Checking all the boxes: a checklist for when and how to use checklists effectively

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ABSTRACT

Checklists are a type of cognitive aid used to guide task performance; they have been adopted as an important safety intervention throughout many high-risk industries. They have become an ubiquitous tool in many medical settings due to being easily accessible and perceived as easy to design and implement. However, there is a lack of understanding for when to use checklists and how to design them, leading to substandard use and suboptimal effectiveness of this intervention in medical settings. The design of a checklist must consider many factors including what types of errors it is intended to address, the experience and technical competencies of the targeted users, and the specific tools or equipment that will be used. Although several taxonomies have been proposed for classifying checklist types, there is, however, little guidance on selecting the most appropriate checklist type, nor how differences in user expertise can influence the design of the checklist. Therefore, we developed an algorithm to provide guidance on checklist use and design. The algorithm, intended to support conception and content/design decisions, was created based on the synthesis of the literature on checklists and our experience developing and observing the use of checklists in clinical environments. We then refined the algorithm iteratively based on subject matter experts' feedback provided at each iteration. The final algorithm included two parts: the first part provided guidance on the system safety issues for which a checklist is best suited, and the second part provided guidance on which type of checklist should be developed with considerations of the end users' expertise.

INTRODUCTION

Checklists have been adopted as an important safety intervention in high-risk industries such as aviation and nuclear power generation.[1] 'A checklist is typically a list of action items or criteria arranged in a systematic manner, allowing the user to record the presence/absence of the individual items listed to ensure that all are considered or completed' (p. 231).[2] Checklists serve as a cognitive aid to help standardise task performance, cue steps and essential tasks, and support task order. Checklists can also depict how systems should work and improve interactions with complicated systems.

A review of safety checklists in healthcare found improved patient outcomes, care and practice, with no negative safety effects.[3] Healthcare checklists have been developed for a variety of applications including anaesthetic crisis management, central line care,[4] transfers of trauma patients and SURgical PAtient Safety System checklist.[5] There are many healthcare tools that are not typically considered as checklists but fit the definition, such as algorithms for resuscitation, mnemonics used to support handoffs and documentation using flowsheet rows in electronic medical records. Despite their popularity, checklists are not an ideal intervention for every clinical system safety issue and poor design, and implementation can limit use, adherence and overall sustainability.[6] Checklists that lack the appropriate level of detail are not concise,[7] slow or interrupt tasks, or are confusing are likely to have low compliance and face resistance from users.[8 9]

Checklists may be poorly designed or become overused due to their perceived ease of development, specifically in comparison with more robust interventions such as forcing functions.[3] The design and implementation of checklists into the clinical workflow may not be well thought out, and individuals developing checklists may fail to recognise the use of a checklist does not ensure adherence nor effective execution. Consequently, the checklists developed will be ineffective and, at worse, negatively impact outcomes. Although patient harm resulting from checklist use has not been reported, prior work has noted that poorly designed or implemented checklist can be perceived as interrupting workflow, increasing workload and causing

unnecessary delays.[10] Additionally, the overuse of checklists, even well-designed checklists, can lead to 'checklist fatigue'[7] and reduced efficiency[11] or result in over-reliance.[6]

Checklists are one example of a moderately effective safety mitigation within the Hierarchy of Intervention Effectiveness[12] or Hierarchy of Hazard Control (eg, National Institute for Occupational Safety and Health, 2023).[13] While these cognitive aids can help guide task completion, other interventions may be more impactful or sustainable. For example, forcing functions can prevent actions by designing out specific unintended actions and computerisation can automate prompts and decision support (see online supplemental appendix A for definitions and examples). However, a well-designed checklist is a more robust intervention than policies, training or vigilance alone. They are also typically easier to create and implement than the stronger interventions such as forcing functions that may require larger process and system redesigns.

