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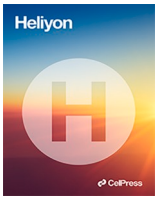

Research article

# Evaluating deviations and considerations in daily practice when double-checking high-risk medication administration: A qualitative study using the FRAM

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ABSTRACT

*Background:* Double-check protocol compliance during administration is low. Regardless, most high-risk medication administrations are performed without incidents. The present study investigated the process of preparing and administrating high-risk medication and examined which variations occur in daily practice. Additionally, we investigated which considerations were taken into account when deviating from the guidelines.

*Methods:* Ten Dutch hospital wards participated. The Functional Resonance Analysis Method was applied to construct a model depicting the Dutch guidelines and a ward-overarching model visualizing daily practice. To create the ward-overarching model, eight semi-structured interviews were conducted per ward discussing the preparation and administration of high-risk medication. Work related Efficiency-Thoroughness Trade-Off rules were used to structure subconscious considerations.

*Results:* In total, 77 nurses were interviewed. Six model deviations were found between the guideline model and ward-overarching model. Notably, four variations in double-check procedures were found. Here, time pressure was an important factor. Nurses made a risk-assessment, considering for patient stability, and difficulty of calculations, to determine whether the double-check would be executed. Additionally, subconscious reasonings, such as trusting their own or colleagues expertise, weighed on the decision.

*Conclusion:* Time pressure is the most important factor that withholds nurses from performing the double-check. Nurses instead conduct a risk-assessment to decide if the double-check will be executed. The double-check can thus become habitual or unnecessary for certain medications. In future research, insights of the FRAM could be used to make ward-specific alterations for the double-check procedure of medications, that focus on feasibility in daily practice, while maintaining patient safety.

## 1. Introduction

The substantial and increasing medication use raises the risk of patient harm [1]. Parenteral medications, like intravenous infusion,

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subcutaneous or intramuscular injections, significantly increase the risk of adverse events (AEs) due to their complexity in use and immediate effect, both increasing the likelihood of an irreversible effect [2]. Due to the increased risk of AEs, parenteral medication is considered to be high-risk medication. Multiple studies have confirmed error rates during the administration of parenteral medication at a minimum of 48 % [3–6]. In the Netherlands, 32 % of all AEs in deceased hospitalized patients were caused by the use of medication in 2019 [7]. To diminish the administration errors globally, guidelines have been established based on the 'five rights' of safe medication administration: right drug, right dose, right patient, right route, and right time [8]. In the Netherlands, such guidelines have been implemented in 2009 [9].

Dutch guidelines include instructions for both the preparation and the administration of high-risk medication, describing 17 actions in total [9]. In the preparation phase, the medication order is checked on, for example, a correct dosage, all provisions for the preparation are executed, and the medication is prepared for administration. In the administration phase, all provisions for the administration are executed, the medication is double-checked, and the administration takes place [9]. The double-check entails an independent check of the medication before administration, by a second qualified health care professional, usually a nurse, who is present at the bedside of the patient at the administration time [10].

Globally, research has shown compliance with most steps of the guidelines is high [11–15]. However, compliance with the double-check remained low over the years [11–18], indicating that it is difficult to perform the double-check in the daily practice. These studies analyzed the compliance with the guidelines [11–16,18], meaning the double-check is mainly monitored from a Safety-I perspective, in which "safety is a state where as few things as possible go wrong" [19]. To achieve this goal, systems need to function accordingly and professionals have to act as they are expected according to the guidelines [19]. However, this gives limited information on practice variation in daily practice.

Little attention has been paid to the double-check from a Safety-II approach. This perspective focuses on "as many things as possible go right", meaning the system can succeed under varying circumstances and with various daily actions [19]. One small study examined the daily practice of the high-risk medication administration in two Dutch hospital wards from this perspective [2], showing a low compliance in hand sanitizing steps, and multiple workarounds when performing the double-check. The latter can be explained with increasing workload, staff shortages, and time restraints in healthcare. Professionals must consider working efficiently or working thoroughly (Efficiency-Thoroughness Trade-Off; ETTO). By working efficiently, the activity will be executed with the need of a minimal amount of resources, such as time, and materials [20]. Translated to the administration of high-risk medication, this means all patients receive their medication in time, but not all steps are executed. When working thoroughly, sufficient resources are available, and high-quality work can be executed [20]. This means administrations are executed according to the guidelines, but not all patients receive medication in time.

