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Evaluation of an Optimized Telemedicine Platform for Needs-Based Care in Outpatient Nursing

A study with four nursing services.

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Abstract: Digital telemonitoring systems offer promising approaches to reducing the burden on nursing staff. In this study, the existing telemonitoring platform COMES® (COgnitive MEdical Systems) was technically further developed for use in outpatient care and tested in a study. Prior to this study, COMES® already received, stored, and displayed vital data from various mobile devices. The system was initially expanded with a Django-based middleware, integrated with the API of the company Withings, and supplemented by a new web app for data visualization designed for nursing staff. The resulting extended system, called DIP (Data Integration Platform), was then tested with various mobile devices (e.g., blood pressure monitor, scale, smartwatch) by 22 care recipients over a period of five weeks. On average, the nursing staff rated the usefulness of the DIP as neutral, primarily due to challenges in integrating it into their daily routines. In contrast, the care recipients rated the system's user-friendliness as good to very good. The results highlight the potential of telemonitoring systems and the need for better integration of such systems into care processes.

Keywords: assistive systems, assistive technology, home care, outpatient care, health data tracking, telemedicine

1 Introduction

The growing aging population presents major challenges for healthcare systems—especially in the field of outpatient care [1]. Digital technologies and telemonitoring systems offer promising approaches to relieving the burden on nursing staff, efficiently capturing health data, and promoting the independence of individuals in need of care [2]. In practice, however, the implementation of such systems often fails due to a lack of user-friendliness, technical complexity, or poor integration into existing care structures.

Against this backdrop, our goal was to further develop the existing telemonitoring platform COMES®* (COgnitive MEdical Systems) so that both care recipients and nursing staff could use it in a user-friendly and beneficial manner. To ensure this, the resulting platform - DIP (Data Integration Platform) - was evaluated in a field study in terms of system reliability, usability, and practicality in everyday care. The study was conducted in cooperation with several outpatient care services in the Bavarian-Swabian region.

2 System Architecture

DIP (Data Integration Platform) is the result of our further development of the telemedicine platform COMES®, originally developed at the Heinz Nixdorf Chair of Medical Electronics (TU Munich), which has already been used in several studies for collecting health data in outpatient care. These studies repeatedly revealed issues in the areas of data transmission, system communication, user-friendliness, and the reliability of individual devices [3]. The aim of the further development was to specifically address these weaknesses.

To this end, a middleware based on the Django framework was developed to enable more stable and flexible communication between end devices and the platform. In addition, the Withings API was integrated into the platform, allowing vital data from Withings devices to be automatically

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***COMES®** is a registered trademark of Bernhard Wolf and the "Steinbeis-Transferzentrum für Medizinische Elektronik und Lab on Chip- Systeme".

received and stored. In our field study, the patients' health data were collected using the following devices (figure 1):

- **Withings Scanwatch 2:** smartwatch that can measure e.g. heart rate, activity, oxygen saturation (SpO2), single-lead ECG, sleep quality and body temperature
- **Withings Sleep Analyzer:** sleep mat that analyses sleep patterns and movements during sleep
- **A&D blood pressure monitor UA-767PBT-Ci:** for regular blood pressure measurements
- **A&D scale UC-351PBT-Ci:** records and monitors weight
- **THERA-Trainer tigo**: leg training device designed to promote mobility and prevent

Figure 2: Assistive systems for health monitoring.

The devices transmitted data either via Wi-Fi or a mobile network connection directly to the platform. The nursing staff could then access the visually processed patient data through a web app. As part of the further development, this web app was completely redesigned to improve usability and clarity.

The server architecture consists of a production and a test environment, both with identical structure and functionality. Each environment (test and production) includes its own API, web app, middleware database, and the pre-existing Sycare database from the original COMES® system, along with the associated Sycare service. The API communicates with its respective web app and accesses the corresponding middleware database. The web app also uses this database, which in turn is linked to the relevant Sycare database. The Sycare service accesses the Sycare database directly.

