Conception of a digitalised material handling and storage workflow for angiography material at the Department of Radiology at A.ö. Bezirkskrankenhaus St. Johann in Tirol.

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***Abstract*—Digitalisation has a big impact on many different industries, especially in material handling a digital workflow and systems that provide online warehouse overview have big advantages. As patient safety is a big point in the medical sector it is crucial to have enough material and being able to check if the material is still up to date and not expired. With conventional storage handling, it is difficult to meet all the requirements of the process and a lot of working time must be spent to have a good storage system and overview of the materials in stock. This work presents a digitalised workflow for material handling and storage and shows results of the evaluation of this workflow for angiography material.**

***Index Terms*—Angiography, digitalisation, hospital, radiology, material.**

I. Introduction

In the upcoming years, there will be an increasing demand in workforce in the field of healthcare professionals due to the ageing population and the increasing need for medical care [1], [2]. This is a trend that already made the healthcare sector the one with the biggest employment growth from 2013-2018. But even this growth was not able to fulfil this increased need and has already led to a lack of specialists in the sector, which might get even worse in the upcoming years due to the expected decline in the working population [1]. To overcome the challenges that occur due to the increasing need for healthcare workers, there may be different solutions that should be combined. Some possible solutions will possibly lead to increased attractiveness of working in healthcare professions, and to an increased volume of employment. Another important role in increasing productivity can also be innovations created through digitalisation, robotics, artificial intelligence and more [1].

> Unless the dynamics of the healthcare labour market change dramatically in the near future, there will be a critical shortage of basic healthcare providers—namely, physicians and nurses—to provide comprehensive medical care for the elderly population between now and the middle of the 21st century [2].

In 2009 Cohen stated that the number of US populates who are older than 65 years would increase from more than 38 million up to 71,5 million in 2030, due to the baby-boomer generation entering this age group. This means that this generation not only retires from their possible healthcare profession, but also might need more healthcare services themselves than before, which might increase the pressure on the healthcare system [2].

In the area of angiography, this trend of the ageing population will challenge the existing system even more. Behrendt et al.'s international report about international variations and sex disparities in the treatment of peripheral arterial occlusive disease also presented the demographic data of 11 countries, including beside some European countries also Australia, the USA and Russia, participating in the VASCUNET register. They showed, that the mean age of patients who had to undergo an open surgical revascularisation or a peripheral vascular intervention was 71,9 years. People older than 80 years were between 7.6% for Russia and 33,0% for Sweden [3].

As increasing the amount of healthcare professionals will not be enough it will be crucial to increase productivity. Therefore an important part can be the use of labour-saving innovative technologies like digitalisation in the working environment [1], [2]. This might although be challenging as the healthcare sector has not proven its openness to innovation. Also increasing digitalisation in other economic sectors could lead to higher availability of workforce for the healthcare sector [1].

A. Current workflow description

Currently, angiography material is handled fully analogue, only in some touchpoints with digital systems there is a digitalisation of paper. To describe the handling of material in angiography, it is important to know, that the material is split up into two groups, like they are described in Table I. The two main groups are general material, which includes disposable items such as gloves or sterile sets, but also hand or skin disinfectants, and angiography material such as stents, guidewires, balloons and closure devices. Some of the angiography material is not purchased in advance, but only after use. From the angiography point of view, these materials are procured in the same way, but it must be noted in the documentation that these products have not yet been paid for so that payment can be triggered. This material provided by

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TABLE I
MATERIAL USED FOR ANGIOGRAPHY AND THEIR CURRENT ORDER AND DOCUMENTATION

	General material	**Angiography material**	
		Bought material	**Consil material**
Example	Gloves, sterile sets	Intravascular devices	Intravascular devices
Trigger for order	Ordered when stock limit reached	Ordered after patient use, or when stock limit reached (for some)	Bought and re-ordered after use for patient
Way of order	Paper sheet with available products	Paper sheet with UDI stickers/products plates	Paper sheet with UDI stickers
Documentation	No documentation of use	Patient specific use documented	Patient specific use documented
Way of documentation	No	UDI barcode stickers on sheet of paper, scanned after	UDI barcode stickers on sheet of paper, scanned after

a manufacturer must not be marked, so these products have to be stored in specific areas, in order to make sure, they are not mixed with the material bought in advance and that it can be marked correctly on the documentation. Another special material is the custom-made products, which are produced specifically for a patient. These products are handled the same way as the bought material [4].

