Continuous real-time remote monitoring of severely or chronically ill children

Claudia Pedron

Estern Switzerland University of Applied Sciences (OST)

claudia.pedron@ost.ch

Eastern Switzerland University of Applied Sciences (OST),
Institute for Information and Process Management,
Rosenbergstrasse 59, CH-9001 St. Gallen, Switzerland

Edith Maier, Pascale Baer-Baldauf, Claudia, Ulrich Reimer, Tom Ulmer

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My Person

Education

- Diploma in Civil Engineering at the University of Trient, Italy
- PhD at the Swiss Federal Institute of Technology Zurich (2005) in the area of e-learning

Position

- Since 2012 lecturer at the Eastern Switzerland University of Applied Sciences
- Focus on Process Management and Process Automation

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Research activities and topics of research interest

Current research activities

- Strategic tools for sustainable urban planning /
  Developement of process management and rule systems /
  Low Code Programming

Topics of research interest of my group

- Digital business /
  Digital health /
  Digital society

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Project objectives

- Develop a remote monitoring system for severely ill children not inferior to stationary monitoring in a hospital
- Reduce the physical and psychological strain of parents taking care of the children
- Thus prevent chronic stress and possible burnout
- Increase safety of patients
- Succeed in the first healthcare market

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Project consortium

Kinder SPITEX SCHWEIZ

Spital Thurgau MÜNSTERLINGEN

XMIND

Net-Monitoring AG

FHS St.Gallen Hochschule für Angewandte Wissenschaften

Duration:

2016 - 2019

Funding:

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

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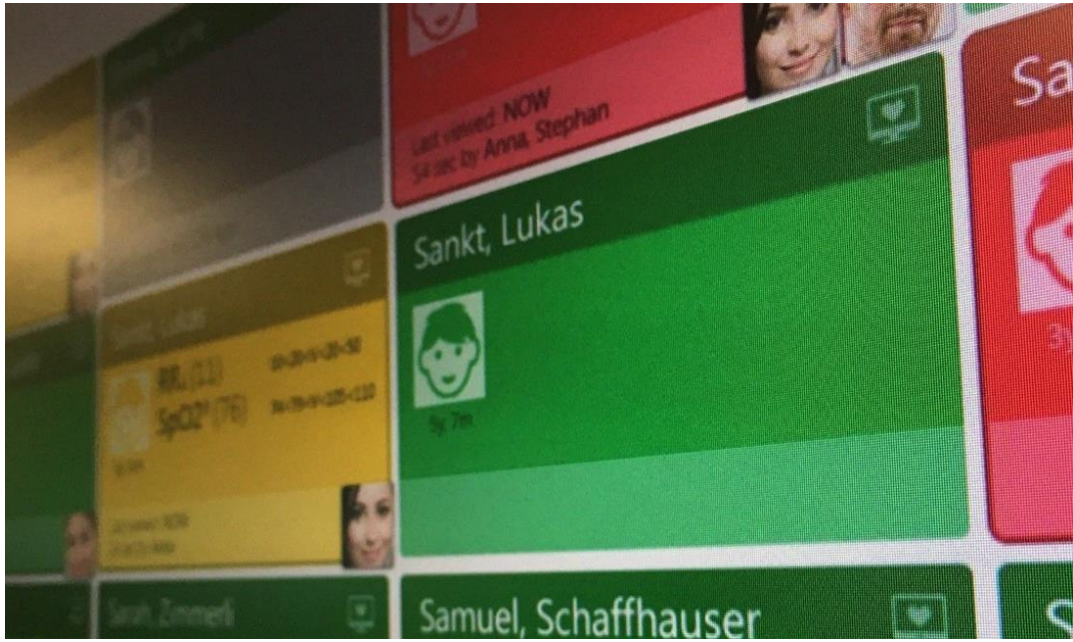
Research questions

1. Can a remote monitoring solution be established that is comparable to stationary monitoring in terms of reliability and accuracy?
2. Which are the relevant processes and how must these processes be designed?
3. How should professional nursing staff intervene to best support the relatives in case of an alarm?
4. Which are the prerequisites to introduce the remote monitoring system into the first healthcare market?