The architecture is characterized by a clear separation between application layer, middleware, and data storage. Each environment (production and test) has its own isolated

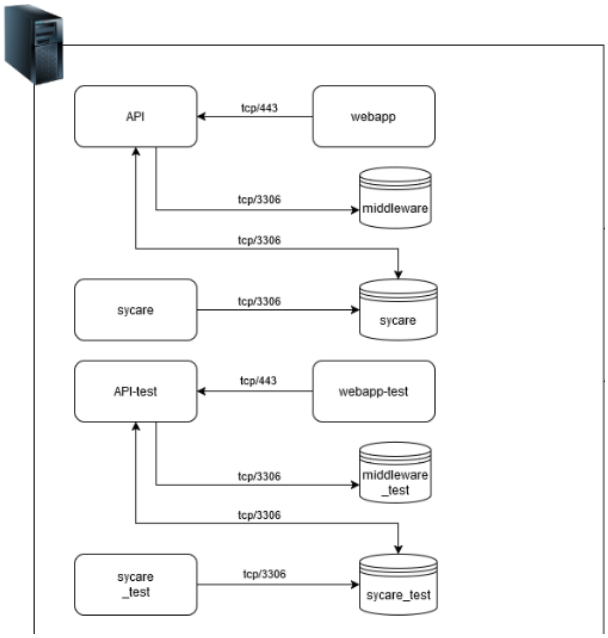

Figure 1: System architecture of the DIP.

components to enable secure testing and stable operations. Communication is standardized via HTTPS (port 443) and MySQL (port 3306).

The test system allows changes and new features to be tested without risk before being deployed in the production system. This helps to detect errors early and prevent system failures.

3 Method

The platform was tested as part of a study conducted in cooperation with four outpatient care services. A total of 11 nurses (all female, mean age = 45.6 years, SD = 10.68 years) enrolled in the study, along with 22 care recipients (10 female, 12 male, mean age = 80.7 years, SD = 11.1 years). Each care recipient, along with their assigned nurse, tested the system for a period of five weeks. The overall study duration was nine months (from the end of March to early December 2024).

A qualitative interview was conducted with each participant before the start and after the completion of the five-week testing period. These interviews explored, among other things, concerns and expectations regarding the use of the system, as well as any issues encountered during use. The usability of the system from the perspective of the care recipients was assessed after the test period using the established System Usability Scale (SUS).

To assess the perspectives of the nursing staff, a custom-developed questionnaire that had not been formally validated was used. This primarily measured the perceived usefulness of the system in daily care routines using a five-point Likert scale.

Service interventions were documented by the study team, and system availability was recorded based on logged errors in the system's log files.

4 Results

4.1 Caregivers and Care Recipients

According to official recommendations, the sample size of the survey is sufficient for quantitative SUS analyses [4].

Therefore, the SUS scores obtained can be considered meaningful. Due to two incomplete SUS questionnaires, the SUS score for assessing usability could only be calculated for 20 out of the 22 care recipients. Overall, the average SUS score

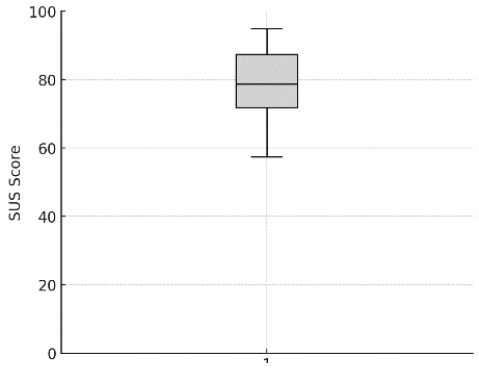

Figure 3: Boxplot of SUS scores (n=20).

was M = 78.6 (SD = 9.8) on a scale from 0 to 100, indicating generally good to very good usability. The boxplot (Figure 3) visualizes the distribution of total scores across all participants.

With regard to the nursing staff, it became apparent that the relief in daily work - particularly in physical, psychological, and time-related aspects—was lower than expected. On average, however, participants could imagine that the use of our technologies could improve both the quality of care and the attractiveness of the nursing profession. This expectation was especially evident among those who had successfully integrated the technology into their daily routines. The key qualitative findings are presented in Table 1.