Every material order is sent to the purchasing department, on paper sheets. General material is ordered two times a week by the radiological technologist who is in charge of angiography on this day, angiography material is ordered after use directly, and only a few angiography material products which are used very often and have a big stock level are ordered together with the general material. The order process for angiography material is triggered by the patient's use and is submitted to the purchasing department of the hospital as a sheet of paper with the UDI codes that are available to be peeled off the packaging. Some pieces of angiography material might not be re-ordered, this is marked on the packaging and has to be announced to the purchasing department. The purchasing department then processes this information further, so that either a payment is induced or pieces are re-ordered [4].

Documentation of use is only made for angiography material directly used for a specific patient. It works the same way as with the order sheets, the only difference is that these sheets are given to the administration office of the department, where they are scanned and stored in the digital patient record. This is important for documentation purpose, so that it can be looked up, exactly which implant is implanted in a patient [4].

B. Digitalisation in health care

Already in 2006, Chaudhry et al. found, in their systematic review of "The Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care", that four benchmark institutions in the US were able to demonstrate the effectiveness of health information technology in terms of improving quality and efficiency.

> The advantages of health information technology over paper records are readily discernible [5].

Moreover, in 2008 Uslu and Stausberg summarised in a systematic review that there was good evidence for treatment improvement in intensive care patients when using electronic patient records. Moreover, the authors found in two studies, that these electronic patient records were able to save physician's and personnel's time, especially concerning drug transcription [6].

When it comes to the digital supply chain, there are many features mentioned in the literature, Buyukozkan et al. summarized some in a literature review [7]. First of all, the digital supply chain was predicted to move a large amount of products in a short time. To do this, the speed of delivery was predicted to be essential for many interests involved in the supply chain [7], [8]. Two important factors to speed up decisions concerning demand change or supply signals might be better information and analytics. The use of predictive analysis for decision support could increase reliability and adaptability [8]. They even mention some cases, where products could be delivered with drones within 30 minutes [7].

Also for medical products, research by Kim showed the beneficial effect of a digitalised supply chain and computer-aided ordering system. To offer a possible efficiency increase, all products in inventory control in a hospital should be classified by their characteristics and significance. Order quantities should be calculated by a computer system based on a demand forecast and safety stock levels, rather than by rule of thumb. This can reduce user interventions and by that reduce the time that has to be spent on order processing. Also, information should be shared between hospitals and the wholesalers to allow the wholesaler to adjust their stock level. To increase the speed and accuracy of order processing, electronic documents should be standardised and digitally transmitted. Barcodes should be implemented to increase the efficiency of material handling in warehouses. Also, RFID (Radio Frequency Identification) technology could be considered to be used for product identification [9].

This paper hast two main objectives. The primary objective is, to present the developed digitalised workflow for angiography material handling at a general district hospital in Austria. The second goal is to present the evaluation of this developed workflow.

II. METHODS

This section is meant to describe the used methods to create the results. First of all, the concepted workflow the software is based on is presented. Then the software environment for programming the software is presented and as the last part of the section, the evaluation setup is described.

A. Concepted workflow

The newly concepted workflow also deals with the same material but is meant to digitalise some steps, which increases the number of possible use cases and might also facilitate work. Some of the old factors had to be implemented like before, due to the needs of the other involved departments. As before, the material is split up into two groups general material and angiography material, where the second group has two sub-groups bought material and consil material, which are listed in Table II. The changed cells are grey.