Although checklists are being increasingly used, there is little guidance explaining the different types of checklists, selecting the most appropriate checklist type, and the influence of user expertise on the design of the checklist. This includes the level of detail included in the procedural steps, the structure of the checklist, and the modality of its delivery (ie, paper based or electronic). This article aims to address this gap in the literature to best support healthcare leaders and frontline workers in the effective development and implementation of checklists. Therefore, we discuss the relevant literature on checklist types and how they mitigate error, as well as propose a two-part checklist design algorithm: (1) situations for where the checklist is best suited and (2) guidance on choosing the most appropriate checklist type. This work is not a systematic review; however, the research we have cited represents foundational articles that we argue provide a strong theoretical foundation for the design of checklists. Given the scope of this article, interested readers may consult other more comprehensive publications that address the implementation, development and maintenance of checklists including Winters et al,[9] Conroy et al[14] and Borchard et al.[15]

CHECKLIST TAXONOMIES

We are aware of three conceptual taxonomies for checklists, including those described by Scriven,[16] Winters et al,[9] and Higgins and Boorman.[17] Scriven's taxonomy distinguishes five checklist types, including the *sequential, laundry list, iterative, diagnostic* and *criteria of merit* (COM) checklists (table 1).[16] A *sequential* checklist emphasises the order of steps or action that is to be executed. Unlike the sequential checklist, the *laundry list* consists of a set of individual items usually lacking a prescribed order. *Iterative* checklists are different in that they may be performed multiple times. For example, a perioperative handoff checklist may be used before, during or after surgery, to ensure consistency in patient information as they move through the hospital. *Diagnostic* checklists in medicine are frequently used as a decision aid in the form of a decision tree to diagnose a medical condition. For example, emergency medical technicians (EMTs) sometimes use a pocket-sized medical protocol to guide them during complex medical decisions. Scriven's final checklist, the COM checklist, consists of a set of evaluative criteria users employ, for instance, when evaluating a medical trainee during a simulation exercise.

Winters et al[9] defined four types of checklist that they referred to as *static parallel, static sequential with verification, static sequential with verification and confirmation,* and *dynamic.* One limitation of this taxonomy is that it compresses multivariate aspects of checklists including the mode of execution (read–do, verification, confirmation), team size (single operator vs multiple operators) and different forms of checklists (static vs dynamic) into four categories. These checklist properties are broken out explicitly in our taxonomy and algorithm. Alternatively, Higgins and Boorman's taxonomy distinguishes among checklists according to their purpose: prevention, preparation, problem-solving, procedural (table 2).[17]

The *procedural* checklist typically consists of complex, lengthy or critical tasks that the operator performs once or intermittently. An important function of this checklist is to ensure the task steps are performed in a specified order. On the other hand, order is less important in a *preparation* checklist, for

Table 1 Type of checklists (adapted from Scriven)[16]

Type of checklist	Definition	Example
Sequential	Individual steps are expected to be performed in a prescribed order	Surgical safety checklist
Laundry list	Loosely organised list of items where order is not important	Medical equipment list
Iterative	A form of sequential checklists that is used multiple times to check or evaluate a system's state or status	Perioperative handoff checklist
Diagnostic	Used to troubleshoot a system, often using a flow chart organisation	Medical protocols commonly used by EMTs
Criteria of merit	List of evaluative dimensions that users are expected to employ to judge the overall quality of a product	Evaluation during medical simulation
EMTs, emergency medical technicians.		

Table 2 Uses of checklists (adapted from Higgins and Boorman)[17]

Uses	Definition	Example
Procedural	Complex, lengthy or critical tasks performed intermittently; ensures certain tasks are performed on time	Handover checklist
Preparation	Multistep procedures certifying that all the steps are performed; order of execution may be less important	Central line checklist
Problem-solving	Sequential, multistep procedure with decision points used to support diagnoses, troubleshooting and so on	Medical diagnostic protocol
Prevention	Addresses known causes of errors or high-risk, high-hazard conditions that may result in injuries or death of users	Surgical safety checklist

which the emphasis is on the collection and organisation of task-related information or tools. For instance, a nurse's preparation checklist might consist of items including ensuring the stocking of blood, surgical instruments, contact numbers for supporting staff in case a complication arises, etc. *Problem-solving* checklists are more algorithmic in nature, emphasising evaluative criteria that are organised into one or more decision points in the form of a decision tree. Checklists used by EMTs to identify a course of treatment given the presenting condition of a patient at an accident scene are an example of the problem-solving checklist. Finally, *prevention* checklists serve as a targeted intervention for known causes of errors or high-risk, high-hazard conditions that may result in injuries or death of users.