Regardless the low double-check compliance, most high-risk medication administrations are performed safely [21], indicating nurses adapt their performance to varying conditions on the ward. However, how nurses successfully adapt and deal with varying circumstances to achieve safe medication administrations without always complying with the guidelines on a large scale remains unexamined. Which considerations nurses take into account or trade-offs they have to make to ensure safe medication administrations has not been examined as well. To understand how the safety is ensured in daily practice regarding the administration of high-risk medication, the undertaken research focusses on how nurses perform the double-check in daily practice, and what considerations are taken into account when deviating from the guidelines and/or standard practice. It is hypothesized that most variations are found during the actions involving a second nurse for a double-check. Also, hand sanitation steps might not always be properly executed. Lastly, we expect that experienced time pressure and availability of colleagues are key considerations when deciding to deviate from the guidelines.

## 2. Methods

### 2.1. Design and participants

A detailed description of the original study protocol for all three safety themes (high-risk medication, medication verification, and frail elderly) can be found in the publication of Van Dijk et al. (2021) [22]. The first findings of the other safety themes can be found in another publication [23]. The focus of this observational study is on the daily practice and the experiences of nurses during the administration of high-risk medication. Due to COVID-19 restrictions, a number of adjustments had to be made to perform the study. Notably, no direct observations could take place, and interviews were conducted online.

Due to large numbers of high-risk medication administrations, three types of hospital wards were eligible, namely: internal medicine, surgery, and intensive care units (ICUs). The study only included adult patient settings. After agreement of participation, a contact person, for example a head nurse, was assigned to each ward to discuss the aim and planning of the study with the researchers. The contact person informed all nurses of the ward about the study and selected eight nurses to participate in the interviews. Nurses had to be willing to talk about the preparation and administration of high-risk medication, and preferably had different views – if applicable – about the execution of the guidelines. The contact person was asked to select nurses with different views for the interviews. This gave us the opportunity to observe and discuss as many variations of daily practice as possible during the interviews. Providing us with the most comprehensive overview of the participating wards.

### 2.2. Functional Resonance Analysis Method

To compare guidelines and daily practice, two models were made for every ward. Based on the hospitals' guidelines, a Work-As-

Imagined (WAI) model was constructed, and based on the results of the interviews, a Work-As-Done (WAD) model was created. The models were constructed using the Functional Resonance Analysis Method (FRAM), a method to visualize and analyze a healthcare process by mapping the differences between guidelines (WAI) and daily practice (WAD) [24]. By identifying and visualizing all activities in the process, relations between activities can be shown [25,26]. All activities are depicted with hexagons, based on 6 aspects (Fig. 1) [25,26]:

1. Input: what starts or changes the activity.
2. Time: all time aspects influencing the activity.
3. Control: what monitors or controls the activity.
4. Output: the output of the activity.
5. Resource: all resources needed to execute the activity.
6. Precondition: preconditions that need to be met to execute the activity.

### 2.3. Efficiency-Thoroughness Trade-Off

The ETTO-principle is based on the trade-offs between how thorough and efficient an activity can be executed [20]. The thoroughness or efficiency of an activity is determined by underlying reasonings concerning the workplace, available colleagues, and the perceived importance [20]. These reasonings can be divided into ETTO rules [20], subdivided into three groups: work related-, individual-, and the collective ETTO rules [20]. Our study focused on the work related ETTO rules, and used the ETTO principle to structure subconsciously made considerations when deviating from the guidelines.