Now, the general material should also be ordered when the stock limit is reached, but the order should be started digitally which means that no paper sheet should be needed

TABLE II
MATERIAL USED FOR ANGIOGRAPHY AND THEIR NEW ORDER AND DOCUMENTATION

	General material	**Angiography material**	
		Bought material	**Consil material**
Example	Gloves, sterile sets	Intravascular devices	Intravascular devices
Trigger for order	Ordered when stock limit reached	Ordered after patient use, or when stock limit reached (for some)	Bought and re-ordered after use for patient
Way of order	Order page of the software, that generates a pdf	Order page of the software, that generates a pdf	Order page of the software, that generates a pdf
Documentation	No documentation of use	Patient specific use documented in software	Patient specific use documented in software
Way of documentation	No	pdf document generated by software, saved to HIS	pdf document generated by software, saved to HIS

TABLE III
MATERIAL USED FOR TESTING THE FUNCTIONALITY OF THE SOFTWARE

#	Manufacturer	Product	Category	GTIN
1	Boston Scientific	V-18 Control Wire	Control Wire 18	08714729070207
2	Boston Scientific	Ranger SL	Drug eluting balloon 4F	08714729830726
3	Cordis	4F UF	Angiographic Catheter 4F	10705032007733
4	Terumo	Guide Wire M angled	Guide Wire 35	08935221210810
5	Biotronik	Dynetic-35	Balloon Expandable Stent 35	07640130454774
6	Biotronik	Pulsar-18 T3	Self Expandable Stent 18	07640130446526
7	Terumo	FemoSeal	Vascular Closure System	00389701011745
8	Boston Scientific	Encore 26	Inflation Device	08714729183624
9	Cordis	Saber	PTA Dilatation Catheter 5F	20705032068670
10	Cordis	Mynx Control	Vascular Closure Device	10862028000441

any more. For the angiography material, it is still important to label bought and consil material, this should be done inside the software by marking each product inside the program. It should not be necessary any more to use specific shelves for consil material. Also whether a product should be ordered as buy, or consil material, or not should be visible inside the program as well as on the order sheet. For patient documentation, there should also be an option inside the program, where each intervention can be documented with the used material. The user should get some information, about products that have reached their expiration date and have the possibility to mark them as removed and also can remove unsterile products from the digital stock. The user should have the possibility to generate a PDF file with the products needed for a patient to be saved to the hospital information system for documentation. For ordering the used products, the user should have the possibility to check whether there are products that are not ordered yet and need to be re-ordered. This should generate a PDF document that can afterwards be sent to the purchasing department digitally.

B. Software environment description

Flutter is meant to be a portable user interface toolkit to develop natively compiled applications for mobile, web and desktop. This is possible with one single codebase [10].Flutter has been developed by Google since 2017 primarily focused more on mobile operation systems, and has supported web applications regularly since Release 2.0 in 2021 [11], [12]. The programming language used in Flutter is called Dart [10], which has been developed by Google for mobile, Web, server and desktop applications. It is an object-oriented language, with C programming language family similarity. For Windows, the embedded layer, which is closest to the hardware and handling rendering surfaces, input, events and more, is written in C++ [11].

To have an open-source database, that is widely supported, PostgreSQL, which has been published by the University of California at Berkeley, was chosen. This open-source database system can be implemented on different platforms and can save different data types, including data objects and also big amounts of data. It also supports many SQL standard functionalities [13]. To make the tables easier maintainable and to facilitate changes in the values, all variables except the index and the main reference value, which is the GTIN, are saved in a JSON (JavaScript Object Notation) object. In 2012 JSON was described as growing from an unknown format to the main choice for data applications. It is based on the JavaScript language and is widely used for encoding data transfer between servers and applications or other servers [14].

To connect the database with the web application running in a browser, node.js is used. It is run by the OpenJS foundation. Node.js is a JavaScript runtime environment, that is open-source and cross-platform compatible, it runs in one single process and does not start a new one for every request [15]. For accessing the tables, SQL queries are used inside the Node.js environment.

C. Evaluation setup

For evaluating the software, there were two main approaches, the functionality of the programmed software was tested primarily by the author, after finishing the first demo version of the product. The second approach was to present the software to the target group to get their feedback on the usability and if all the needed features were implemented according to the needs.

To evaluate the software's functionality, all the working steps were tested to see if they worked as intended with a test set of products. The tests were performed on an HP ZBook Firefly 14 Zoll G9, with Windows 11 and the software running in debug mode with Flutter 3.19.6 in Chrome browser version 124.0.6367.202. The used barcode scanner was the Inateck barcode scanner BCST-73. The scanned material was selected from two interventions performed on two patients, who were chosen randomly. From this material, 10 different products were chosen randomly, these products are listed in Table III. The tests were performed continuously during the development process for each step and again for each step after finishing the version to be tested by the users. The final test was performed on the 8th of May 2024.