Table 3 shows an integration of the two taxonomies where the columns reflect Higgins and Boorman's framework that stresses the goal or purpose of a checklist and Scriven's taxonomy represents the rows reflecting the different forms a checklist may take. The marks in the cells indicate the correspondence between the checklist types and how they are functionally used.

THEORIES OF EXPERTISE AND ERROR
The utility of a checklist depends on the experience of the user and its design. Rasmussen's influential theory of cognitive control provides a foundational framework for considering how cognitive information processing and the errors operators are involved in change as a function of experience.[18] For example, knowledge-based errors are more prevalent when performing novel or unfamiliar tasks, and when operators are less experienced, whereas slips are more prevalent when performing familiar tasks and operators

have more expertise.[19] Consideration of these factors can inform decisions about the type of checklist to use and the amount of procedural detail necessary to aid the user in the operational environment. We first consider two taxonomies of error that are relevant for checklist design.

The action/inaction taxonomy proposes that users make two general classes of errors, errors of omission—a failure to perform some action—and errors of commission—the act of performing the wrong action (table 4).[18 19] Forgetting to administer a medication is an example of an omission, whereas wrong site surgery is an example of error of commission. The works of Reason,[20 21] Norman[22 23] and Rasmussen[18] have highlighted other error types and how error types vary according to user experience. The error taxonomy shown in table 4 includes lapses, slips, mistakes, mode errors and violations.

Rasmussen's model of cognitive control offers a conceptual framework for considering the role of experience, and the selection and design of checklists that may be appropriate for different levels of expertise (table 5).[18] Rasmussen defined three types of cognitive control that actors exercise depending on the task or situation and their experience with the said task or situation. The three levels—ordered from lowest to highest in terms of the degree of conscious cognitive control—are titled: (1) Skill-based behaviour, (2) Rule-based behaviour and (3) Knowledge-based behaviour (SRK).

The skill-based level is the development of pattern recognition that elicits related action patterns (eg, differential diagnosis, treatment, stabilisation) in response to signals in the environment. The process unfolds with little conscious thought or deliberation

Table 3 Overlap between alternative taxonomies of checklists

		Uses of checklists (adapted from Higgins and Boorman)[17]			
		Procedural	Preparation	Problem-solving	Prevention
Types of checklists (adapted from Scriven)[16]	Laundry list		X		X
	Sequential or weakly sequential	X		X	X
	Iterative	X		X	X
	Diagnostic	X		X	
	Criteria of merit	X			

Table 4 Error taxonomy

	Error	Definition	Example
Action/ inaction	Commission	Performing the wrong action	Administering the wrong medication
	Omission	Failing to complete a task that should have been done	Failure to start a medication
Intention	Lapses	Failure to carry out an action (an error of omission)	Forgetting to document removal of catheter
	Slips	When an intention is executed in an inappropriate manner	Accidentally hitting an artery during a surgery
	Mistakes	Failure to come up with appropriate solution	Incorrectly calculating a weight-based dose
	Mode errors	Making the right response, but while in the wrong mode of operation	Making incorrect inputs into an anaesthesia machine because it was in rest mode
	Violations	Deliberate choice to deviate from standard operating procedures	Using family members as translators when policy specifies the use of professional interpreters

of the signals (eg, patient symptoms) and what actions need to be taken. For instance, an experienced doctor who has performed a procedure or diagnosis many times is hypothesised to respond to the available perceptual information automatically, without consciously evaluating the meaning of the cues or evaluating alternatives.[24] For individuals functioning at the skill level, many tasks have become routine and can be performed with little conscious deliberation or control. At this level, errors take two forms, lapses of memory and slips of action. Slips and lapses of memory represent a failure to perform some required and intended action.[25]

