust to these changes. Our hypotheses include a wide variety of possible mechanisms for the effects of automation, and in them, we aim to illustrate comprehensively the systemic effects caused by pharmacy robots in tandem with the organizational setup.

HYPOTHESES

Pharmacy regulation, spatial, temporal, and professional boundaries - qualitative hypotheses

The duties of pharmacists affect how pharmacy automation is used and what is achieved with the effectiveness of automation. Pharmacy spatial design has potential to support automation and bring qualitative changes to the pharmaceutical service. According to Barrett et al. (2012) pharmacy automation creates spatial changes that reflect the existing professional boundaries. The regulation and organization of retail pharmacies affect how automation is used and creates unique effects compared to how the similar technology works in hospital pharmacies.

> *Hypothesis 1* Pharmacy spatial design supports automation accompanying qualitative changes to the pharmaceutical service.

> *Hypothesis 1a* The regulation and organization of retail pharmacies affect how automation is used creating distinct effects compared to the hospital pharmacies.

Furthermore, technology can challenge professional authority (Wajcman 2017:123) and institutes power to those who control the technology. Thus, pharmacy automation has means to impact the power dynamics at the workplace, and this contests the established pharmacy institution with its boundaries between professions, occupations and demographics in the organization (see Mäkinen 2018; Mellström 2009).

> *Hypothesis 2* Pharmacy automation changes the power dynamics and contests the established pharmacy institution, which relates to both professionalism and gender.

Perceived usefulness of pharmacy robots – quantitative hypotheses

To study user experiences of pharmacy automation, we utilized a modification of the Technology Acceptance Model, or TAM, (Davis 1989) and its expanded version where compatibility of values is linked to the perceived usefulness or the technology (Karahanna, Ritu and Corey 2006). TAM models understand 'perceived usefulness' as the perquisite for technology acceptance. Additionally, perceived usefulness has also been found to be a decisive factor especially in professional settings while the common TAM variable 'ease of use' does not provide consistent results explaining technology acceptance (Chau and Hu 2001:712).

> *Hypothesis 3* Greater value-congruence is associated with higher perceived usefulness of robots.

Autonomy is an aspect that is often related to automation but also to working life in both theoretical studies (Wajcman 2017:124; Vidal 2013) and empirical findings (Turja, Minkkinen and Mauno 2021). Automation can support or undermine the autonomy of workers (Turja, Särkikoski, Koistinen and Melin 2022) and we expect it also to be related to the perceived usefulness of pharmacy automation. Barrett et al. (2012) describe an effect of strengthening professional power of pharmacists during workplace automation but also note how the opposite may occur as technicians take over the tasks linked to the new technology. We expect that automation will affect organizational hierarchies by strengthening some positions while possibly undermining others. The division is made between the professional working groups and the occupational working groups.

> *Hypothesis 4* Greater work-related autonomy is associated with higher perceived usefulness of robots.
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> *Hypothesis 4a* Automation will have a different association on autonomy depending on the occupational group.

Hypothesis 5 Perceived usefulness of robots varies between occupational/professional groups.

Lastly, technological time pressure has so far been studied through the concept of technostress, which relates to both the increased time pressure of work and the blurring of work-life balance (e.g., constant availability outside working hours enabled by communication technologies) (Wang, Shu and Tu 2008). We expect 'technological time pressure' to emerge as a factor explaining the perceived usefulness of pharmacy automation.

Hypothesis 6 Technological time pressure is associated with lower perceived usefulness.

Triangulation of the qualitative case study and the quantitative data

A common point of view in the study of automation is the comparison between occupations with 'high' or 'low' general skills level and pharmacy context is no exception (Piercy and Gist-Mackey 2021). Technical assistants in pharmacies may have a formal education, but this is not necessary for the work specifically associated with pharmacies. Keeping this in mind, we expect the low-skilled group to be more affected by automation than the pharmaceutical professional group. Pharmacy automation can have a deskilling effect on both professionals and non-professionals, but based on the earlier literature, we expect lower skilled workers to be more affected (Barrett et al. 2012). Triangulation in this study helps us understand the qualitative changes to their work.

