technische universiteit eindhoven

PRISMA-Medical

A brief description

Eindhoven University of Technology
Faculty of Technology Management
Patient Safety Systems

T.W. van der Schaaf PhD
T.W.v.d.Schaaf@tm.tue.nl
+31 40 247 4380

M.M.P. Habraken MSc
M.M.P.Habraken@tm.tue.nl
+ 31 40 247 3701

August 2005

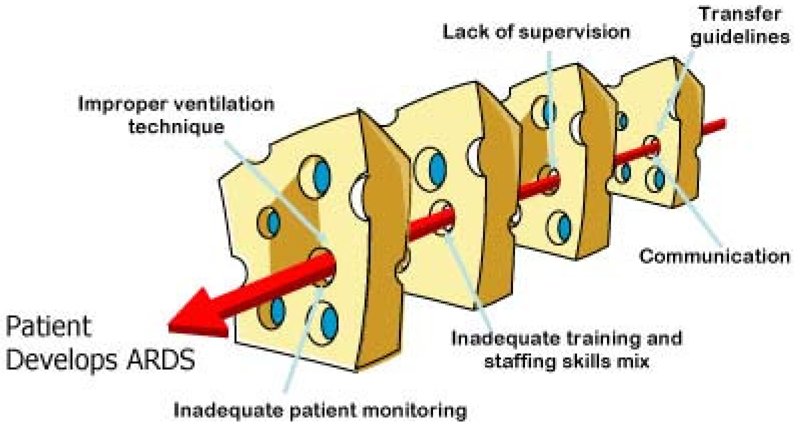
PRISMA-Medical method

General information

PRISMA stands for **P**revention and **R**ecovery **I**nformation **S**ystem for **M**onitoring and **A**nalysis. The method was developed by van der Schaaf of the Eindhoven University of Technology in the Netherlands. It was originally developed to manage human error in the chemical process industry, but it is now being applied in the steel industry, energy production and in health care. The main goal of the PRISMA method is to build a quantitative database of incidents and process deviations, from which conclusions may be drawn to suggest optimal countermeasures [van Vuuren et al., 1997].

The PRISMA method is based on the so-called system approach to the problem of human error. The system approach assumes that humans are fallible and that errors are to be expected in each organisation. The system approach therefore concentrates on the conditions under which individuals work and tries to build defences to avert errors or to mitigate their effects [Reason, 2000a]. In the system approach defences and barriers (like alarms, double checks, automatic shutdowns etc.) occupy a key position. The function of these defences and barriers is to protect potential victims from local hazards. Mostly they do this very effectively, but there are always weaknesses. According to Reason [2000a] the different defence layers can in fact be seen as slices of Swiss cheese, having many holes. The presence of holes in any one slice (i.e. defence layer) does not normally cause a bad outcome. Usually this can happen only when the holes in many layers momentarily line up to permit a trajectory of accident opportunity – bringing hazards into damaging contact with victims (see Figure 1).

Figure 1. The Swiss cheese model of accident causation [Reason, 2000b].



The holes in the defences arise for two reasons: active failures and latent conditions. Nearly all events involve a combination of these two sets of factors. Active failures are the unsafe acts committed by people who are in direct contact with the patient or system, e.g. slips, lapses, mistakes, and procedural violations. These active failures have a direct and usually shortlived impact on the integrity of the defences. Latent conditions on the other hand, are the inevitable “resident pathogens” within the system. They arise from decisions made by designers, builders, procedure writers, and top-level management. Latent conditions have two kinds of adverse effect: they can translate into error provoking conditions within the local workplace (e.g. time pressure, understaffing, inadequate equipment, fatigue, and inexperience) and they can create longlasting holes or weaknesses in the defences (untrustworthy alarms and indicators, unworkable procedures, design and construction deficiencies, etc.). Latent conditions may lie dormant within the system for many years before they combine with active failures and local triggers to create an accident opportunity [Reason, 1990; Reason, 2000a].

Van der Schaaf [1992] developed a framework that outlines the various purposes and goals of a near miss management system, and details the various modules necessary to fulfil these goals. In the box below the seven modules are presented. Modules 1, 2, and 3 represent the inputs to the system, modules 4, 5, and 6 represent the way these inputs are processed, and module 7 represents the output and evaluation which follows the preventive measures [van der Schaaf, 1992; van der Schaaf and Wright, 2005].