Rule-based behaviour is associated with the use of heuristics or rules of thumb (eg, given X symptoms, the most likely cause is Y) that mediate the relationship between perceptual cues and action.[26 27] An individual performing at this level can readily report the explicit know-how and rules they employ to arrive at a diagnosis.[18] By contrast, a medical resident lacks the repeated experience of the expert and thus the associated level of behavioural automaticity. A diagnostic characteristic of performance at this level is the absence of automaticity, the resident may attend to the same symptoms or cues but the raw perceptual information functions primarily as a *sign* that triggers the recall from memory of rules, strategies or other information they have learnt for performing a differential diagnosis, the symptoms typically associated with different

medical conditions and the medications used to treat different conditions. At the rule-based behaviour, individuals are prone to make errors researchers call mistakes, including those that arise from the *misapplication of good rules* and those that are due to the *application of bad rules*. In the former case, there are standard practices for stabilising a patient or treating a patient with condition Y but there are also exceptions where standard practices are not applicable. The overgeneralised application of the rule and a failure to recognise cues indicating an exception to the rule are examples of *misapplication of good rules*. The application of bad rules may originate from failures to encode important features of the current situation or misrepresentation of aspects of the current situation resulting in an action that is inadvisable given the true circumstances. Problem-solving/diagnostic, prevention and COM checklists aid performance by serving as reminders of critical decision points that are common causes of error and reminding the actor of important criteria for evaluation and deciding among alternative actions or choices.

The term 'knowledge based' refers to the highest level of behaviour that dominates when a decision-maker lacks experience, or an experienced actor confronts a novel or unfamiliar situation. In these conditions, the individual searches for cues and engages in sense-making, seeking to interpret and integrate cues to arrive at a single or a set of potential

Table 5 Checklist type by Rasmussen's SRK model

Checklist type/use		Rasmussen SRK		
		Skill-based level	Rule-based level	Knowledge-based level
Uses of checklists (adapted from Higgins and Boorman)[17]	Procedural	X		X
	Preparation	X		X
	Problem-solving		X	X
	Prevention		X	
Types of checklists (adapted from Scriven)[16]	Sequential or weakly sequential checklist	X		
	Laundry list	X		
	Iterative checklist		X	X
	Diagnostic checklist		X	X
	Criteria of merit checklist	X	X	X

diagnoses. Decision-making at this stage is deliberate, analytical, effortful, attention demanding and the ability to multitask is severely limited. In addition, the same perceptual cues that trigger an automatic response from an experienced doctor or that trigger recall of the appropriate treatment protocols for the medical resident lack the learnt associations and rich meanings derived from experience. The cues instead function as symbols whose meaningfulness as an indicator of a medical condition is inferred. Performance at the knowledge–behavioural level is typical of situations where individuals confront new or novel situations for which no learnt rules exist. Under these conditions, the physician must rely on conscious sense-making to identify, evaluate and interpret cues, generate and evaluate hypotheses about the cause of the observed conditions. Errors characteristic of this level of behaviour include incorrect interpretation of cues and information and errors of inference and reasoning. Researchers have identified a variety of systematic errors in human reasoning referred to as biases and heuristics (rules of thumb).[18 25] Because tasks are novel or rarely performed, the operator cannot retrieve sequence of behaviours or evaluative criteria from memory. In these cases, many of the forms of checklists may aid performance by outlining what tools or resources are needed (preparation checklist), the steps that must be completed (procedural checklist), decision points (problem-solving checklist) and the criteria for evaluating a job candidate for instance (COM).

Rasmussen's SRK behavioural hierarchy highlights how the meaning of information depends on the observer's behavioural level and that the amount of information (eg, cues) needed to elicit effective performance declines with the behavioural level. It follows that considerations of the user's experience and frequency of performing said tasks or procedures should mirror the degree of detail contained in the checklist, the choice of checklist type and how the checklist is performed (ie, read–do, do–confirm). For example, a doctor performing a procedure they have some familiarity with may need a cue in the form of a label or short action description (eg, stabilise blood pressure) to prompt recall of the actions that need to be performed and their order and thus a *read–do* execution may be appropriate. A *do–confirm* execution may be more appropriate when performing a well-learnt task allowing the actor to leverage their competency and familiarity while confirming they have completed all the necessary steps. Short brief labels or directives that would be appropriate for the user operating at the skill level would be insufficient for the same user performing an unfamiliar procedure.

Research highlights how the selection and design of a checklist should reflect the consideration of a range of factors including the context of use, level of user experience and what types of errors the aid is intended to address.[6] We have developed an algorithm to aid the development of a checklist which is described below.