### 2.4. Data collection

Data collection took place between June 2020 and June 2021. Participating wards gradually entered the study to spread workload and anticipate on ward availability. The enrollment of participating wards can be found in Table 1. Guidelines of the participating hospitals regarding the preparation and administration of high-risk medication were requested at the beginning of participation. In this way, the researcher was aware of the set rules and guidelines on the ward before starting the interviews. All interviews were scheduled between the participants and the researcher. Almost all interviews were executed one-on-one. This way, all nurses were present for the interviews. During the interviews, the researcher made sure all administration steps, according to the Dutch guidelines, were discussed. Consequently, the administration process as a whole was discussed. Specific attention was paid to the double-check and hand sanitation actions, as these steps showed the lowest compliance rates in previous research in Dutch hospitals [2]. The semi-structured interviews lasted approximately 30 min. The interview guide (Appendix A) was based on the six FRAM-aspects. All interviews were conducted in Dutch and, after oral permission from the interviewee, audio recorded. The recordings were transcribed verbatim. A summary was made and sent to the interviewee for authorization.

### 2.5. Data analysis

Data analysis of the interviews was performed with MAXQDA 11 software. WAI- and WAD-models were made per participating ward using FRAM Model Visualizer [27]. After data collection was completed, hospital guidelines were compared with the Dutch guidelines and checked for discrepancies. When only minor discrepancies were found, it was decided the Dutch guidelines [9] would be used as a base to conduct a ward overarching WAI-model. To construct an overarching WAD-model, all similarities between the participating wards WAD-models were used to establish a rough setup of the overarching model. Subsequently, differences between the WAD-models were used to complete the overarching model.

To establish which reasonings determine the deviation of the guidelines (ETTO rules), the transcripts were analyzed using

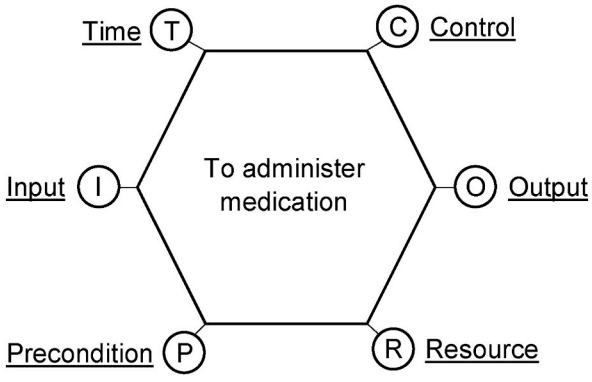


**Fig. 1.** Example of a FRAM hexagon with the corresponding aspects.

**Table 1**
Overview of enrollment of participating wards.

| | 2020 | | | | | | | 2021 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ward | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
| A | x | x | | | | | | | | | | | |
| B | | x | x | | | | | | | | | | |
| C | | x | x | | | | | | | | | | |
| D | | x | x | | | | | | | | | | |
| E | | | | x | x | | | | | | | | |
| F | | | | x | x | | | | | | | | |
| G | | | | | | x | x | | | | | | |
| H | | | | | | | | x | x | | | | |
| I | | | | | | | | | | | x | x | x |
| J | | | | | | | | | | | x | x | |

combined inductive and deductive coding. The deductive coding was based on the six FRAM-aspects (Fig. 1) [26], and the work related ETTO rules [20]. The inductive coding consisted of axial coding, and selective coding. When new codes were discovered during the coding, they were added to the codebook. In addition, when existing codes did not occur, the codes were deleted. Two researchers (SvS, AV) coded all transcripts of two hospital wards independently. Differences were discussed until consensus was reached. Hereafter, all transcripts were coded by one researcher (AV), and checked by another (SvS) to ensure the coding was complete.

### 2.6. Ethical approval

This study was assessed by the Medical Ethics Committee of the VU University Medical Centre Amsterdam, and it was declared that the study was not subjected to Medical Scientific Research with humans (WMO) (number 2019.571). This study complies with all regulations and informed consent from all participants was obtained before starting the interview. The data are stored securely, accessible only to the research team.

## 3. Results

### 3.1. Study population

In total, ten wards from nine different hospitals participated. These hospitals were four general hospitals, two academic hospitals, and three tertiary hospitals. In this study, 77 nurses were interviewed, of which 30 nurses worked on an ICU, 24 on a surgery ward, and 23 on an internal medicine ward. Of all interviewees, 91 % was female, and the average work experience was 13 years (SD = 5.9).