To evaluate the software from a user's point of view, the defined setup for all the participants was identical to the setup mentioned above for the functionality test. The participants were three voluntarily selected radiological technologists and one radiologist, who were working at the point of evaluation in angiography at the same hospital and were used to the same workflow. The tests were performed between the 9th of May 2024 and the 15th of May 2024. All participants first had an explanation of the program's functionalities in advance of having the opportunity to test the functions. During these tests, the author was present and answered upcoming questions. Within these tests, no data was captured, the main goal was to give each participant an impression of the functionality.

All participants were informed about the research project in advance and signed a declaration of consent before being interviewed by the author. To evaluate whether the new workflow has a positive influence on workload and opens new possibilities in the management of the handled material, the participants were interviewed by the author after being introduced to the new workflow and having the possibility of trying out the software, as described above. Due to the small number of possible participants, the author decided to interview the participants orally in a personal interview. The interviews were all done in German, to facilitate the interview process and to get all possible answers. The questions were split up into 3 main parts, where the first one targeted some demographic data. The second part targeted, to find time-consuming worksteps and get the ideas of the interviewees on how to possibly reduce the time. The third part mainly targeted the usability of the software and aimed to find possible improvements in the software or the workflow in general. At the end of the interview each participant had the opportunity to add some additional comments. The questions asked in the interviews are listed below:

- Demographic Data
  - age
  - gender
  - qualification
  - working experience
- General Questions
  - Please name 3 time-consuming working-steps in the field of angiography.
  - How would you reduce the workload within these steps?
- Questions concerning the new workflow
  - What benefits do you see in the software?
  - Is the software designed user-friendly?
  - Where do you see the potential to produce an error?
  - Which functionality should be added to the software?
- Do you have anything to add?

III. Results

This section is divided into three sections: a description of the resulting system, the results of functionality tests, and the outcomes of the interviews.

A. Resulting System Description

The system developed within this thesis consists of three main parts:

- the user interface with its functionality
- the database
- the connection between user interface and database

Figure 1 describes the functionalities schematically and describes how to add a product to stock, how to mark a product as used, how to order products and how to check for expiration dates.

TABLE IV
Product information saved in the database

Table 1	Table 2	Table 3
standard order value	product order value	order value (changed after ordering)
product category	product category	product category
timestamp of creating the product	timestamp of adding the product to stock	timestamp of adding the product to stock
dimensions of this product	dimensions	dimensions
product name	product name	product name
manufacturer	manufacturer	manufacturer
	lot number	lot number
	serial number	serial number
	expiration date	expiration date
	production date	production date
		timestamp of use
		reason for use
		timestamp of order (after ordering)

1) User Interface: The user interface consists of four screens with different functionalities:

- **New Product Screen:** This screen allows users to add new products to stock by scanning the UDI code on the packaging. The UDI is parsed into components such as GTIN, LOT Number, Expiration Date, Production Date, and Serial Number. If the product is known, details are auto-filled from the database, otherwise, users manually input the information. The data is then saved to the stock table with a timestamp with date and time of adding the product to stock.
- **Use Products Screen:** This screen is used for marking products as used. It parses the UDI code, checks stock availability, and documents the reason for use. Users can generate a PDF listing all products used for a specific intervention and update the database accordingly.
- **Order Products Screen:** This screen loads products that need to be ordered based on their value, how they should be ordered. Users can generate a PDF for the purchasing department and mark products as ordered in the database.
- **Expiration Screen:** This screen displays products that expire within a certain period of time, by default two months from the current date.

2) Database: The database, implemented in PostgreSQL, includes three tables:

- **Products Table:** Contains static information such as manufacturer, product name, category, dimensions, and standard reorder value.
- **Stock Table:** Stores dynamic information like LOT number, serial number, expiration date, and production date. Data is moved to the used products table upon usage.
- **Used Products Table:** Records details of used products, including usage reasons, order status, and timestamps with date and time of use and order.