DEVELOPING AN ALGORITHM TO GUIDE CHECKLIST DESIGN

In order to support healthcare leaders and frontline workers in effective checklist use, we developed a two-part algorithm to provide guidance on system safety issues for which a checklist is best suited, and guidance on checklist design, primarily on which type of checklist should be developed. The checklist algorithm was developed within a larger effort to support checklist development that includes five stages: (1) conception; (2) content/design determination; (3) testing and validation; (4) introduction, training and implementation; and (5) ongoing evaluation, revision and possible retirement.[28] The algorithm, intended to support conception and content/design determination, was created based on a review of the literature on checklists and the research team's experience developing and observing the use of checklists in clinical environments. The team then refined the algorithm iteratively based on subject matter experts' feedback provided at each iteration (online supplemental appendix B).

As checklists are best suited for standardised, repetitive procedural tasks, or those with a finite number of steps that are susceptible to memory failures,[8] the first section of the algorithm helps individuals determine if a checklist is an effective intervention for the specific intended context by asking a series of questions about the problem the checklist is expected to solve (figure 1). The questions include the following: whether the tasks that will be performed are (1) agreed upon, (2) tangible, (3) finite, (4) repetitive, (5) actionable and (6) achievable, and (7) whether critical steps are commonly missed. If the answer to any of these questions is 'no', we recommend identifying alternative solutions, such as those on a higher level on the Hierarchy of Intervention Effectiveness (online supplemental appendix A).[12]

The second part of the algorithm helps individuals determine which checklist is most appropriate (figure 2). The five choices listed are based on Scriven's previously defined five checklist types: sequential, laundry list, iterative, diagnostic checklists and COM.[16] The questions used to guide users' choice include the following:
- ► Will the checklist be used for troubleshooting (*if yes, diagnostic checklist*)?
- ► Does the checklist provide dimensions for evaluation (*if yes, COM checklist*)?
- ► Is the order of steps critical (*if no, laundry list checklist*)?
- ► Is the process iterative (*if yes, iterative checklist; if no, sequential checklist*)?

Additionally, this section helps users decide if a 'read–do' checklist or 'do–confirm' execution is preferable. 'Read–do' checklists require users to read then complete each step before moving onto the subsequent

Checklist Algorithm:
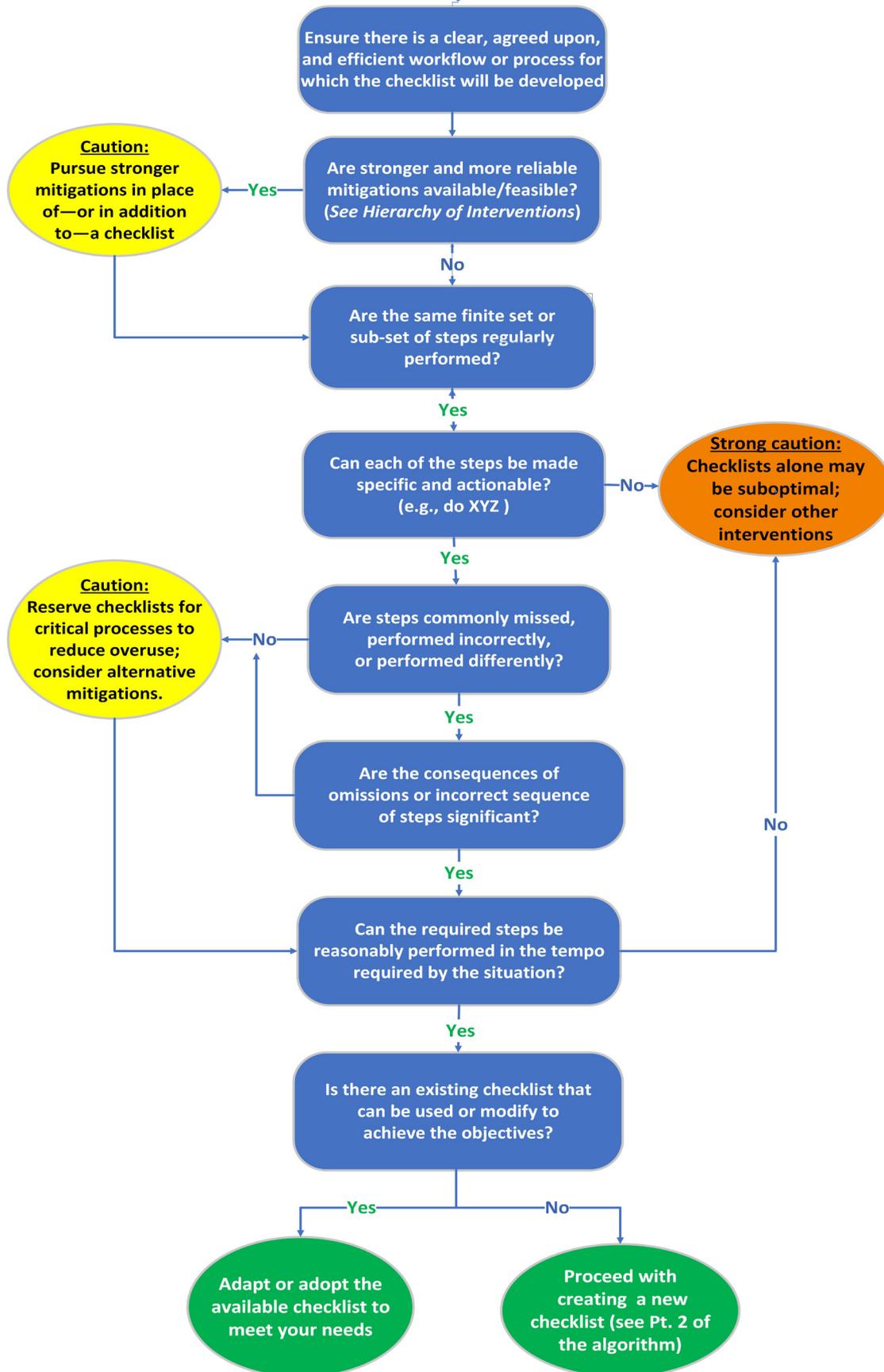## Is a checklist an effective solution?