### 3.2. Work-As-Imagined

The guidelines describe seventeen actions, of which nine occur in the preparation phase and eight in the administration phase [9]. To improve the readability of the model, the actions “to prepare the medication” and “to initial the medication label” are merged, as well as the actions “to double-check the prepared medication (by a second nurse)” and “to initial the medication label (by a second nurse)”. This resulted in a ward overarching WAI-model (Fig. 2) containing seven hexagons in the preparation phase. The hexagon colors indicate the healthcare provider performing the action shown in the hexagon. Hexagons are colored blue when the action is performed by a nurse preparing and/or administrating the medication (first nurse). The hexagons are a green color when another nurse

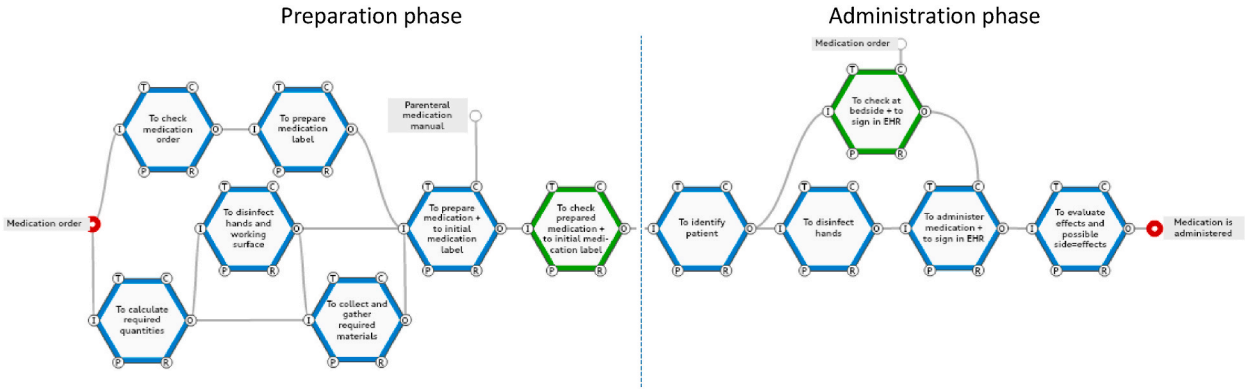


**Fig. 2.** The WAI-model based on the Dutch guidelines.

(second nurse) checks the actions performed by the first nurse.

The Dutch guidelines distinguish the nurse who prepares the medication from the nurse who administers it. To prevent repetition in the WAI-model, the first three steps in the administration phase of the guidelines are not inserted, showing only the last five steps as hexagons.

### 3.3. Differences guidelines and daily practice

Also the overarching WAD-model (Fig. 3) can be divided into the preparation phase and the administration phase, both containing eight hexagons. In the preparation phase, four notable differences were found between the overarching WAI-model and WAD-model:

1. "to calculate the required quantities" was not found in the WAD-model,
2. "to disinfect the working surface and hands" was not mentioned,
3. "to conduct a risk-assessment" was added to the WAD-model,
4. a variation was found in which order "to prepare the medication and sign the medication label" and "to double-check the medication and sign the medication label (by a second nurse)" were executed. One variation (preparing the medication first, and checking afterwards) corresponds with the WAI-model, while the other does not.

Which variation was chosen, was based on two factors. Firstly, in the immediate presence of another nurse, the double-check was conducted in order to save time. Secondly, it depended on the knowledge, experience, and confidence of the nurse involved if the double-check was performed. Inexperienced nurses were more inclined to ask for a double-check before starting the preparation.

In the administration phase, two differences were noticed between the models; 1) the absence of the action "to disinfect hands", and 2) the double-check by a second nurse. During the interviews, the nurses indicated the double-check was the hardest step to perform. This is evident in the WAD-model, showing four variations.

