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Design and implementation of a platform for configuring clinical dynamic safety checklist applications

Key words: Checklist; Workflow; Clinical decision support; Process management; Patient safety

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Motivation

Deaths by medical mistakes hit records



The way IT is designed remains part of the problem

WASHINGTON | July 18, 2014

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It's a chilling reality – one often overlooked in annual mortality statistics: Preventable medical errors persist as the No. 3 killer in the U.S. – third only to heart disease and cancer – claiming the lives of some 400,000 people each year. At a Senate hearing Thursday, patient safety officials put their best ideas forward on how to solve the crisis, with IT often at the center of discussions.

Tejal Gandhi, MD, president of the National Patient Safety Foundation and associate professor of medicine, Harvard Medical School, spoke at the hearing.

Hearing members, who spoke before the Subcommittee on Primary Health and Aging, not only underscored the devastating loss of human life – more than 1,000 people each day – but also called attention to the fact that these medical errors cost the nation a colossal \$1 trillion each year.

"The tragedy that we're talking about here (is) deaths taking place that should not be taking place," said subcommittee Chair Sen. Bernie Sanders, I-Vt., in his opening remarks.



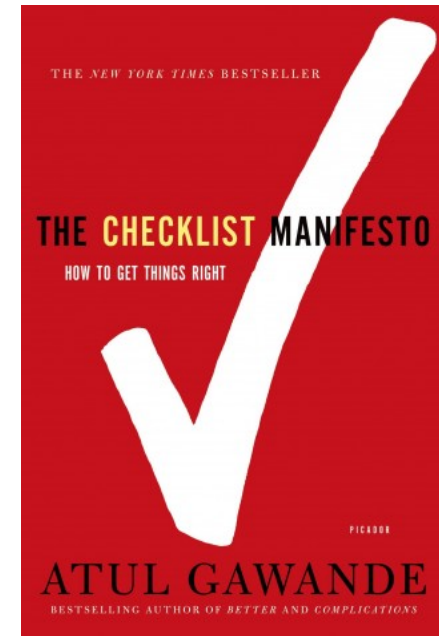
&



World Health Organization



Checklist is proposed as an effective tool to help reduce preventable medical errors.



Motivation

Paper checklists

Surgical Safety Checklist

World Health Organization | Patient Safety

Before induction of anaesthesia (with at least nurse and anaesthetist)

- Has the patient confirmed his/her identity, site, procedure, and consent?
- Is the site marked?
- Is the anaesthesia machine and medication check complete?
- Is the pulse oximeter on the patient and functioning?
- Does the patient have a:
 - Known allergy?
 - Difficult airway or aspiration risk?
 - Risk of >50ml blood loss (7ml/kg in children)?

Before skin incision (with nurse, anaesthetist and surgeon)

- Confirm all team members have introduced themselves by name and role.
- Confirm the patient's name, procedure, and where the incision will be made.
- Has antibiotic prophylaxis been given within the last 60 minutes?
- Anticipated Critical Events
- To Surgeon:
 - What are the critical or non-routine steps?
 - How long will the case take?
 - What is the anticipated blood loss?
- To Anaesthetist:
 - Are there any patient-specific concerns?
 - Has the patient's airway been confirmed?
 - Are there any equipment concerns?
 - Is essential imaging available?
- To Nursing team:
 - Has the patient's identity been confirmed?
 - Are there any equipment concerns?
 - Is essential imaging available?

Before patient leaves operating room (with nurse, anaesthetist and surgeon)

Nurse Verbally Confirms:

- The name of the procedure
- Completion of instrument, sponge and needle counts
- Specimen labelling (read specimen labels aloud, including patient name)
- Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:

- What are the key concerns for recovery and management of this patient?