1. Detection:	recognition and reporting
2. Selection:	according to specific purpose(s)
3. Description:	all relevant hardware-, human-, and organisational factors
4. Classification:	according to human behaviour model
5. Computation:	statistical analysis of large database of incidents to uncover (patterns of) causal factors
6. Interpretation and Implementation:	translation of statistical results into corrective and preventive measures
7. Evaluation:	measuring the effectiveness of proposed measures after their implementation

The PRISMA approach consists of the following main components, which are described in the following sections [van Vuuren et al., 1997]:

1. The Causal Tree incident description method.
2. The Eindhoven Classification Model (ECM) of System Failure.
3. The Classification/Action Matrix.

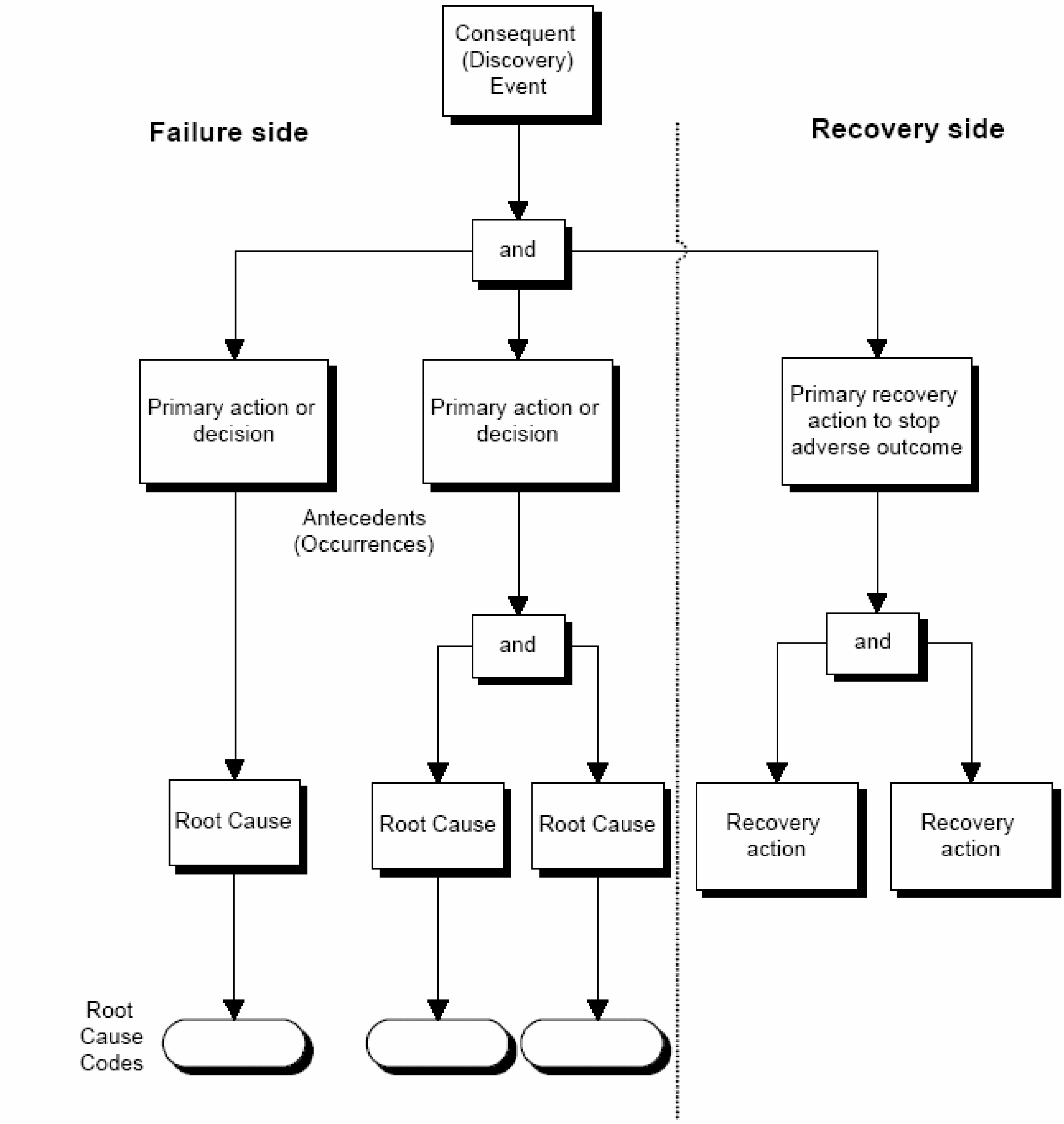
Step 1: Incident description

In this step incidents are described by means of causal trees. Causal trees provide a visual representation of the incident and are therefore useful for uncovering what the underlying factors, circumstances, and decisions were that contributed to the event in question. Causal trees support the fact that nearly all incidents have more than one cause and they visualise the grouping and hierarchy of these causes. At the top of the tree the consequence or discovery event (i.e. the symptom) is placed, as the visible reason for the analysis. This event is called the “top event”. Below the top event, there are two sides of the tree: failure and recovery. Underneath the top event all necessary direct causes are mentioned. These are displayed in both logical and chronological order. These direct causes often have their own causes. By continuing to ask “why” of each event (beginning with the top event), all relevant antecedent events, as well as the so-called root causes, are revealed. Thereby a structure of causes and consequences arises, until the root causes are identified at the bottom of the tree. It is not until the root causes are identified, that both the active failures and the latent conditions that caused the incident are revealed. Once the root causes are identified, they can be used to provide a more realistic view of how the system is actually working, as well as contribute to the creation of effective and lasting solutions [MERS TM, 2001; van der Schaaf, 1997; van Vuuren et al., 1997]. Two “stop rules” apply regarding the building of causal trees [van der Schaaf, 1997]:

1. Stop extending the tree when no objective facts can be put forward anymore.
2. Stop searching for causes of causes when the system boundary is passed, that is when the accompanying measures are outside the range of influence of the organisation.

In Figure 2 the structure of a causal tree is showed.

Figure 2. Structure of a causal tree [MERS TM, 2001].



In the causal tree of Figure 2 the so-called "AND-gates" are presented. These gates indicate that the accompanying (root) causes for sure contributed to the incident. The "AND-gates" thus show what *really* happened. All (root) causes that are directly connected to an "AND-gate" are necessary to make happen the cause that is mentioned one layer higher. Removing one of the (root) causes that is connected to an "AND-gate" is therefore sufficient to prevent the cause that is mentioned one layer higher from happening. Besides these "AND-gates", the PRISMA method consideres "OR-gates", which are meant to indicate which (root) causes *might* have contributed to the incident. However, these relations are not proven (because of a lack of information); they are *plausible*. Because of the fact that "OR-gates" represent plausible connections, root causes that are connected to such "OR-gates" should not be registered in an incident database. The "OR-gates" are only used for a modelling purpose.

Step 2: Classification of causes

The root causes that are identified in step 1 are subsequently classified by linking them to one of the categories of the Eindhoven Classification Model [van der Schaaf, 1997], which is displayed in Figure 3[1]. As mentioned before, the PRISMA method is based on the system approach, which distinguishes two types of error [MERS TM, 2001; Reason, 1990; Reason, 2000a]:

1. Active failures: the unsafe acts committed by people who are in direct contact with the patient or system. Their actions and decisions may result in errors that can immediately impact safety.
2. Latent conditions: “resident pathogens” within the system that arise from decisions made by designers, builders, procedure writers, and top-level management. These decisions have delayed, unintended consequences that can impact safety at some point in the future.