1. The steps are executed as described in the guidelines, namely a double-check during the administration by a second nurse at the bedside. To speed up the process, nurses share information about the medication or administration.
2. No double-check is performed. The nurse administers the medication alone.
3. A double-check is performed after the administration. In this variation, a second nurse visits the patient sometime after the administration. The elapsed time between the administration and the double-check can reach up to 30 min.

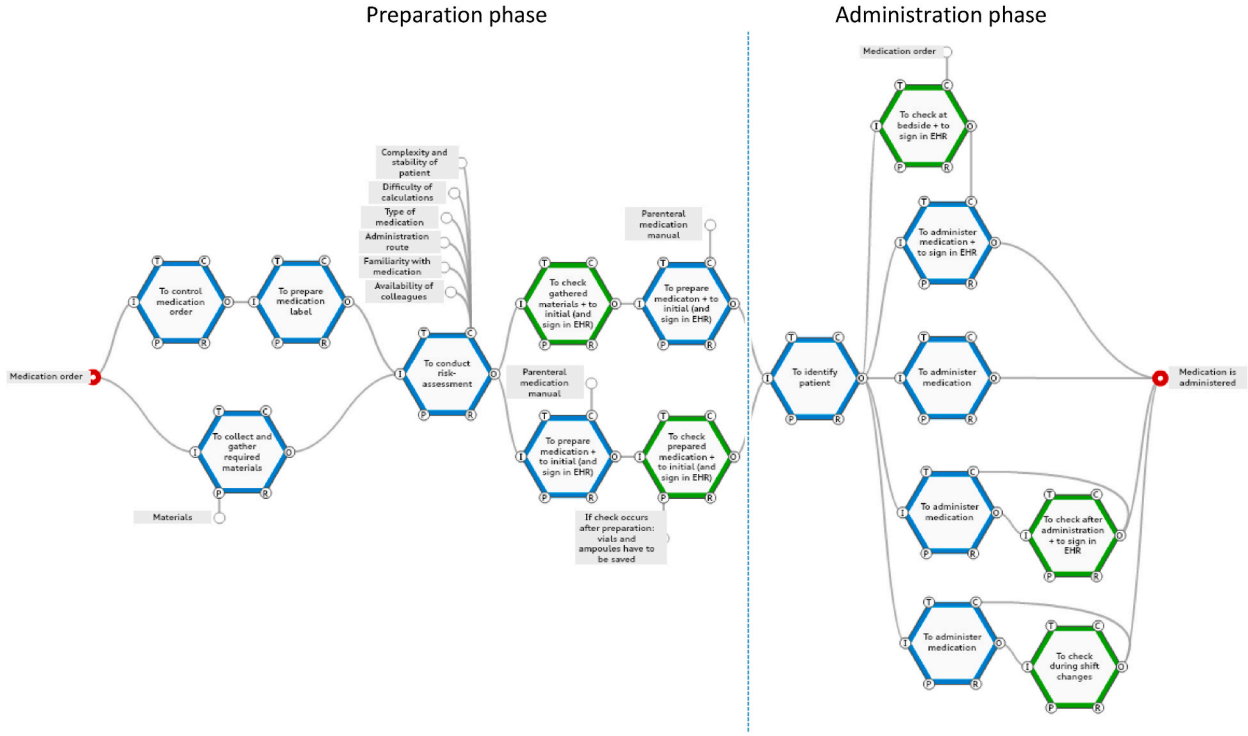


**Fig. 3.** The ward overarching WAD-model.

4. The administered medication is not checked during the administration, however, it is double-checked during shift changes. Both the nurse whose shift is ending, and the nurse whose shift is starting, visit all patients and check if all administrations are executed correctly.

The guidelines state it is obligatory to sign the double-check during or directly after the administration of high-risk medication in the patient's electronic health record (EHR). The results show the signing of the double-check can occur at different moments in the process of administration. When no double-check will be executed, nurses anticipate this by already signing the EHR during the double-check of the preparation.