Hypothesis 7 Low-skilled workers are more affected by pharmacy automation by mechanisms of deskilling or other qualitative changes.

Based on what we currently know about pharmacy automation, we expect professional boundaries within the pharmacy, namely the division between pharmaceutical staff and technical assistants, to be an important division in how automation is experienced, but we also expect there to be differences due to the variation in occupational/professional groups and the retail pharmacy setting compared to a hospital pharmacy. We will use our mixed methods approach to explore the spatial and temporal changes occasioned by automation in the pharmacy service. Research on pharmacists shows that automation and the electronic prescription system have freed pharmacists from routine tasks (Beard 2017:142) but there is less evidence on how these have affected the large group of assistants.

> *Hypothesis 7a* Automation creates boundary shifts between the professional/occupational groups in pharmacies, which can be seen through acceptance of robots as well as qualitative shifts in work tasks.

Finally, we expect the qualitative changes to reflect how productivity is measured through OTC and how pharmacy automation accelerates the other social phenomena, such as increased usage of drugs. We expect that automation is conducive to pharmaceuticalization.

> *Hypothesis 8* Automation accentuates pharmaceuticalization.

DATA AND METHODS

Our survey data was divided into high-general skilled professions and low-general skilled occupations, which are crudely the pharmacists and the technical assistants (see Table 1 for a more detailed breakdown of the groups). This division was used to create a occupational level-variable including pharmacists (51%) and technical staff (49%). The sample reflects the distribution in the population with the exception of pharmacists, for the reason that head pharmacists are over-represented (Table 1).

[TABLE 1 ABOUT HERE]

The survey data were collected from various levels of workers within the pharmacies (N = 573). The data collections were coordinated first by The Association of Finnish Pharmacies, and second, the labour union Service Union United (PAM) to reach also technical assistants working in pharmacies. Before the actual data collection, the survey was piloted and legitimized with the help of The Association of Finnish Pharmacies with commentaries from PAM. For analyzing the survey data, a statistical model was built based on technology acceptance models (Davis 1989; Karahanna, Ritu and Corey 2006). The theoretically rationalized dependent variable, perceived usefulness, was summed out of four questions (See Appendix). The dependent variable perceived usefulness is a dichotomized variable, where 20.8% of the respondents perceived automation to be less useful.

The respondents who worked in an automated pharmacy totalled in n = 192. Descriptive information for the independent variables is presented in Table 2. Autonomy was measured using the variable from the Work Design Questionnaire (Morgeson and Humphrey 2006). The measure for technological time pressure followed the example of a technostress study by Wang, Shu and Tu (2008). Items measuring values were adapted from Karahanna et al. (2006). The control variables for the statistical model were gender, age, and subjective happiness.

[TABLE 2 ABOUT HERE]

In the qualitative part of the study, interviews were conducted with two automation manufacturers, a company designing pharmacy interiors, a head pharmacist retired from a hospital pharmacy and technical assistants working in a community pharmacy. The interviews included questions about the relationships of the different actors and stakeholders, and about automation developed in the field. Particularly the interviews with the technical assistants provided a diverse perspective for understanding the more profound substance of pharmacy robot acceptance. The interviews (n = 3) were semi-structured and followed the previously conducted factorial model. This enabled a mixed methods approach and the triangulation of the results. The number of interviewees were restricted to those who volunteered after completing the survey and worked in pharmacies already automated. The pharmacy employee interviews were conducted in the pharmacies in which they worked, and the manufacturer and interior designer interviews were conducted at their respective workplaces.

FINDINGS

By investigating the interior design of pharmacies based on an interview with a representative of a front-line pharmacy interior design firm, we found a spatial change within the pharmacy that was caused by automation, or rather, the interior design was heavily influenced by automation. The changes to the pharmacy interior aimed to increase the space for selling non-prescription drugs, which was found to be present in the changed work tasks of the pharmacy workers, leading us to conclude that the spatial rearrangement was also supported by a temporal change.