PRE-OPERATIVE ON WARD before transport to holding area

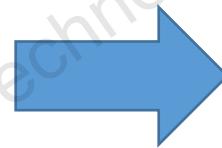
to be completed by: Ward doctor

	not applicable	yes
1 Patient seen by ward doctor	☐	☐
2 Medical data (including letters and previous operation reports) seen by ward doctor	☐	☐
3 Relevant imaging present and assessed	☐	☐
4 Relevant consultations by other disciplines performed	☐	☐
5 Preoperative advice anaesthesiologist / other disciplines executed	☐	☐
6 Relevant laboratory checks (including ionizing) performed	☐	☐
7 Medication prescribed	☐	☐
8 (Timely) cessation of anticoagulants checked	☐	☐
9 Postoperative ICU-bed arranged	☐	☐

Date: _____
Name and signature ward doctor: _____

Computerized systems

Hard-coded



Clinical
information
systems

Checklist

Before Induction of Anaesthesia

- Have you confirmed patient identity? **Yes**
- Have you confirmed surgical site? **Yes**
- Have you confirmed the procedure? **Yes**
- Have you obtained consent? **Yes**
- Is the surgical site marked? **Yes**
- Is the anaesthesia safety check complete? **No**
- Is the pulse oximeter on the patient on and functioning? **Yes**

Pre-operative

- Checklist: All team members
- Checklist: All team members
- Checklist: All team members
- Checklist: All team members
- Checklist: All team members
- Checklist: All team members

Post-operative

- Checklist: All team members
- Checklist: All team members
- Checklist: All team members
- Checklist: All team members
- Checklist: All team members
- Checklist: All team members

Developing checklist systems is time consuming as vendors will have to hard-code all the knowledge in the paper checklists and integrate them with information systems.

Motivation

This paper aims to simplify the development by proposing a dynamic checklist configuration platform.

Front Inform Technol Electron Eng

Main ideas

Two research questions need to be answered:

1. Which features should dynamic checklist applications provide in general?
2. Which mechanisms can support the realization of the above-mentioned features through configuration?

Methods: 1. Design criteria of the platform

By reviewing existing checklist applications, we extracted the following design criteria:

1. Point-of-care related:

- A dynamic checklist system should facilitate adapting checklists at the point of care
- Technical solution: rule engine/clinical decision support

2. Process related:

- A dynamic checklist system should facilitate the application of checklists in clinical processes
- Technical solution: workflow engine/workflow management system