### *3.4. Risk-assessment*

When deciding how the double-check will be performed, multiple factors were taken into consideration. A risk-assessment – sometimes subconsciously – is performed before preparing or administrating a medication to assess the necessity of a double-check. The risk-assessment was executed on eight of the ten participating hospital wards. On the two wards where it was not executed, the double-check was not executed (or mentioned in the guideline) or the guideline already differentiated the parenteral medication into two separate groups; for the high-risk medication group, the double-check was mandatory, and for the other group it was not. This made the guidelines more feasible to follow in daily practice and therefore, the nurses did not conduct a risk-assessment. During the risk-assessment on the other wards, nurses consider multiple factors to determine if and how the double-check will be performed during administration. These factors were different for each ward, and moreover, could differ between nurses of one ward. In general, nurses of a hospital ward considered three factors during the risk-assessment. One frequently mentioned factor was the patient's complexity. For example, when the patient received palliative care or a patient with multimorbidity (and accompanying medications), nurses were more inclined to double-check the administration.

'Sometimes the medication seems very simple and straightforward. However, the patients we care for are very ill. Their bodies just work differently, so you always need to be precise. All medications become very complex, especially with unstable patients.' – Nurse 1, Intensive Care Unit.

Another factor was the type of medication. Nurses would determine if the medication really was a high-risk medication, by estimating the consequences and adverse effects when making a mistake. In addition, the nurse's familiarity with the medication was mentioned. If a nurse administered the medication more often or recently, they were less inclined to ask a second nurse to conduct the double-check.

'I am less strict with some medications we use frequently. In my opinion, the guidelines can be too rigid with some medicines, since those medicines are very simple and the consequences are not severe when an incident happens.' – Nurse 2, Internal medicine unit.

Another mentioned factor was the administration path. If nurses had to change pump modes/rates, they were inclined to ask a second nurse for a double-check. In addition, difficulty of the calculations was mentioned. According to the guidelines [9], possible calculations only have to be double-checked during the preparation phase. However, with very difficult calculations, nurses were more inclined to perform the double-check during administration, since the double-check could also act as a triple check for the calculations. Lastly, the availability of colleagues, and the crowdedness on the ward were frequently mentioned factors. If no other nurse was available, or if the medication had to be administered at a very busy moment, nurses often did not try to find an available second nurse for the double-check.

### *3.5. Work related ETTO rules*

Besides the evaluated factors during the risk-assessment, other reasonings were also taken into consideration by the nurses. These are considered subconsciously, and therefore not weighed during the risk-assessment. The most mentioned work related ETTO rule was "deviation due to time pressure", meaning no colleague was available at the moment the high-risk medication had to be administered. Therefore, they were forced to administer medication without a double-check.

'In the night shift, every nurse is responsible for fifteen patients. Most times, when a high-risk medication has to be administered at night, no colleague is available. However, my patient still needs their medicine at that moment.' – Nurse 3, Surgical unit.

The second most mentioned work related ETTO rule was "deviating out of habit". Nurses indicated that they would forgo the double-check when administering certain medications. This may denote nurses would stop performing the double-check, when previously the administration of a certain medication was executed without incidents.

'All nurses think more lightly about high-risk medication. Most of the medications are administered without the double-check, and it's done out of habit. It has become the standard procedure.' – Nurse 4, Surgical unit.

Other high scoring ETTO rules were "trust in own expertise" and "trust in the expertise of a colleague", which suggests nurses did not think the double-check was necessary, since they found their colleagues or themselves capable enough to administer the medication without the double-check. Furthermore, the ETTO rules "the medication has already been checked", and "not important" were mentioned frequently on some wards, indicating nurses sometimes found the double-check superfluous.

'I have to admit, I don't always know the added value of the double-check. The checks the system gives, decrease the risk significantly, and the few things the system cannot check, are checked during the shift changes. Not knowing the added value makes it difficult to motivate myself to execute the double-check.' – Nurse 5, Internal medicine unit.