3) Connection to the database: A Node.js script handles the connection between the user interface and the database, with APIs for:

- Autocomplete requests for filling product fields.
- Checking product existence in the database.
- Submitting product data to the database.
- Fetching product details for the Use Products screen.
- Marking products as used or ordered.
- Listing products by reorder type and expiration date.

B. Functionality Tests

Functionality was tested throughout development and in a final test with angiography products. Tests included verifying

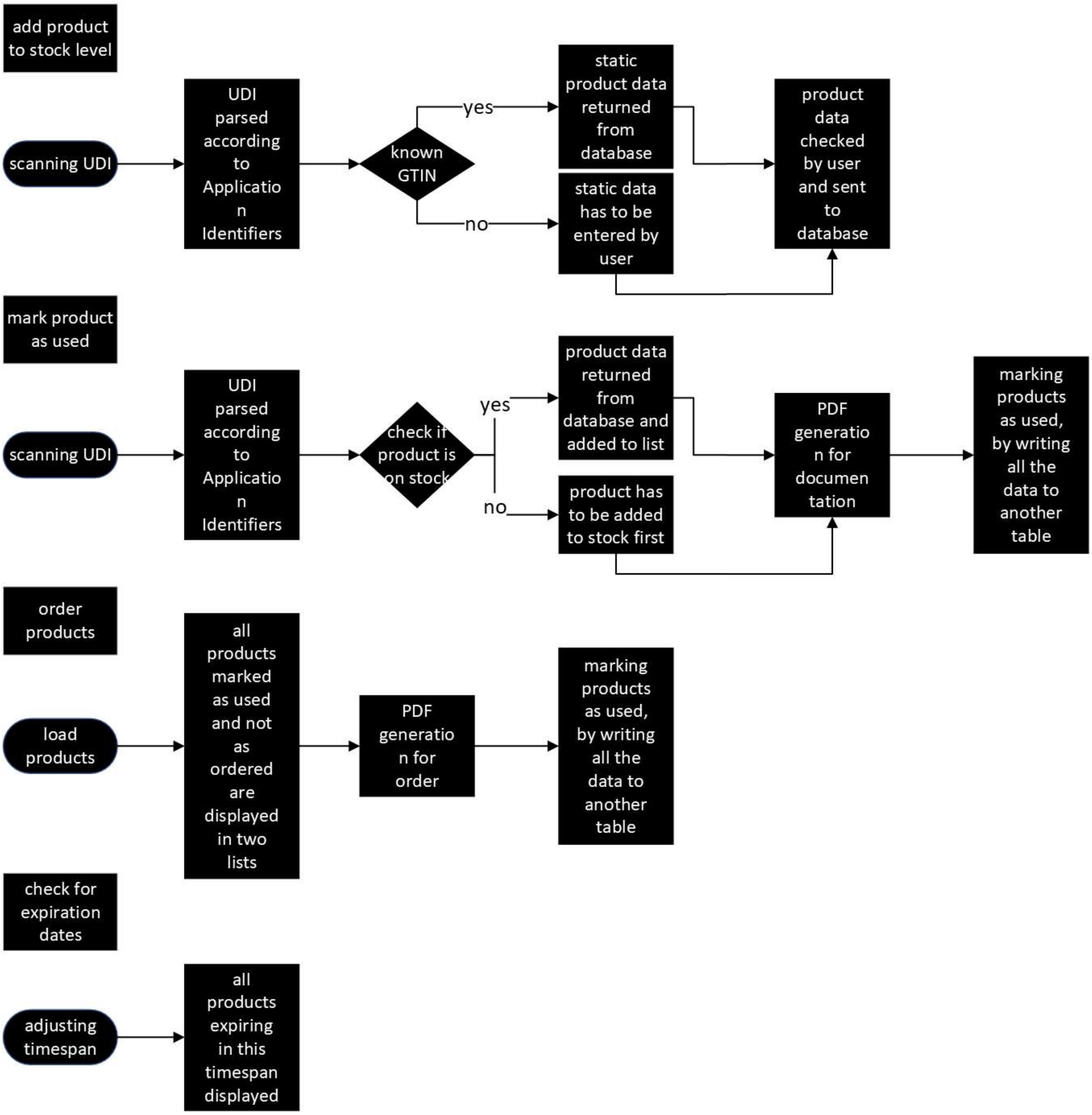

Fig. 1. Schematic Representation of the System

UDI parsing, correct database entry, product quantity submission, data fetching, PDF generation, and expiration date listing. The perfomred tests including the results are listed in table V. Most tests were successful, with minor issues noted in updating known product values and handling dual barcodes on certain products.