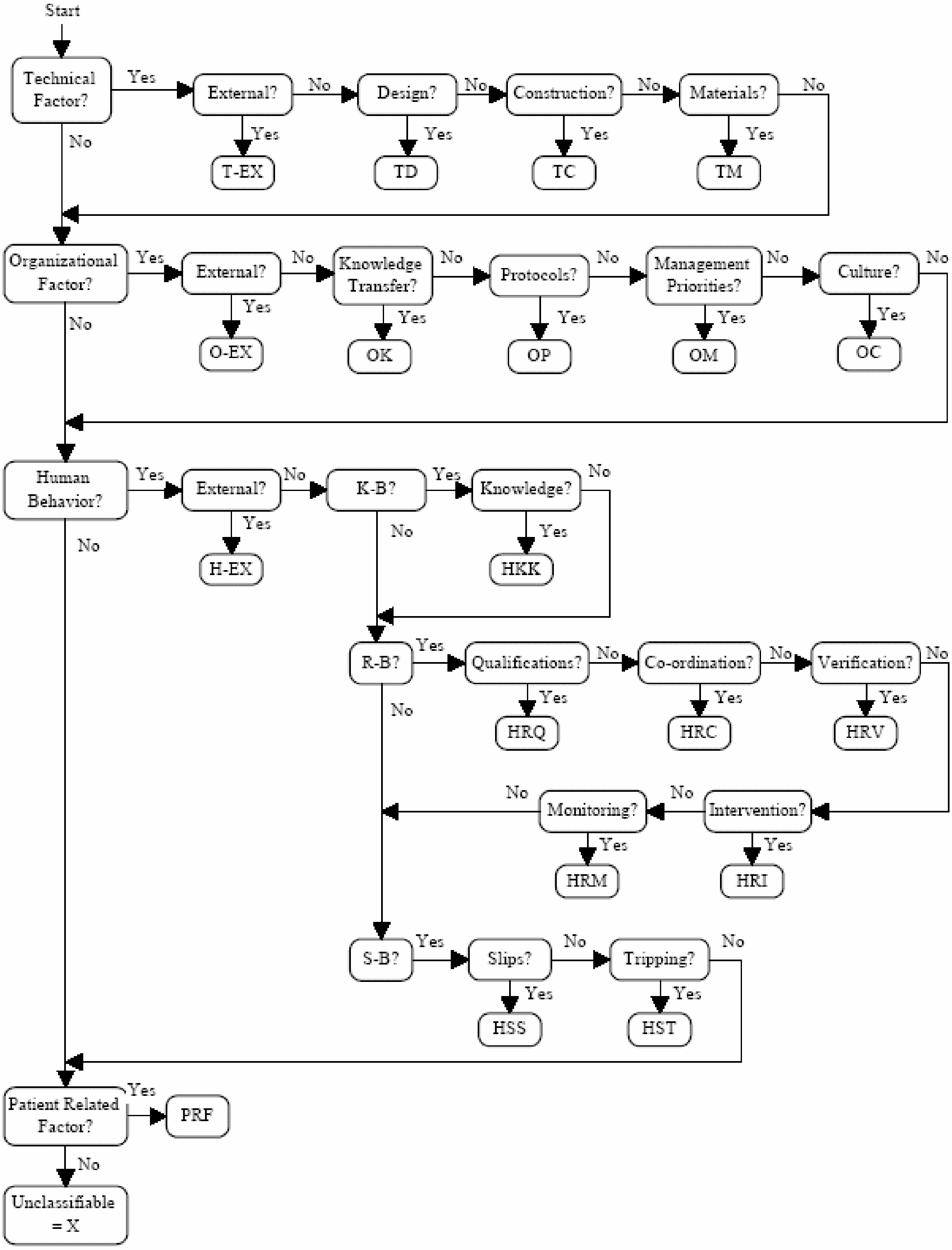
In the Eindhoven Classification Model both active failures and latent conditions are dealt with. Active failures are represented by human error. The human section of the model is based on the SRK-model by Rasmussen [1976]. Rasmussen has developed a basic model of human error based on three levels of behaviour [MERS TM, 2001; Rasmussen, 1976; van der Schaaf, 1992; van Vuuren et al., 1997]:

1. Skill-based behaviour, which involves “automatic” tasks requiring little or no conscious attention during execution.
2. Rule-based behaviour, which involves the application of existing rules or schemes to the management of familiar situations.
3. Knowledge-based behaviour, which involves the conscious application of existing knowledge to the management of novel situations.