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State-of-the art

According to a recent meta-analysis there are many remote monitoring solutions, usually based on wearables, ambient sensors and systems based on contactless camera-based methods

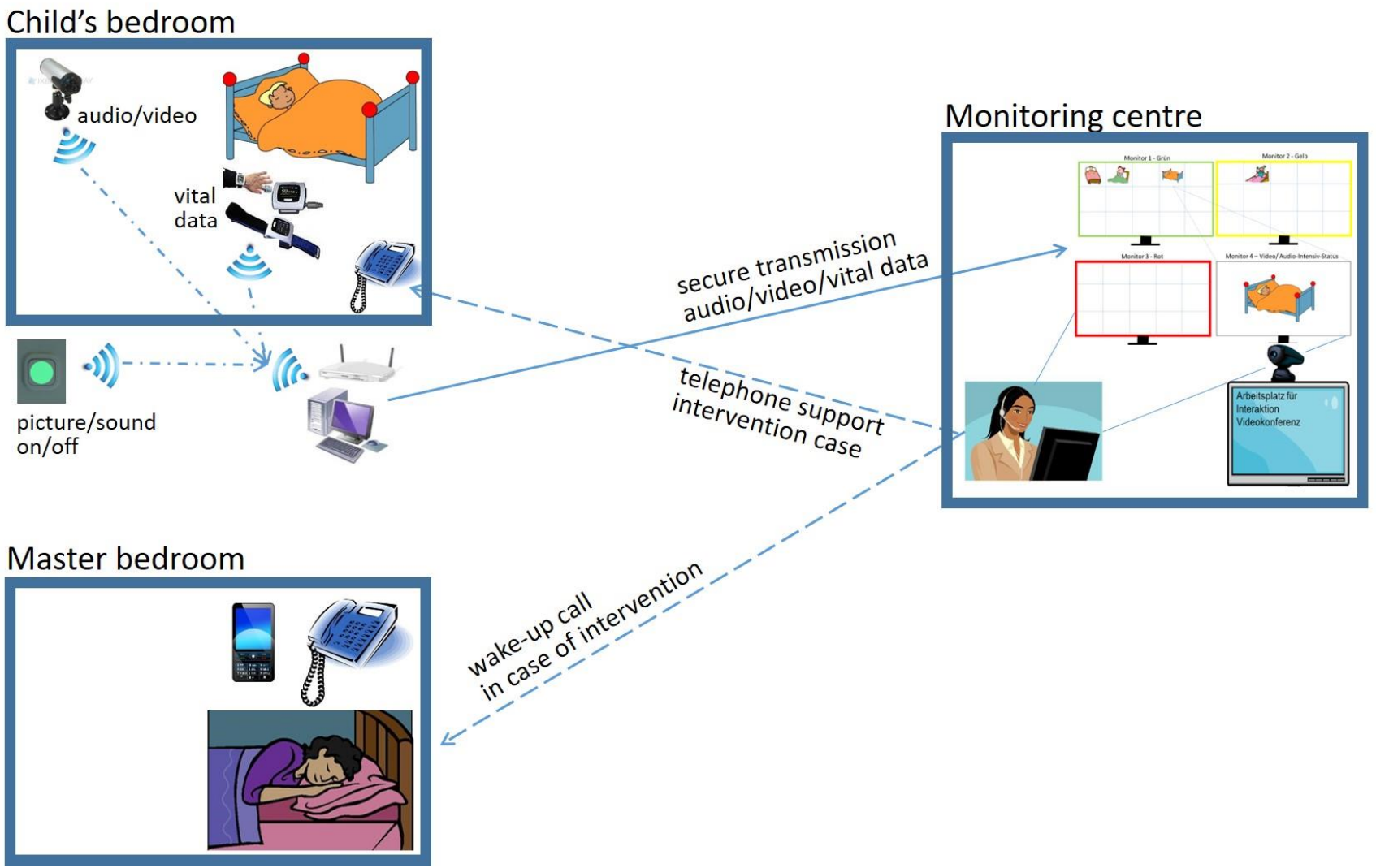
Application areas: Monitoring of chronic diseases such as diabetes, the cardiovascular and respiratory systems, fall detection and mobility-related diseases as well as neurological disorders and mental health.

Few solutions target children, among them:

- A smart monitoring solution based on wearable sensors and a smartphone that continuously monitors a child's activity and vital signs (Malasinghe et al., 2019)
- A system based on wearable vests which monitors children who suffer from chronic illness. Parents/Caretakers are continuously notified about the health conditions and the activities performed by their children using a smart android application (R. Jansi et al., 2019)

Gap: Most studies fail to discuss how to embed the remote monitoring system into organizational processes.

Solution



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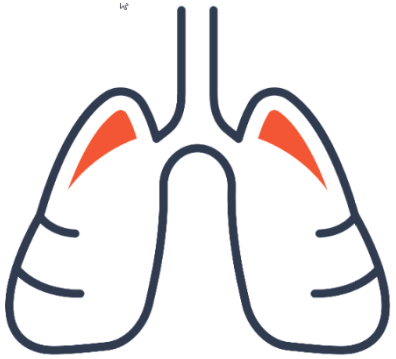
Implementation (1) - Vital parameters

Heart rate

Most relevant parameter,
Measured via

- ECG (medical grade)



Respiration rate

May be measured via

- Impedance pneumography

Oxygen saturation

Measured with

- Pulse oxymeter (with adhesive tape)

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Implementation (2) - Relevant processes

A major task consisted in defining the processes to accompany the implementation of the remote monitoring system, i.e.