C. Interviews

Interviews revealed that the most time-consuming tasks were patient preparation, material recording, and reordering. Participants emphasized the need for digitalization, barcode integration, and improved cooperation to reduce workload. The software was seen as potentially increasing time efficiency, reducing errors, simplifying inventory management, and enhancing data accuracy.

1) Key Findings:

- **Time Efficiency:** Digital documentation and automated reordering could save time.
- **Error Reduction:** Reducing human errors in tracking and reordering.

TABLE V
TABLE OF FUNCTIONALITY TESTS

#	UDI Parsed Correctly	All Values Correctly Written to the Right Tables	Quantity Correctly Implemented	UDI Parsed Correctly Again	All Values Correctly Fetched	Check Data Throws Right Value	Use for Field Correctly Written to PDF	Use for Correctly Written to the Database	Load Products Lists All Unordered Products in the Right Category	PDF Generation Generates Correct PDF	Mark as Ordered Marks All Products Correctly as Ordered in the Right Category	Expiration Date Lists All Expiring Products in the Selected Timeframe
1	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
2	Pass	Partially	Pass	Pass	Partially	Pass	Pass	Pass	Pass	Pass	Pass	Pass
3	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
4	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
5	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
6	Partially	Pass	Pass	Partially	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
7	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
8	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
9	Pass	Partially	Pass	Pass	Partially	Pass	Pass	Pass	Pass	Pass	Pass	Pass
10	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

- **User-Friendliness:** Clear interface with suggestions for improving font size and button recognition.
- **Error Potential:** Data entry and barcode scanning errors were the main concerns.
- **Additional Functionality:** Search features for product names or manufacturers, statistical analysis, and reminders for expiration dates and reordering.

Participants appreciated the project's implementation and looked forward to continued software refinements based on practical use and feedback. The insights gained highlight the importance of continuous feedback, iterative development, and collaboration in enhancing digital healthcare solutions.

IV. DISCUSSION

The conception of a digital warehouse management for angiography material showed, that it needs three main software parts, a user interface, a database and a connection between the two parts of the whole concept. To fit all the needed functionality into one user interface, these were split up into four process workflows, to ensure usability, especially in case of clarity, where which function could be found. It also needed a background function, that could deal with the data inside the UDI codes and present them in a user-friendly way, especially for dates, but also splitting up the UDI into the single parts to make sure, that the user could also have an overview of the data. Especially this splitting up was crucial to offer the whole functionality of the program, because, especially the order and expiration date screen needed the single data values of the UDI for its functionality.

Another crucial part of data, especially to get a good overview of the products, used, to order products, or to get an overview of the expiration dates, was the user input fields, where the evaluation showed, that wrong user input could lead to misunderstanding, or problems with the functionality, as the re-order value was the key value for the re-order of products.

The "Use-Products" and the "Orders" screens showed, that multiple buttons near each other, as well as the font size of the buttons labelling decreased the clearness of the screen. The readability of text was also reduced, after input, where the text size was reduced automatically. Moreover, colours were reported, to be able to improve the visibility of buttons.

Especially for the expiration date control, it was reported, that this feature might have the potential to improve expiration date handling, which could save a lot of money easily, as expiring material could produce high costs. Also, the time saving for the working steps documentation and orders was mentioned to be potentially high, after taking the effort of creating all the material in the system.

The content saved to the database was split up into three parts, while the first table was mainly created to find the correlation between the GTIN of each product to its clear name, the second table was meant to contain the current stock items and the third table was created to contain all used items. This breakdown into the 3 tables was intended to increase the performance, as well as offer all the functionality. The second and third table were mainly generated separately, to separate the current stock items and the used items, because the differentiation might become more difficult with bigger data volumes, as the query would have to check each item, to which table it belongs. This separation of tables made it necessary to have a separate table, containing the static data of the known products, to make sure, these products don't have to be entered into the table every time. This separation made it possible to have standard values for each known product, but also have the possibility of changing some of them, especially the re-order value.