Ensure there is a clear, agreed upon, and efficient workflow or process for which the checklist will be developed

Are stronger and more reliable mitigations available/feasible? (*See Hierarchy of Interventions*)

Yes → Caution: Pursue stronger mitigations in place of—or in addition to—a checklist

No ↓

Are the same finite set or sub-set of steps regularly performed?

Yes ↓

Can each of the steps be made specific and actionable? (e.g., do XYZ)

No → Strong caution: Checklists alone may be suboptimal; consider other interventions

Yes ↓

Are steps commonly missed, performed incorrectly, or performed differently?

No → Caution: Reserve checklists for critical processes to reduce overuse; consider alternative mitigations.

Yes ↓

Are the consequences of omissions or incorrect sequence of steps significant?

Yes ↓

Can the required steps be reasonably performed in the tempo required by the situation?

No →

Yes ↓

Is there an existing checklist that can be used or modify to achieve the objectives?

Yes → Adapt or adopt the available checklist to meet your needs

No → Proceed with creating a new checklist (see Pt. 2 of the algorithm)
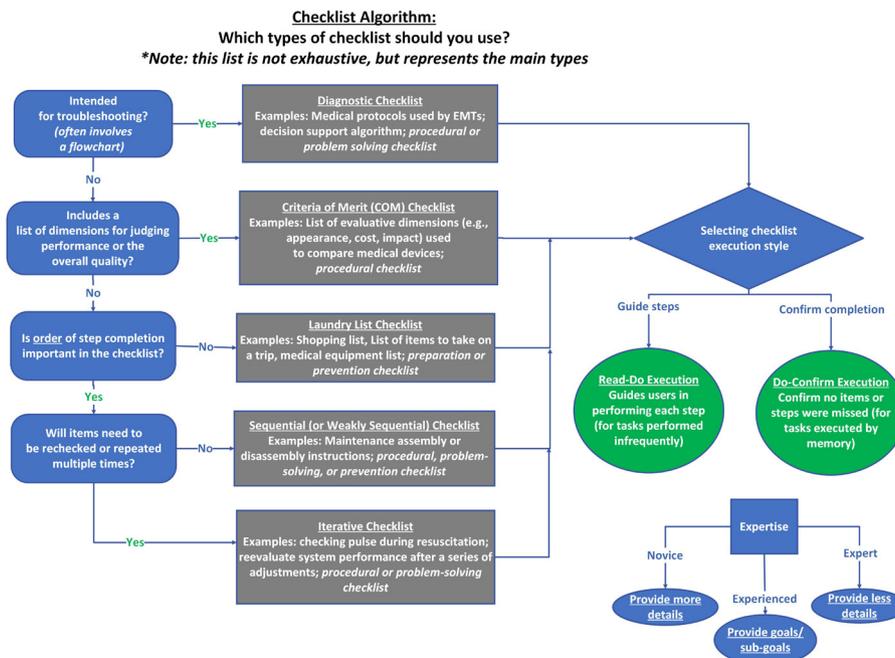
Figure 1 Checklist algorithm part 1.