The spatial changes were designed to increase the customer area in the pharmacies and due to the modified nature of work among the technical assistants, which became apparent in the interviews with these individuals, the change in the functionality of the pharmacy was meant to enhance the productivity through additional sales of OTC. The spatial change can be seen in the growth and central positioning of the OTC area (Fig1).

[FIGURE 1 ABOUT HERE]

[TABLE 3 ABOUT HERE]

The pharmacy floor was said to be designed as a “service path”, which was also informed by customer purchase data. For example, if someone is buying ibuprofen, the purchase data can show other products that are typically bought simultaneously, which leads to the service path design where product placement is arranged so that these additional products are found within a convenient distance.

As a comparison, Figure 2 by Barret et al. (2011) shows how automation changed the space in the back of the hospital pharmacy without making changes to the service area. This makes a significant difference to the spatial changes in retail pharmacies using automation where rearrangements of the shopping area are essential to the functionality of a modern retail pharmacy (cf. Figure 1). This finding comes to support our qualitative hypotheses 1 and 1a.

[FIGURE 2 ABOUT HERE]

In the retail pharmacies, there has been a clear shift in how the service is designed. The space design has been reorganized in conjunction with automation to create more space for OTC medicines. This “commercialization” underlines the divergence in how pharmacy automation works in the retail pharmacy compared to the hospital pharmacy. As mentioned earlier, this shift is also supported by the change in the technical assistants’ work as in the supplementary interviews they reported their responsibilities to have moved into tasks relating to OTC. The technical assistants also reported having lost their previous tasks related to prescription medicines, such as mixing medicinal doses and rewriting prescriptions, which is considered a form of *medicinal knowledge*.

The different impacts of automation on the group of technical assistants are also apparent in the quantitative analysis. The binary logistic regression model (Table 4) shows that among the pharmacy staff, automation is perceived as more useful when it manages to support employee autonomy, does not increase technostress, and is compatible with personal values of how the automation should be used. Furthermore, the pharmaceutical staff found pharmacy automation considerably more useful than the auxiliary staff. The model was controlled for gender, age, and subjective happiness, which did not play a part or diminish the associations found between the factors hypothesized in the perceived usefulness of automation.

[TABLE 4 ABOUT HERE]

Along the more anticipated findings, such as feelings of autonomy and congruence of values affecting the perceived usefulness of automation supporting our hypotheses (H3–4), a significant association was found between occupational groups and perceived usefulness of automation (H5).

Pharmacists considered automation useful seven times more likely than technical assistants (Table 4). This effect is mitigated if head pharmacists and manager-level pharmacists are removed, but the effect persists when comparing the two occupational/professional groups. Post hoc analysis of the interactions between the explanatory variables did not produce significant results. Autonomy, value-compatibility, and technostress were associated consistently and without occupation-dependence with perceived usefulness. Thus, the quantitative hypotheses H3–6 were supported in a straightforward manner.

Based on the interviews and the statistical analysis together, the effect of occupational group comes as no surprise as the technical assistants have experienced a radical change in their work tasks. Compared to earlier technological developments in pharmacies with the electronic prescription system, automation had a similar effect where auxiliary work with prescription drugs was replaced by new technology. Automation provided the next step in this development – removing auxiliary work away from prescription drugs apart from loading the robot, which according to the interviews was still said to be a part of the technical assistants' work. The technical assistants felt that they had been separated as a group from the pharmacists. According to Goldin and Katz (2016) ICT (e.g., the e-prescription system) has already had significant impact on the work of pharmacists by making the work, services, and products more standardized and therefore further exchangeable by other pharmacists. A new discovery here is the change these technologies have caused in auxiliary work and how automation continues the separation of this work and its tasks away from prescription drugs. A further study of the qualitative changes in the work of pharmacists is also warranted as automation may also have likewise shifted their work towards OTC.

The technical assistants felt they had lost their previously required medicinal knowledge. The loss of prescription medicine-related tasks was deemed regrettable, but as the spatial change supported work with the greater requirements in the shopping area, the technical assistants found the new tasks relating to OTC products interesting. Given how the technical assistants had worked under numerous job titles, such as “medicine technician”, it can be assumed that the knowledge base of this group had also changed over the years, and they remained confident that auxiliary work would always be needed in the future.