- the interaction processes between nurses, caregivers at home and emergency staff, e.g. when to issue an alert and whom to alert whenever there was an emergency.
- The process of alerting the parents; e.g. to make sure that it really is an emergency (verified by means of audio-visual surveillance)
- The process of the intervention, especially the taking over of the responsibility from the parents and/or assisting them during an emergency situation by talking them through the necessary steps on telephone.

Challenges

- Prove and demonstrate that our system is not inferior to stationary monitoring in a hospital (Prerequisite: only use devices that have already obtained medical approval)
- Strike the right balance between safety and missing an emergency
- Find monitors that provide access to non-aggregated raw data in real-time
- Reduce number of alarms due to false positives
- Optimizing acceptance and usability of the system (e.g. unobtrusive sensors, suitable for target group)

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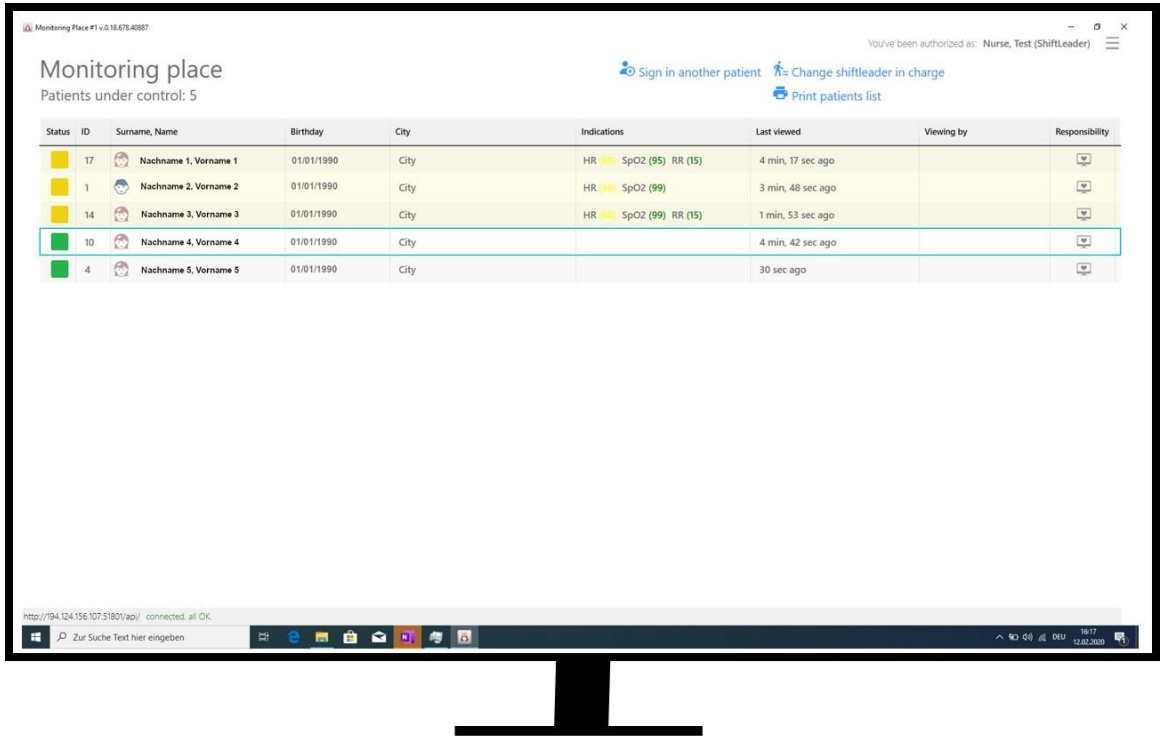
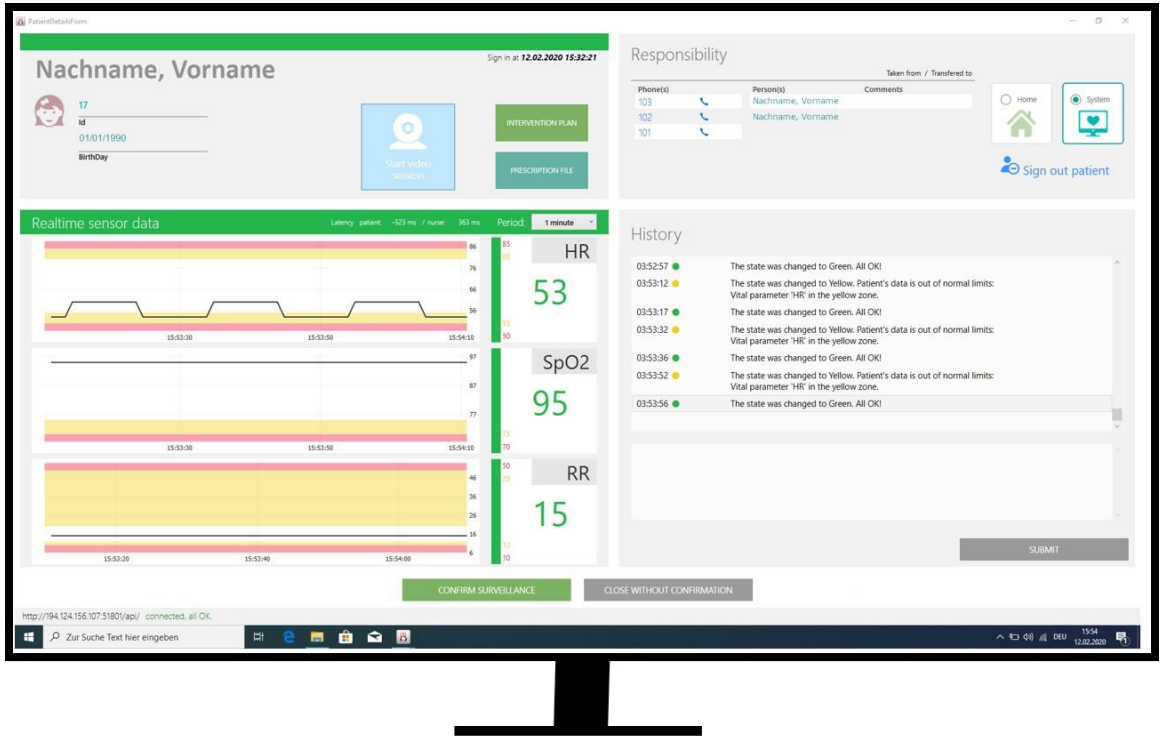
Results (1) – Monitoring infrastructure