The Eindhoven Classification Model distinguishes two types of latent errors: technical and organisational. Technical errors occur when there are problems with physical items such as equipment, physical installations, software, materials, labels, and forms. Organisational errors occur when there are problems with protocols and procedures, transfer of knowledge, management priorities, and culture or the collective approach to safety and risk [MERS TM, 2001].

[1] Because the root causes that are connected to “OR-gates” have a plausible (but not proven) relationship with the incident, these root causes should not be registered in the incident database and therefore these root causes are not classified either.

Figure 3. Eindhoven Classification Model: medical version [van Vuuren et al., 1997].



Technical and organisational factors often contribute to latent error and are considered first when classifying root causes. Human failures are associated with active error and are considered last in the classification of root causes [MERS TM, 2001]. This bias in the sequence of phrasing questions that can be seen in Figure 3 seemed to be necessary, because one forgets too quickly that so-called human errors are in fact caused by bad working environments or by management that says “safety first”, but does not act that way. So the sequence helps to counteract the tendency to start and end with human failures, ignoring the latent conditions that set up the human to fail. Looking for latent errors first increases the likelihood that all causes underlying the event will be discovered [MERS TM, 2001; van der Schaaf, 1997; van Vuuren et al., 1997].

In Table 1 the main categories and the subcategories of Figure 3 are listed and explained.

Table 1. Categories of the Eindhoven Classification Model: medical version [MERS TM, 2001; van Vuuren et al., 1997].

		Code	Category	Definition
Technical		T-EX	External	Technical failures beyond the control and responsibility of the investigating organisation.
		TD	Design	Failures due to poor design of equipment, software, labels or forms.
		TC	Construction	Correct design, which was not constructed properly or was set up in inaccessible areas.
		TM	Materials	Material defects not classified under TD or TC.
Organisational		O-EX	External	Failures at an organisational level beyond the control and responsibility of the investigating organisation, such as in another department or area (address by collaborative systems).
		OK	Transfer of knowledge	Failures resulting from inadequate measures taken to ensure that situational or domain-specific knowledge or information is transferred to all new or inexperienced staff.
		OP	Protocols	Failures relating to the quality and availability of the protocols within the department (too complicated, inaccurate, unrealistic, absent, or poorly presented).
		OM	Management priorities	Internal management decisions in which safety is relegated to an inferior position when faced with conflicting demands or objectives. This is a conflict between production needs and safety. An example of this category is decisions that are made about staffing levels.
		OC	Culture	Failures resulting from collective approach and its attendant modes of behaviour to risks in the investigating organisation.
Human		H-EX	External	Human failures originating beyond the control and responsibility of the investigating organisation. This could apply to individuals in another department.
	Knowledge-based behaviour	HKK	Knowledge-based behaviour	The inability of an individual to apply their existing knowledge to a novel situation. Example: a trained blood bank technologist who is unable to solve a complex antibody identification problem.
	Rule-based behaviour	HRQ	Qualifications	The incorrect fit between an individuals training or education and a particular task. Example: expecting a technician to solve the same type of difficult problems as a technologist.
		HRC	Coordination	A lack of task coordination within a health cares team in an organisation. Example: an essential task not being performed because everyone thought that someone else had completed the task.
		HRV	Verification	The correct and complete assessment of a situation including related conditions of the patient and materials to be used *before* starting the intervention. Example: failure to correctly identify a patient by checking the wristband.
		HRI	Intervention	Failures that result from faulty task planning and execution. Example: washing red cells by the same protocol as platelets.
		HRM	Monitoring	Monitoring a process or patient status. Example: a trained technologist operating an automated instrument and not realizing that a pipette that dispenses reagents is clogged.
	Skill-based behaviour	HSS	Slips	Failures in performance of highly developed skills. Example: a technologist adding drops of reagents to a row of test tubes and than missing the tube or a computer entry error.
		HST	Tripping	Failures in whole body movements. These errors are often referred to as “slipping, tripping, or falling”. Examples: a blood bag slipping out of one’s hands and breaking or tripping over a loose tile on the floor.
Other factors		PRF	Patient related factor	Failures related to patient characteristics or conditions, which are beyond the control of staff and influence treatment.
		X	Unclassifiable	Failures that cannot be classified in any other category.