As previously mentioned, technical assistants do not necessarily need formal qualifications to work in the pharmacy, which possibly makes them more vulnerable to negative impacts brought by automation or other organizational changes. The professional qualifications of technical assistants are achieved in Finland through apprenticeship contracts or lower-level college programs, meaning that pharmacy technical assistant is not a profession per se, but the efforts to identify and institutionalize their roles in pharmacy work are similar to the ways in which professions tend to build their knowledge base (cf. Martin et al. 2009). Automation undermines the necessity for technical assistants to have medicinal knowledge, thereby creating deprofessionalization. This could also be an additional explanation for value-congruence being such a significant variable in relation to perceived usefulness of pharmacy automation. In this case, automation is viewed as distancing a group of pharmacy workers from the core task of dispensing prescription medicine.

In the survey we elicited the respondents’ core tasks from nine options (e.g., customer service, client consultation, sales). First, sales and customer service were often together with a relatively strong correlation ($r = 0.431$), which is also seen in Figure 3. Second, having automation does not have a statistically significant relationship to engaging in more customer service or client consultation, which supports earlier finding of automation not creating those sectors (see Angelo et al. 2005). However, when automation is applied, customer service and sales have a closer relationship than without it (Figure 4). Combined with the spatial change we discovered, this can be interpreted such that automation brings sales and customer service closer together in pharmacies. This provides further support for our hypothesis 8 and suggests that automation indeed accentuates pharmaceuticalization.

[FIGURE 3 ABOUT HERE]

Despite automation making rudimentary medicinal knowledge of technical assistants redundant, it does not seem to create unemployment (reported by PAM in a consultation session). The technical assistants whose tasks were moved to the OTC area of the pharmacy, also received marketing education along with their new tasks. Additional education and new tasks have been identified as a source of legitimacy for professions at least (Selander 1991:141–142), meaning that technical assistants may not have been deskilled. Our hypothesis 7 is partially supported by a qualitative change but no obviously deskilling effect can be said to have occurred. Automation has created a new type of auxiliary work for the retail pharmacy.

The technical assistants also reported that utilizing automation meant that there was a lack of space. This is in line with the findings of the hospital pharmacy studies (Barrett et al. 2012). In the case of retail pharmacies, the cramped space did not seem to bother any particular group as the assistants worked more out in the open in the shopping area of the pharmacy rather than solely remaining in the “back room”. Restocking the robot was still described as a part of the technical assistants’ job, which is, again, similar to the hospital pharmacy case. As for our hypothesis 7a, no boundary conflicts between pharmacists and technical assistants appeared in our data. Hypothesis 7a is partially confirmed through the qualitative changes, but not through boundary changes between the groups.

We hypothesized (1 & 1a) that spatial change creates qualitative changes that affect all occupational groups but also reflect the role of pharmacies as public/private hybrid and privately owned businesses. OTC sales are promoted through the effectiveness achieved by automation. Also, despite the similar machinery, the effects of automation are noticeably different in the hospital pharmacy compared to the retail pharmacy. The main reason for this difference seems to be OTC medicines. This also relates strongly to hypothesis 8, where the effectiveness of automation accentuates the increased use of medication, or at least makes pharmacies stress the sales of OTC more.

The interview with a pharmacy automation manufacturer in Finland confirmed our preliminary knowledge about how the medicine dispensing could be done completely automatically, but the regulation requires that solely the pharmacists are handing out medicines to the customers. The rationale for this regulation has been based on medicinal knowledge and consultation with customers. Furthermore, this regulation ensures the demand for pharmacists being on site. Our interview here also confirmed what we had learned in the field that in the Finnish retail pharmacy "no-one was carrying a wrench", that is , no group of 'technicians' was formed to maintain the robot's operations. This finding is opposite to previous findings in the field (Barrett et al. 2012; White 2009: 388–389). The pharmacies are dependent on the manufacturer and do not have the knowhow to control the system at a deeper level.