Figure 2 Checklist algorithm part 2. EMTs, emergency medical technicians.

step.[28] I-PASS, a handoff tool which uses a mnemonic for illness, patient summary, synthesis and summary, follows a 'read–do' structure for presentation of information about patients during handoffs.[29] 'Do–confirm' checklists are less prescriptive, allowing users to complete steps from memory and consulting the checklist as needed to ensure a step was not omitted. The WHO surgical safety checklist uses a 'do–confirm' approach.[30] We should note, execution style may also differ based on the checklist users' experience.

OTHER CONSIDERATIONS
Developing checklists
The goal is to design checklists that are clear and concise, and that eliminate unnecessary steps particularly in non-normal situations. Normal checklists, checklists for procedures that are infrequently performed or that are being performed by less experienced users may require more detail. The medium, electronic versus paper based, is also an important decision with implications for accessibility, flexibility and maintenance. Prototyping and conducting simulation and usability testing throughout the design process are recommended. Even a small sample of iterative usability—examining ease of use, time and errors—can highlight issues and aid in finding the balance between brevity and detail and ensuring the presentation medium is appropriate.

Training and implementation
Successful implementation of checklists requires consideration of how they will be integrated into existing workflow or affect other process changes being made or considered by the organisation.[13 28]

Different clinical settings, for example, the operating room or behavioural health unit, may also have unique considerations for the implementation of checklists in those environments including due to darker settings, infection control guidelines and hazard abatement strategies. During training and implementation, it is also important to dispel any myths including clarifying that the checklist is not a replacement for individual competence and autonomy.[31] Rather, the purpose of a checklist is to provide support and reduce memory burden. Following implementation, checklists can be evaluated with a broad range of measures including perceived utility, adherence (including steps not followed or skipped), performance measures (eg, number of errors, task time, near-misses) and patient outcomes (eg, harm, readmission).[32] Lastly, use and maintenance must also be considered. Maintenance involves devoting time to examining barriers and facilitators, including production pressure and poor integration into the workflow. Maintenance also includes identifying when checklist items need to be changed or updated or retired due to lack of usefulness or relevance. For a comprehensive review of considerations, we recommend Burian *et al*.[28]

LIMITATIONS
The article is not a systematic review but rather a summary of relevant literature on checklist taxonomies and the error types they are designed to prevent. It does not include an exhaustive review of the research conducted on checklists but rather a synthesis that supports healthcare professionals in understanding when checklists can be an effective intervention. Additionally, we present other considerations but did not

cover these topics at length. We encourage readers to review Winters *et al*,[9] Conroy *et al*,[14] Borchard *et al*[15] and Burian *et al*,[28] for more detailed information covering the checklist lifecycle from design to maintenance and retirement. The algorithm offers guidance for designing checklists primarily for non-routine tasks. Checklists required for different circumstances may have additional considerations. Lastly, we obtained feedback from human factors experts; however, we did not evaluate the algorithm with healthcare workers. This represents an opportunity for future research.

SUMMARY

Checklists have been examined through the lens of cognitive principles. This article addresses this issue by approaching checklists as specific cognitive aids that help task performance by compensating for the limitations of memory and differences in expertise. The design of a checklist must consider many factors including what types of errors it is intended to address, the experience and technical competencies of the targeted users, and the specific tools or equipment that will be used. Even so, this does not ensure that the checklist will have the desired effects on the relevant dependent measures of interests (eg, errors, deaths, communication) possibly due to the resistance of users or organisations to the use of checklists. Checklists are not static artefacts but a complex intervention that must be maintained, edited and appended in response to continuing changes in personnel, tools, environments and practices. The proposed algorithm and design considerations were conceived to support healthcare leaders and frontline workers in determining when checklists would be an effective solution and the type of checklist available.

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