To connect the user interface to the database, it needed some connection, as the database supported SQL queries, this was the chosen form of communication. As the queries should be as efficient as possible, there had to be multiple connections established.

In order to test the functions, it was necessary to get a deck of products to test the performance of the software, there were also single-function tests in the development process, but a final validation of the software was performed with this set of products. As it was not feasible, to test all the products currently available, the set was restricted to these ten products selected randomly from two interventions. As the evaluation showed, the additional information included in the LOT number for tests one and four did not cause any problems in the evaluation of the software, as it has been parsed the same way in both tests. In addition, the issue with changed values in the input fields that were not written to the products table if the product was already known, was only a displaying problem at the screen for marking products as used, but had no functionality issues, as the table for products in stock had the values correctly saved. Although the evaluation contained 12 tests, it might be the case, that not all necessary functions have been tested and some of them may not be working as intended. For example, none of the selected products contained a serial number or a production date, so the parsing of this part of the UDI could not be verified.

The interviews mainly showed that the workflow at the point of evaluation was fully analogue with only scanning sheets of paper in some steps of the process, as described in the workplace description [4]. It also showed that the interviewed persons saw the potential in digitalisation and in the described workflow and the developed software. Although the number of participants might be a limitation of the survey, it might be conclusive for this specific case due to the small number of possible participants and the narrow field of use, especially if it is limited to the specific hospital. As some of the participants were also a source to get the information of the needed features, there might be some bias there.

One limitation in developing the parsing logic of the UDI code was, that the barcode scanner used at this point of development did not have the ability to display separators inside the UDI code, so there had to be a way, to find especially serial numbers, that directly follow the LOT number. This would have been handled by user interaction because there was no other way found at the time of development. During the process, there was the option to switch the used scanner to the model also used for the evaluation, because this one had the ability to show separators. Because of the limited timeframe between the exchange of the barcode scanner and the tests, there were no further modifications made to the parsing process.

V. Conclusion

The project highlights crucial steps including researching the current workflow, understanding the labelling system, defining software needs, and developing and evaluating the software. Initially, it became evident that there was significant potential for digitalization, as the department's only digital part of the old workflow involved scanning paper documentation. Continuous re-evaluations ensured the feasibility of the new process, aiming to integrate the new workflow into daily routines after the angiography unit's relocation.

The research focused on using standardized UDI codes, but there were challenges with the barcode scanner, that did not support separators. As the problem with the could be solved, future development will improve the UDI parsing algorithm and additionally will enhance user-friendliness. The software requirements were centered on managing product data, documenting usage, re-ordering, and handling expiration dates. User feedback from interviews will guide future feature additions and error reductions. Adjustments will be made to output files and data fields, particularly where products are ordered and marked as used, to enhance usability.

User interface development prioritized functionality and error prevention, including mandatory fields and drop-down selections. Improvements will address data consistency and error reduction. For final implementation, the software will run on a local server for enhanced security and accessibility, allowing radiologists to plan interventions and all personnel to manage inventory remotely. Features will be accessible from different locations within the hospital, accommodating the department's relocation.

The software has potential for extension to other hospital departments and facilities, enhancing digital workflows for various medical materials. This expansion could include operating rooms and other areas using implantable materials, as well as simpler supplies like gloves and syringes. The project's impact includes time reduction and fewer material handling errors. Continuous feedback and iterative development proved crucial, emphasizing the importance of persistence and collaboration.

The successful development and implementation of this software highlight its scalability and adaptability to various medical environments. The project underscores the potential for digital solutions to streamline processes and improve efficiency across multiple departments. By reducing manual errors and optimizing inventory management, the software can significantly enhance operational effectiveness. This project serves as a model for future initiatives aimed at digital transformation within healthcare settings.

The project underscored the value of digital healthcare solutions, inspiring future research and development in medical digital workflows. The lessons learned highlight the importance of continuous feedback, iterative development, and collaboration. This project has not only been a significant academic achievement but also an extensive learning journey, reinforcing the potential for tangible improvements in medical processes, patient care, and labor savings. Looking forward, the insights gained from this project will guide ongoing efforts to innovate and improve healthcare through digitalization.

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