The dependency of pharmacies towards the manufacturer was later given additional support in our interview with a head pharmacist retired from a university hospital in Finland. We found that even though the source code for the automation system was provided for the hospital, there would be no knowhow in its use should the company cease to exist. Both hospital and community pharmacies are dependent on and vulnerable because of automation. We consider this as shifting the interorganizational power dynamic where lack of knowhow in pharmacies to fully control the technology they use, renders the organization in a vulnerable position and the professions possibly undermined. This dependency relationship gives legitimacy to our hypothesis 2 as it pertains to the pharmacy institution.

Despite this, pharmacists seem to enjoy relative security over the technical assistants when it comes to how pharmacy work is automated. Automation and robots can have positive effects on the work profiles of technical assistants, too, but only the security of pharmacists can be attributed to the status of an established profession and its legitimate mandate and inclusion in the design of automation. Our own case studies of robot manufacturers confirm that pharmacists have had an important role both in initial and later phases of product development. An increasing need for codesigning methods and "in situ" iterations for the best solutions has been widely identified and emphasized in the research literature. Especially in the case of interactive social robot technology it has been stressed that not only designers and experts (e.g., Sabanovic 2010; Sabanovic et al. 2014) but even the end users like older adults (e.g., Breazeal et al. 2019) should be involved in a participatory, user-centered design approach. From a sociological perspective, this underlines the fact even if technology is functionally justified, it cannot be taken as a self-evident and neutral construction but the one showing consistently the values and attitudes of the designers and all those included in the process (Wajcman 2017:122–123; Forsythe 2001:101).

DISCUSSION

Pharmacy automation is mostly discussed in the terms of functional efficiency and the reduction of medication errors, but our results show that it also has remarkable organizational consequences, including increasing time pressures and reduced autonomy for certain worker groups. Autonomy and technical time pressure were found to be connected to perceived usefulness of pharmacy automation and this confirms the already established link between employee autonomy and technology acceptance (Wajcman 2017:124; Vidal 2013; Turja et al. 2021; Turja et al. 2022) and also reveals how the technological time pressure can affect the user experiences when robotizing workplaces.

Pharmacy automation has similar effects in terms of compatibility of values in relation to perceived usefulness as found in earlier research (Karahanna et al. 2016). The more value-compatible the worker finds automation in their job, the more useful they are prone to see it. It is plausible that the congruence of values with perceived usefulness on the pharmacists' side comes from the practical reality that dispensing errors are reduced. On the technical assistants' side, then, the reported market-oriented tasks and the separation of former tasks from prescription drugs can emphasize the importance of value-congurence. The latter is supported by the findings of this study, but the former warrants additional investigation.

In professional settings, perceived usefulness is a key determinant in intention to use (Chau and Hu 2001:712). Chau and Hu (2001: 712) also consider the possibility of this being a result of "constant and reliable access to staff assistance in technology operations", which can be a key factor in our case as well. However, in our case this staff assistance did not come from within the pharmacy as discovered by Barrett et al. (2012) as there was no group of 'technicians' who were tasked with handling the device. An important note here is that professionalism and technology adoption has been criticized for handling professional groups as homogenous. It has been observed that while selecting technologies to adopt, at least among physicians, the process has been identified as a practice that strengthens the professional's control over their tasks (Menchik 2017:488–491).

It appears that pharmacies have come to rely on the technology manufacturers for equipment maintenance and the functionality of pharmacies depends on that maintenance. This means that the role of new technology and its control will become more decisive in the pharmacy functions. This also relates to the notable gendered pharmacy work that stands in contrast to gendered work in technology. Pharmacists are predominantly female whereas technology has traditionally been regarded as a sphere of men and is still found to be nothing less than hostile towards women (Wajcman 1991; Forsythe 2001; Mellström 2009). Within the pharmacy organization, we found no gendered phenomena in regard to perceived usefulness of technology but the found dependency of automation manufacturers supports a gendered shift of power from pharmacies to technology companies.