## 4. Discussion

In this study, the FRAM method was used to assess variations in the daily practice of administering high-risk medication, with a key-focus on the double-check. Additionally, considerations that are taken into account when deviating from the guidelines were assessed. Discrepancies between the guidelines (WAI) and daily practice (WAD) were found in the process of preparing and administering high-risk medication. Four differences were found in the preparation phase, namely "to calculate the required quantities" and "to disinfect the working surface and hands" were not found in the WAD-model. Further, "to conduct a risk-assessment" was added. Lastly, the execution order of "to prepare the medication and sign the medication label" and "to control the medication and sign the medication label (by a second nurse)" could differ. The variation of first checking the required materials, and afterwards preparing the medication was not found in the WAI-model. Both the absence of a working surface and hand sanitizing step and the variation in the controlling the medication were in line with our hypotheses.

These hypotheses were also in line with the results of the administration phase. Two differences were noticed between the WAI- and WAD-model of the administration phase. Firstly, "to disinfect hands" is absent, and secondly, four variations were identified for the double-check by a second nurse during administration. Namely, (1) a double-check was conducted at bedside during administration, (2) no double-check was conducted, (3) a double-check has taken place after the administration, and (4) the medication is not checked during the administration, but during shift changes. This is in line with previous research, showing low compliance with "hand hygiene" and "double-check by a second nurse" [13,14], and showing variability in the process of double-checking [2,17,28]. Additionally, nurses indicated that the COVID-19 pandemic did not make preparing nor administering high-risk medication easier. Nurses experienced an increase in time pressure due to the COVID-19 pandemic, because of greater staff shortages. However, nurses elaborated time pressure was already present before the start of the pandemic. Isolation measures were considered greater barriers for executing the double-check during the pandemic.

Considerations that the nurses made were assessed as well. This way, the FRAM method provided a better understanding in how nurses achieve safe medication administrations without always complying with the guidelines, and in varying daily circumstances. In the current study, multiple factors that were taken into consideration during the risk-assessment were found. The availability of a second nurse and crowdedness on the hospital ward can be seen as variations on the overarching factor "lack of time/time pressure". This agrees with our hypothesis and with previous findings, showing time pressure as a key component for low double-check compliance rates [2,10,18,29,30]. The risk assessment was key for considering a double-check at administration, with nurses finding a balance between maintaining patient safety under the high amount of time pressure. Literature shows the double-check is time-consuming [10,14,30,31], and with high double-check frequencies, it compels nurses to determine when a double-check is conducted. Criteria such as "patient complexity" and "type of medication" were previously recorded in other research [2,10,17]. Other considerations of the risk-assessment, like "familiarity with medication", "administration path", and "availability of colleagues", were only mentioned before by Schutijser et al. (2019) [2]. However, our study found an additional criterion, namely "difficulty of the calculations". Literature shows that calculation tasks occur frequently in high-risk medication errors in hospitals [32]. Some studies showed that calculation knowledge of nurses was lacking or that nurses though of their own skills to be insufficient [33,34]. This underlines the double-check as an important act in order for nurses to ensure patient safety.

Additional subconscious considerations were found and structured by means of work related ETTO rules. They showed the general rationale and morale of nurses of the ward towards the double-check. Interestingly, for most wards, one or two work related ETTO rules were mentioned predominantly. However, the most frequently mentioned ETTO rules differed per ward. This may suggest that they are influenced by the culture on the ward, and the attitude of their colleagues. Most often, "deviation due to time pressure" was mentioned. Second, "deviating out of habit" was specified, indicating that nurses would forgo the double-check when a previous administration of a certain medication was executed without incidents. Other ETTO rules frequently mentioned were "trust in own expertise", "trust in the expertise of a colleague", "the medication has already been checked", and "not important". These suggests nurses did not think the double-check was necessary for safety, or they found themselves or their colleagues capable enough.

A positive result of nurses assessing the situation on the ward is the willingness of nurses to maintain the patients' safety as much as possible. However, the differences in experience between nurses make the risk-assessment highly individual and variable, showing a negative consequence. Additionally, when performing an administration often without double-check, it can be found unnecessary with certain medications by nurses. The results also showed the double-check can become habitual, since it is a frequently executed procedure. This can lead to an ineffective double-check, increasing the risk of medication errors [29,31].