In the case of near misses recovery factors can also be identified. The following classification codes can be used for the classification of these recovery factors:

Table 2. Classification of recovery factors [Personal communication with van der Schaaf, March 2005].

	Planned	Not planned
Human	P-H	NP-H
Technical	P-T	NP-T
Organisational	P-O	NP-O
Patient-related	(P-PRF)	NP-PRF
Unclassifiable		NP-X

Step 3: Formulation of structural measures for improvement

The classification codes that are selected in step 2 are registered in a database. In time, across a number of incidents, the most frequent (combinations of) root causes become visible in a so-called PRISMA profile. A PRISMA profile is a graphical representation of the root causes of all incidents or of a certain type of incident. A structural approach of these causes will probably be much more effective than ad hoc measures after each (serious) incident [van der Schaaf, 1997]. The so-called Classification/Action Matrix provides support for the formulation of the most effective measures (see Table 3). The following classes of actions are distinguished:

- Technology/Equipment: redesigning of hardware, software or interface parts of the manmachine system.
- Procedures: completing or improving formal and informal procedures.
- Information and communication: completing or improving available sources of information and communication structures.
- Training: improving (re)training programmes for skills needed.
- Motivation: increasing the level of voluntary obedience to generally accepted rules by applying principles of positive behaviour modification.
- Escalation: handling the problems at a higher organisational level.
- Reflection: evaluating the current way of behaving regarding safety.

Table 3. Classification/Action Matrix [Personal communication with van der Schaaf; March 2005].

Classification code	Technology / Equipment	Procedures	Information and Communication	Training	Motivation	Escalation	Reflection
T-EX						×	
TD	×						
TC	×						
TM	×						
O-EX						×	
OK						×	
OP		×					
OM						×	
OC							×
H-EX						×	
HKK			×		**NO**		
HRQ				×			
HRC				×			
HRV				×			
HRI				×			
HRM				×			
HSS	×				**NO**		
HST	×				**NO**		
PRF[1]							
X							

[1]If particular patient related factors (such as language problems) that cannot be prevented by the patients themselves recur, then these problems should be solved at an organisational level (i.e. escalation).

In the column "motivation" "NO" has been placed three times because it is a common error of management to motivate (or punish) employees to prevent knowledge-based errors and skill-based errors from happening.

The Classification/Action Matrix should not (always) be followed literally. Which measures are necessary is of course completely dependent on the organisation and the nature of the incidents. Therefore it is important to register context factors too. These context factors answer questions as: who?, what?, where?, and when?.

PRISMA-Medical offers the analytical methods for a complete system to learn from incidents: the effects of the measures that have been taken after a previous PRISMA analysis can be assessed by comparing the actual changes in the subsequent PRISMA analysis with the predicted changes [van der Schaaf, 1997].

References

MERS TM (2001). *Medical Event Reporting System for Transfusion Medicine reference manual version 3.0.* New York. Available at http://www.mers-tm.net

Rasmussen, J. (1976). Outlines of a hybrid model of the process operator. In: Sheridan, T.B. and Johanssen, G. (Eds.). *Monitoring behaviour and supervisory control.* London: Plenum Press

Reason, J.T. (1990). *Human error.* New York: Cambridge University Press

Reason, J.T. (2000a). Human error: models and management. *British Medical Journal, 320,* 768-70

Reason, J.T. (2000b). *Managing the risks of organisational accidents.* Aldershot: Ashgate

Schaaf, T.W. van der. *Het bouwen van een oorzakenboom.* Eindhoven: Technische Universiteit Eindhoven

Schaaf, T.W. van der (1992). *Near miss reporting in the chemical process industry.* Eindhoven: Technische Universiteit Eindhoven

Schaaf, T.W. van der (1997). PRISMA incidenten analyse. Een instrument voor risicobeheersing in de zorgsector. *Kwaliteit in beeld, 5,* 2-4

Schaaf, T.W. van der, Wright, L.B. (2005). Systems for near miss reporting and analysis. In: J.R. Wilson and E.N. Corlett (Eds.), *Evaluation of human work.* CRC Press

Vuuren, W. van, Shea, C.E., Schaaf, T.W. van der (1997). *The development of an incident analysis tool for the medical field.* Eindhoven: Technische Universiteit Eindhoven