A key discovery of the effects of pharmacy automation is the change occasioned by robots and how the service of the pharmacy has changed both in terms of work and spatial arrangements. Automation is closely related to OTC as the effectiveness of automation is utilized to bring more work and to create more space to the shopping area of the pharmacy. Resources were directed to the selling of medicines from a marketing perspective. Price regulation means that OTC is probably the most effective way for a pharmacy to improve its profitability and productivity (cf. Lluch and Kanavos 2010), which creates a distinct frame for automation to function compared to hospital pharmacies. In addition to the key difference provided by OTC, in Barrett et al. (2012) there were also various occupational/professional groups with different work arrangements and workflows. In Barrett et al. (2012), automation prioritized the pharmaceutical work without other major changes in the organization of work, except for the addition of technicians working directly with the machine. In the hospital pharmacy the auxiliary staff remained behind the machine (Barrett et al. 2012), but in the retail pharmacies, the technical assistants, while still in charge of loading the machine, were not assigned new tasks with the robot, but in the retail area and marketing.

Technology is increasingly discussed in terms of including end users and stakeholders in the design and development (Niemelä et al. 2021; Turja et al. 2022). Positive attitudes towards new technology play a part in technological changes and successful deployment of robots (Krutova et al. 2021). Although the technical assistants in pharmacies are not sceptical regarding pharmacy automation, they see it as far less useful than pharmacists. The tasks of the technical assistants have been subjected to changes, and this change is understood as both negative and positive – losing medicinal knowledge-related tasks but gaining new tasks and training relating to marketing and OTC. The effect of reorganizing work for the assistants has also been established previously in Blaker (2013, 101), but in that case assistants felt that their original tasks in medical management remained relatively fixed after the change.

Increased OTC turnover connects pharmacy automation to the increased use of drugs that has been seen as a trend in contemporary society (Williams et al. 2011). Pharmacy automation is an expensive investment and has not so far been paid for with layoffs or clear deskilling of workers. It stands to reason that the effort to increase OTC sales has been successful as pharmacy automation has become so widely used. In Finland, most OTC drugs continue to be confined to pharmacies. In our research we have shown changing work and a shift towards more market-focused tasks of the auxiliary workers accompanied by a spatial reconfiguration that creates more space for these new tasks. We argue that implementing of automation/dispensing robots for routine tasks creates favourable options for this. The effectiveness of automation then is utilized as an effort to increase OTC sales. Whether this phenomenon is pharmaceuticalization instead of medicalization is not clear cut, as Abraham (2010: 6) defines the former when "...the medical profession is by-passed in pharmaceutical choice, purchase and use". We believe an argument could be made for either one as pharmacy automation does increase OTC sales but the medical profession is still involved as consultants, but their role can also become more passive with technological change.

As for the other aspects of pharmaceuticalization, such as the increasing power of the pharmaceutical industry, a further study regarding vertical integration i.e. pharmaceutical companies and wholesale companies owning medical dispensing technologies is warranted. This could lead to important examinations of what kinds of motives, values and incentives are behind the creation and development of this technology and moreover, are the associated health outcomes beneficial in the long run.

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Appendix

Dependent variable: Perceived usefulness	*Cronbach's alpha 0.879 α*
1. Automation makes my work more efficient	0.832 *(if removed)*
2. Automation gives me time to work with more interesting tasks	0.845
3. Automation makes the pharmacy work better	0.827
4. Automation is irrelevant	0.87
Independent variable: Autonomy	*Cronbach alpha 0.880 α*
1. I can figure out my own schedules	0.851 *(if removed)*
2. I can decide the order of my work tasks	0.850
3. I can design the way I work	0.851
4. I can make independent decisions in my work	0.863
5. I have been a part of the planning the purchases and implementation of new devices in the pharmacy	0.887
6. I can use different ways to work at my job	0.858
7. My tasks are varied	0.879
Independent variable: Values	*Cronbach alpha 0.846 α*
1. Using automation generally is not good in working life	0.854 *(if removed)*
2. Automation should not be used in my line of work	0.825
3. Utilizing automation fits together with my perception of my own work	0.818
4. Automation is beneficial for me at my work	0.806
5. I am interested in the development of automation	0.808
6. I am positive about automation	0.808
Independent variable: Technological time pressure	*Cronbach's alpha 0.796 α*