The results show the FRAM is a suitable method to visualize a (healthcare) process and give understanding in the current course of daily practice. However, the results also question the effect of the double-check in daily practice, since nurses often find it unnecessary. Literature does not provide sufficient evidence about the effect of the double-check [35], and researching the effectiveness appears to be difficult. A number of studies used self-report or incident reports [36–38], however, it has been shown those methods lead to underreporting [21]. Studies researching the difference in medication errors between a single- and a double-check show different results. Some studies show a significant association between the double-check and a decreased risk of medication errors [38–40]. In contrast, other studies show no significant difference [31,36,37].

While interpreting above mentioned results, it has to be remarked that the execution of the double-check in daily practice differs from the guidelines. The work related ETTO rules showed most deviations were conducted out of habit or time pressure, as the double-check is a time-consuming procedure. Nurses considered their own expertise as well as their colleagues' expertise when deviating from standard practice. This is in line with the considerations contemplated in the risk-assessment, showing that hospital nurses weigh in daily circumstances, such as time pressure, patient complexity, and their own familiarity with the medication. This results in an execution that is vastly different from the guidelines most of the time, and when the double-check is executed at bedside, it is not done

independently. Nurses share information about the medication or administration with each other, making it a primed double-check [29,31]. A primed double-check can lead to an undetected error, due to conformation bias [31,41]. In line with this evidence, the question arises if an independent double-check is feasible in daily practice [31], and furthermore, if it is something that needs to be achieved. Research has shown most high-risk medication administrations are performed without any incidents [21], with the risk-assessment helping nurses to maintain patient safety. Therefore, in future research the insights given by the FRAM should be used to make ward specific alterations to adjust to the daily practice of that ward, while maintaining patient safety. This could lead to more time for double-checks.

### *4.1. Strengths and limitations*

Some methodological issues should be considered in the interpretation of the findings. Firstly, no direct observation could take place during the study due to the implemented safety measures regarding the COVID-19 pandemic. Secondly, interviews could not be held at location on the hospital ward due to the safety measures. As a consequence, we were completely dependent on the nurses for reconstructing the process of preparing and administering high-risk medication. It is possible nurses did not mention unconscious actions during the interview. However, by interviewing multiple nurses per ward, the missed unconscious actions are expected to be limited. In addition, the study was performed on multiple wards from different hospitals, giving a comprehensive view of the preparation and administration of high-risk medication in a Dutch hospital setting.

## 5. Conclusion

Our results showed a difference between the guidelines (WAI) and the daily practice (WAD) regarding the preparation and administration of high-risk medication. The double-check is a frequently performed action, and it cannot always be executed due to time pressure. Nurses performed a risk-assessment in which multiple criteria, like type of medication, patient complexity, and difficulty of the calculations, to decide when the double-check was necessary. The assessed criteria were considered to ensure the patient's safety, however, they were highly individual for every nurse. A downside of the risk-assessment is the risk of performing a double-check, or not performing it, out of habit. This can eventually lead to the double-check feeling unnecessary or superfluous to nurses during certain administrations, and making it ineffective. Abovementioned results raise the question if always executing the double-check correctly is something that needs to be achieved in daily practice. Therefore, in future research, the insights given by the FRAM should be used to make hospital ward specific alterations to adjust the daily practice of that ward, while maintaining patient safety.

## Ethics statement

This study was assessed by the Medical Ethics Committee of the VU University Medical Centre Amsterdam, and it was declared that the study was not subjected to Medical Scientific Research with humans (WMO) (number 2019.571). This study complies with all regulations and informed consent from all participants was obtained before starting the interview. The data are stored securely, accessible only to the research team.

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## CRediT authorship contribution statement

**Sharon A. van Stralen:** Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Linda van Eikenhorst:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Formal analysis, Data curation, Conceptualization. **Astrid S. Vonk:** Writing – review & editing, Validation, Resources, Investigation, Formal analysis, Data curation. **Bernadette C.F.M. Schutijser:** Writing – review & editing, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Cordula Wagner:** Writing – review & editing, Supervision, Methodology, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e25637.

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