Methods: 2. Design of the platform

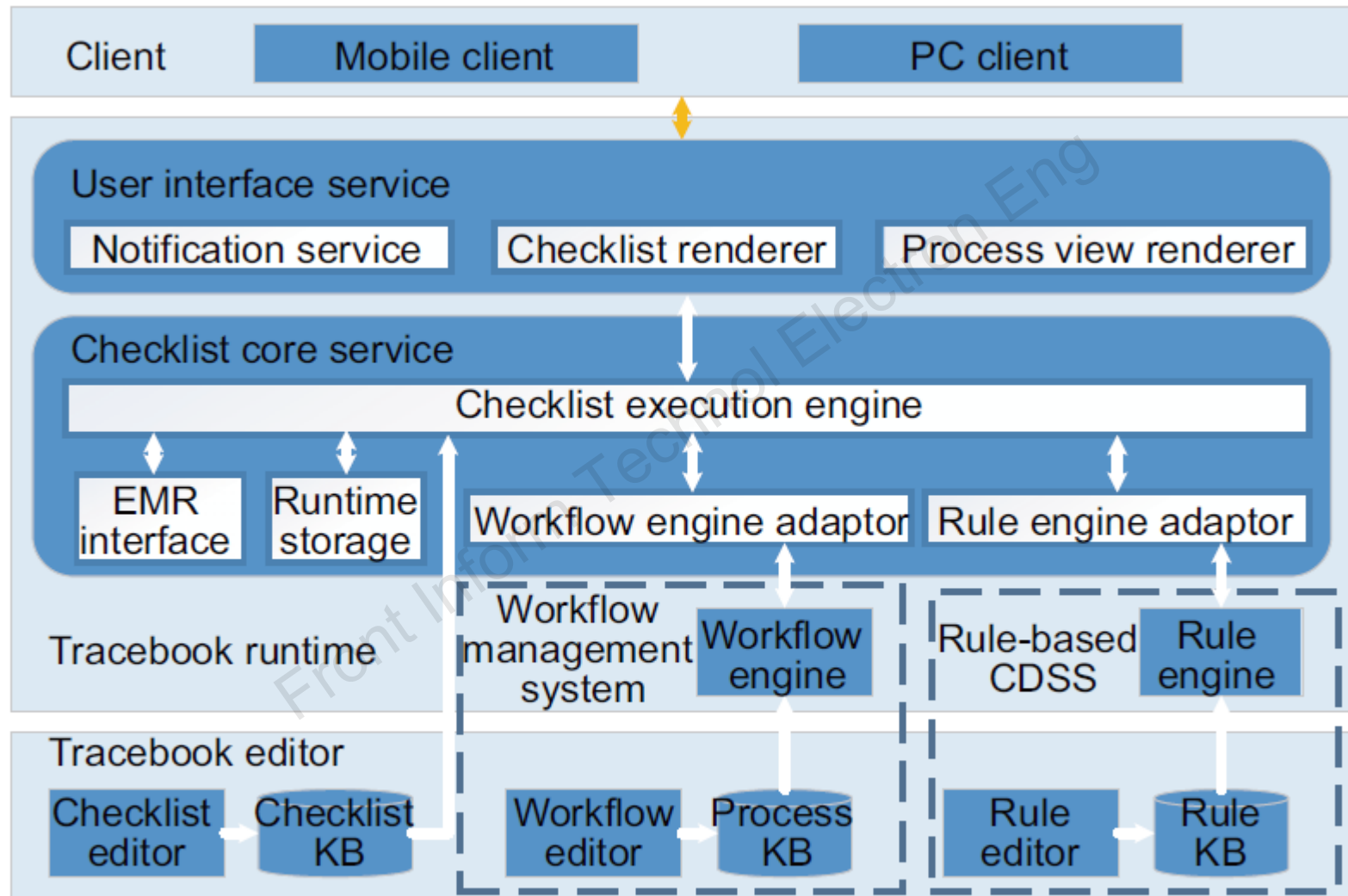


Fig. 1 Technical architecture of the platform

Results: feasibility

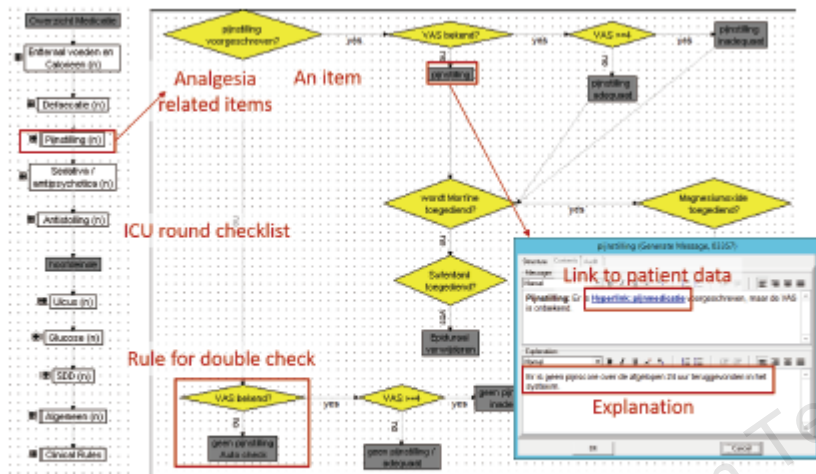


Fig. 5 Implementation of the ICU round checklist

It is feasible to configure a model-based dynamic checklist application in which the detailed constraints are considered.