1. *Technology makes my work more hectic*	0.736 *(if removed)*
2. *The technology related to my work forces me to work a lot faster*	0.745
3. *The technological maintenance and interruptions make me busier*	0.749
4. *I have to be available in my free time due to technical issues at work*	0.806
5. *The complexity of technology increases my workload*	0.745

Pharmacies in Finland (2017)		Survey Data (2018)	
Head pharmacists	6.9 %	Head pharmacists	25.8 %
Pharmacists	44.7 %	Pharmacists	15.5 %
University-educated pharmacists	9.0 %	University-educated pharmacists	9.8 %
Technical assistants	39.3 %	Technical assistants	48.9 %
	N = 8’620		N = 573

Table 1. Sample distributions reflecting the population

Variable	Scale	Mean	Std. Deviation	Cronbach's Alpha
Autonomy	7–35	24.6773	6.80147	0.880 α
Technological time pressure	5–24	10.0971	3.99093	0.796 α
Values	11–30	25.5505	4.41329	0.846 α

Table 2. Descriptions of the sum variables used as the independent variables in the statistical analysis

Terminology for occupational and professional groups used in Finnish pharmacies

Technical assistants = Multiple occupational titles, Pharmacy assistant (apprenticeship training or lower-level college programs)
Pharmacist, bachelor's degree (3 years, 180 course credits)
"Provisor" = pharmacist, master's degree (2 years more, + 120 course credits)
Head pharmacist = graduate degree, licensed by a national authority

Table 3 Terminology for occupations and professions in the Finnish pharmacy

	p	OR	95% C.I.for EXP(B)	
			Lower	Upper
Gender	0.214	3.145	0.515	19.195
Age	0.057	1.047	0.999	1.097
Happiness	0.109	0.715	0.474	1.077
Occupational group	0.008	6.851	1.649	28.471
Autonomy	0.027	1.143	1.015	1.288
Values	<0.001	1.396	1.172	1.662
Time pressure	0.027	1.232	1.043	1.456
Constant	-13.741	0.000		

Cox & Snell R Square	Nagelkerke R Square
0.388	0.612

Table 4 The perceived usefulness of pharmacy automation

FIG. 1. Spatial changes in the retail pharmacy after automation.