Table 1: Results of the self-developed questionnaire for caregivers (1 = strongly disagree to 5 = strongly agree).

Question	Mean	SD
Q1: I already had experience with digital assistive technologies in nursing before the project.	3,91	1,30
Q2: I have always been very open to digital assistive technologies in nursing.	4,18	0,75
Q3: My opinion of digital assistive technologies in nursing has improved as a result of the study.	3,82	0,60
Q4: The assistive technology has reduced my physical (bodily) workload.	2,18	0,98
Q5: The assistive technology has reduced my psychological (mental) workload.	2,55	1,04
Q6: The assistive technology has helped me save time.	2,64	0,81
Q7: The assistive technology has improved the quality of care.	3,00	0,89
Q8: I can imagine that the assistive technology increases the attractiveness of the nursing profession.	3,45	0,93

4.2 System Stability and Service

Over nine months, server data were analyzed to assess system stability and resource use. Overall, server availability was very high. Only occasional short-term limitations occurred, which were also reflected in the network data:

- Availability (Agent & Ping): consistently 100% – with one exception, where the average ping on November 30, 2024, at 1:00 PM was 0.8.
- HTTPS Availability: 99.85%, with 9 hours of reduced availability. On September 17, 2024, at 10:00 AM, there was an HTTPS outage accompanied by high outbound traffic due to a planned server migration.
- Latency behavior: slightly elevated during outage periods; average latency was 1.276 ms (normally ~0.9 ms).

The events suggest temporary disturbances, partly due to planned interventions. No system overload was detected. The evaluation of CPU metrics indicated that the system was only lightly utilized throughout the entire period. CPU idle time averaged 98.18%, showing minimal load. Only eight hours recorded values below 90%; the lowest value was 5.87%. However, this did not coincide with known accessibility issues.

CPU wait time for I/O processes (IOWait) was also negligibly low. The average value was only 0.0048%, with a maximum of just 0.10%. This indicates no significant memory or network bottlenecks.

Service interventions were analyzed relative to users, devices, and study duration. With 23 documented interventions over nine months, distributed among 33 participants (care recipients and nursing staff), this results in an average intervention rate of 0.12 interventions per participant per month. Only three service interventions per device type support the system's reliability. Only 43% required on-site support. Particularly noteworthy is the decline in service interventions over time, suggesting successful problem-solving and growing user familiarity.

5 Discussion

The average SUS score of 78.6 indicates generally good to very good usability from the perspective of the care recipients. The qualitative survey revealed that the nursing staff surveyed were generally open to digital assistance systems and, in some cases, perceived them positively. At the same time, the perceived relief was rather low, so the overall benefit was rated as neutral. The success of our system largely depended on its effective integration into the caregivers' daily routines and the availability of accompanying training measures.

During the analysis period, the system demonstrated very high availability and stability, which is also reflected in the low number of service interventions. The few observed HTTPS outages resulted from temporary network issues or planned actions (e.g., server migration).

Compared directly with industry-specific requirements—such as those considered critical in telemedicine—the system performs very well overall. For instance, guidelines such as the NIST Special Publication 1800-30 for secure telemedicine infrastructures recommend a minimum availability of 99.9% to ensure uninterrupted use of medical applications. With measured availability rates of 100% for agent and ping and 99.85% for HTTPS, the system is very close to this target, with the small deviation being technically explainable and well-documented [5].

6 Conclusion

The developed Data Integration Platform (DIP) specifically improves upon the predecessor solution COMES® in terms of system communication, data integration, and user-friendliness. The field study demonstrates high usability from the perspective of care recipients, as well as excellent system stability and low susceptibility to technical issues.

For nursing staff, the perceived benefit largely depends on the integration of the technology into their daily work routines and the availability of accompanying training. While the expected relief was only partially achieved, the potential for improving the quality of care was recognized.

The integration of technical assistance systems into care processes is a key leadership responsibility. System reliability, training, and support are essential for successful implementation. Only under these conditions can real added value be created for both nursing staff and care recipients - and successful transfer into practical care settings be achieved.

Author Statement and Acknowledgements

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