Results (2) - Monitoring infrastructure





Results (3) - Monitoring service

All relevant alarms have to be identified by the system

Number of alarms was reduced by
- adjusting the algorithm and
- checking the video surveillance

Table shows the number of alarm recordings per child per night after adjusting the algorithm and fine-tuning the thresholds.

	Patient 1	Patient 2	Patient 3	Total
Green	0	0	0	0
Yellow	16	12	18	46
Red	**11**	**1**	**33**	**45**
Unjustified alarm	8	0	31	39
Justified alarm	3	1	2	6
Reasons for alarm				
Sensor lost	3	1	0	4
SpO2 data missing[1]	4	0	15	19
Data transfer issues	3	0	2	5
Awake	0	0	0	0
Respiration rate artefact	0	0	11	11
Others	1	0	5	6

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Evaluation (1)

- Starting point: According to the nurses providing on-site night watches, all parents with severely ill children suffer from poor sleep.
- Nurses expect that in 75% of the cases, on-site night watches could be replaced by remoting monitoring.
- In about half of the cases without night watches (usually the less severe cases), nurses expect that sleep problems can be reduced in over 90% of cases by remote monitoring.

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Evaluation (2)

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Introduction of the monitoring system into regular health care delivery (1)

- Goal: reimbursement of the remote monitoring service
- To achieve this:
  - the remote monitoring system has to be approved by Swissmedic (the Swiss Agency for Therapeutic Products), and
  - evidence must be furnished to prove the *usefulness*, *cost-effectiveness* and *efficiency* of the solution

Introduction of the monitoring system into regular health care delivery (2)

Usefulness: preventive and therapeutic purpose

- Detection of exacerbations and enablement of early interventions
- Restful nights for the parents and increase of parents' endurance
- Contribution to recovery and enhancement of the quality of life

Cost effectiveness:

- Need to introduce a tariff number for issuing an invoice; currently no such a number exists
- Proof that remote monitoring is cheaper than on-site night watches

Introduction of the monitoring system into regular health care delivery (3)

Efficiency:

- Increase in productivity due to the simultaneous monitoring of up to 20 patients by 3 nurses instead of 1 nurse per child on-site
- More efficient use of nursing staff, which is short supply
- Reduction of costs incurred by burn-out or chronic stress of caring parents

Conclusions

Continuous remote monitoring is basically feasible and, if implemented properly, is equivalent or not inferior to monitoring in a hospital environment.

The main challenge consisted in reducing the high number of alarms per child per night, in defining the number of children that a professional nurse might monitor simultaneously as well as in defining thresholds for the various parameters.

The audio-visual surveillance component turned out to be essential.

Embedding the system into a process landscape of the monitoring organisation is a prerequisite for its acceptance.

Nurses expect the system to reduce the burden on parents.

Once home monitoring has been approved officially, interesting business opportunities open up for insurance companies, hospitals and home care organisations