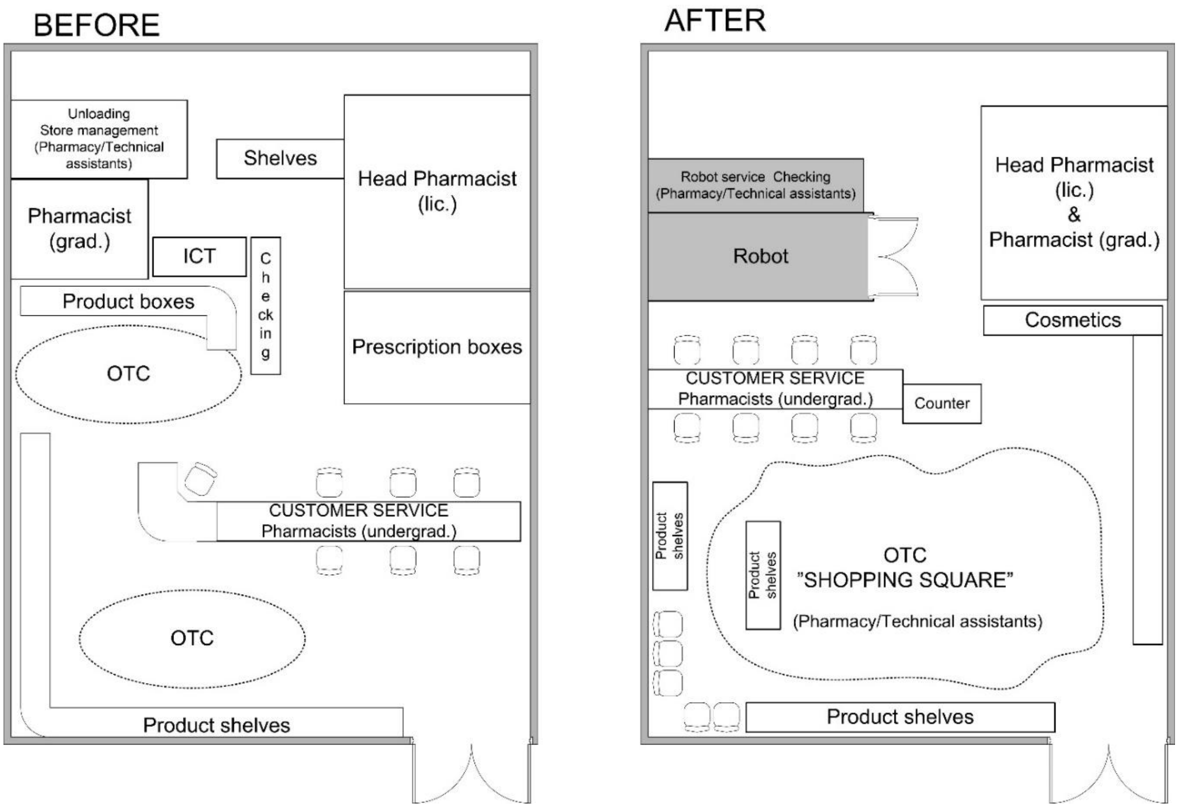

FIG. 2. Change in a hospital pharmacy after automation (Barrett et al. 2011)

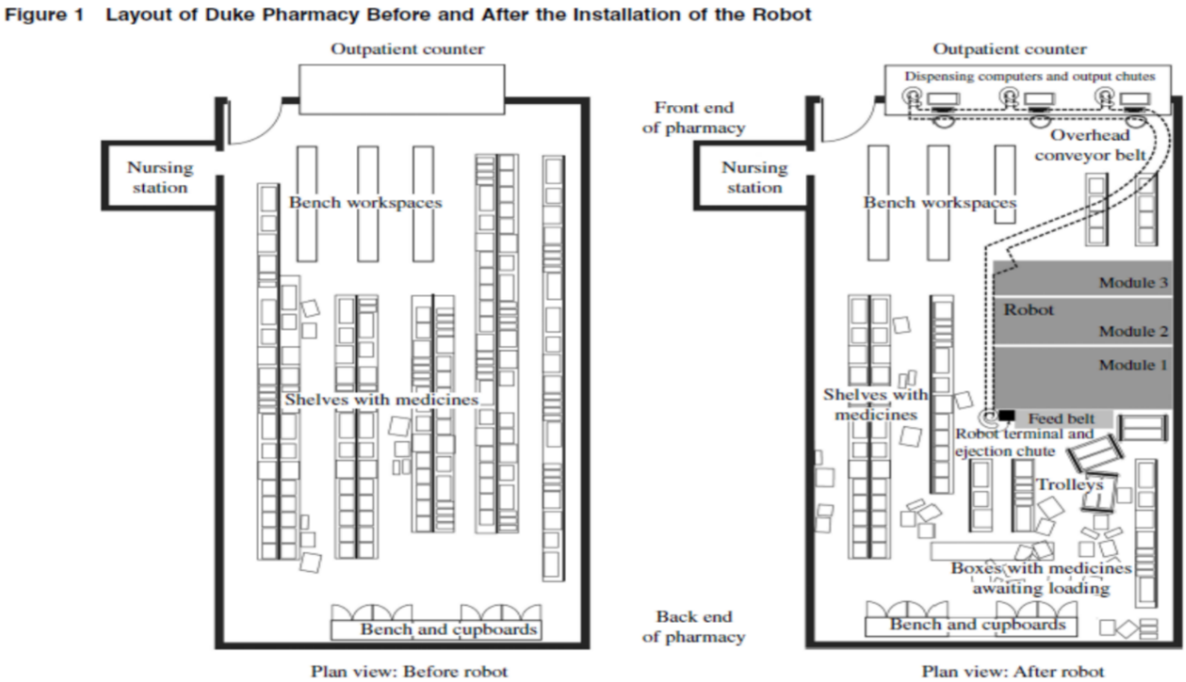

FIG. 3. Automation brings sales and customer service closer together in pharmacies

F (1, 447) =5.556, p=.19, η2=.012)