The screenshot shows the Tracebook application interface. At the top, there is an email notification titled "Email notification" addressed to "Nurs, S.". The notification contains a link to the checklist: http://192.168.1.10/ChecklistSolution/ChecklistSheetFrame.aspx?ChecklistID=203PRE_OK_POSTGaston_524785. Below the notification, there is a patient data window titled "Instructies_bij_opname" for patient John Doe. The window shows a list of items with checkboxes for "Check" and "Note". The items include: "Lid waste zijn bevestigd", "Medicatie instructies zijn uitgevoerd volgens voorschrift PPO's, hoofdbehandelaar en/of hoofdbehandelaar", "Sedatie is uitgevoerd", "Huidproefdragen zijn bevestigd", "Pijnstilling is bevestigd", "Huidproefdragen is gemeten in de juiste toestand", and "Alergieën zijn bevestigd". The bottom part of the screenshot shows a detailed checklist table with columns for "Item", "Check", "Note", and "Sum". The table lists various medical items and their status, including "Sedativa / antipsychotica: Er zijn geen Antipsychotica voorgeschreven", "Antibiotica: Wordt monicaat niet voorgeschreven", "Medicatieoverzicht", "Voedingstatus: Er wordt geen (pre)medicatie gegeven. Criteria: entereale voeding", "Defensie: Geen registratie van de afgeleverde 48 uur", "Pijnstilling: Er is pijnstilling voorgeschreven, maar de VAS is onbekend", "Pijnstilling: Er is pijnstilling voorgeschreven, maar de VAS is onbekend", "Sedativa / antipsychotica: De voorgeschreven Sedativa en de dosering daarvan is bevestigd", "Antistolling: Er wordt geen therapeutische antistolling voorgeschreven. Advies: overweeg antistolling", "Hoofdeinde: Het hoofdeinde van de patiënt is in een trussel 30 graden geplaatst", "Ulcus: Patiënt krijgt geen preventieve medicatie voor Ulcusproefdragen", "Glucose: Advies: start Glucoseproefdragen, geen recente Glucose (POK) metingen uitgevoerd bij deze diabetische patiënt", "Voorgeschiedenis: De voorgeschreven greff wel geen reden om af te wijken van de normale procedures.", "Onderzoek: Lichaamlijk onderzoek greff wel geen reden om af te wijken van de normale procedures.", "Onderzoek: Laboratorium onderzoek greff wel geen reden om af te wijken van de normale procedures.", "Onderzoek: Radiologisch onderzoek greff wel geen reden om van beleid te wijken c.q. interventie (positieve röntgen, pneum etc.)", "Conclusie: Met alle betrokken partijen (verpleegkundigen, consultants en familie) is gecommuniceerd over de diagnose, behandelplan en het doel.", "Complicaties: Geen registratie gevonden in EZIS", "Complicaties: De NICE data is ingevuld".

Results: generalizability

Table 1 Dynamic checklist applications developed with the platform

Name	Number of checklists	Description
Peri-operative checklist set	17	Used for peri-operative care for general surgery by ward doctors, nurses, anesthesiologists, and surgeons. These checklists are based on published SURPASS checklists and localized to the target hospital. Developed by an engineer under the supervision of a surgery nurse practitioner.
Unstable angina care pathway checklist set	7	A set of checklists supporting the standardized diagnosis and treatment of unstable angina based on the localized unstable angina care pathway. These checklists are developed primarily based on observational study and interviews with cardiologists, nurses, and nurse practitioners. Developed by a master student under the supervision of two surgery nurse practitioners.
ICU daily round checklist	1	A daily round checklist in ICU with the purpose of providing essential concerns to the patient and gathering patient information related to the concerns. This checklist is based on the hospital-localized version of the FAST HUGS checklist and combined with clinical rules proposed by intensivists. Developed by two engineers and two intensivists. Tested in a simulation-based environment.
Antibiotic checklist	1	Checking the correctness of antibiotic prescriptions and raising concerns based on antibiotic protocols used in the hospital. This checklist is developed from protocols for antibiotic choices for specific diseases and dosage adjustment for specific kinds of patients. Developed by an intensivist.
Resuscitation protocol checklist set	6	A checklist for the standardized steps in advanced life support. Helps participants to know each other, to count the rounds, and to list critical steps based on rounds. These checklists are developed based on a hospital-localized version of an advanced life support protocol. Developed by two engineers and an internist.
Bariatric surgery checklist set	23	Used for the longitudinal care process for bariatric surgery ranging from pre-operative care to follow-up after five years. These checklists are developed from clinical guidelines and refined with surgeons. Developed by a bachelor student under the supervision of a gastric surgeon.
Lung cancer surgery checklist set	15	A set of peri-operative checklists for lung cancer surgery based on the lung cancer surgery clinical pathway published by the Ministry of Health of the People's Republic of China. Developed by a master student under the supervision of a surgeon.
Breast cancer diagnosis and treatment pathway checklist set	172	A group of checklists for the comprehensive process of breast cancer from screening to diagnosis and treatment. The process is divided into 12 processes including screening, diagnosis, second opinion, hormone therapy, chemo therapy, debulking surgery, and their combinations. These checklists are developed based on guidelines, observational studies, and interviews with all stakeholders involved in the process. Developed by a post-master researcher.

The proposed approach is generic to use. A total of 242 checklists have been configured by a group of clinicians and engineers.

Conclusions

1. We discussed the scalability issues of dynamic checklist applications and presented a novel solution that overcomes these issues via configurable models.
2. We demonstrated that the use of a model-based approach does not lead to compromises regarding the dynamics or level of details.
3. We demonstrated that a model-based approach enables us to keep the infrastructure stable while expanding the number of models on top of it.