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Using PVS to investigate incidents through the lens of distributed cognition

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Contribution

- A systematic tool-based method to help investigators understand the circumstances surrounding an incident
  - Aim of the investigation: re-design the socio-technical system so as to avoid the recurrence of similar accidents

- Illustrative example based on a real incident in healthcare
  - Drug infusion pump accidentally programmed with a wrong rate
  - Original report: “Fluorouracil incident root cause analysis report”

    http://www.ismp-canada.org/download/reports/FluorouracilIncidentMay2007.pdf

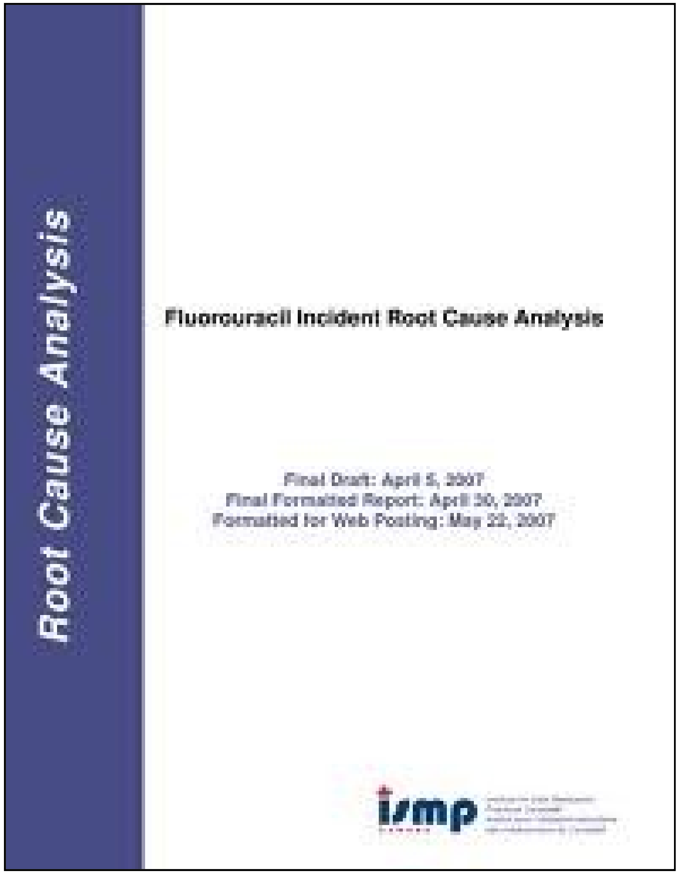
Cognition in the head vs. Cognition in the world

- Information resources can constrain activities carried out by users (e.g., ‘speed bugs’, checklists, ...)
  - These constraints can drive the analysis of plausible user trajectories
  - Their analysis provides insights about how to re-design the system so as to make the path to achieving a task apparent

(Reference: E. Hutchins, “Cognition in the wild”, MIT Press, 1995)

Fluorouracil incident

http://www.ismp-canada.org/download/reports/FluorouracilIncidentMay2007.pdf

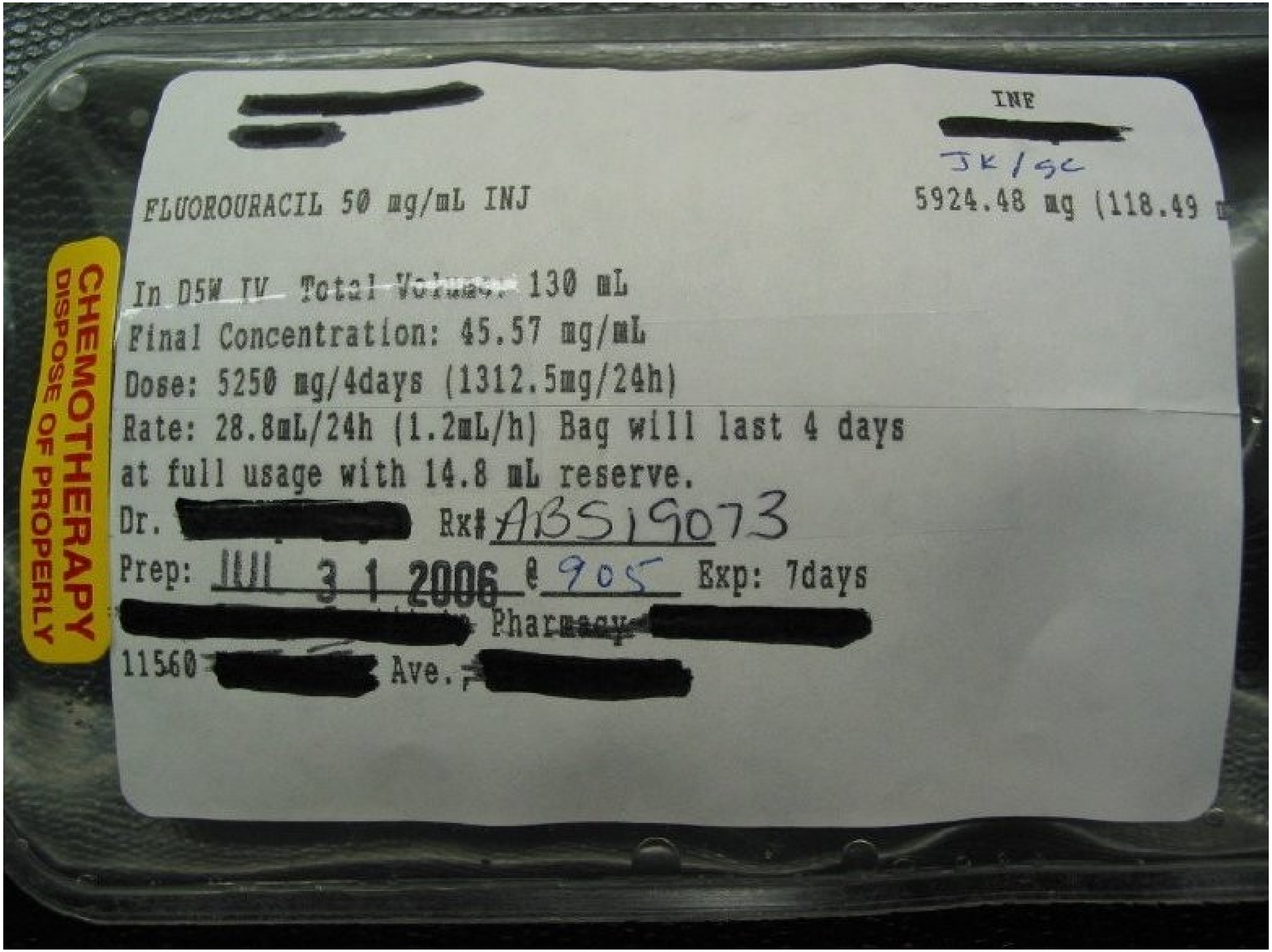


Root Cause Analysis

Fluorouracil Incident Root Cause Analysis

Final Draft: April 5, 2007
Final Formatted Report: April 30, 2007
Formatted for Web Posting: May 22, 2007

ismp



[redacted]

INF

[redacted]

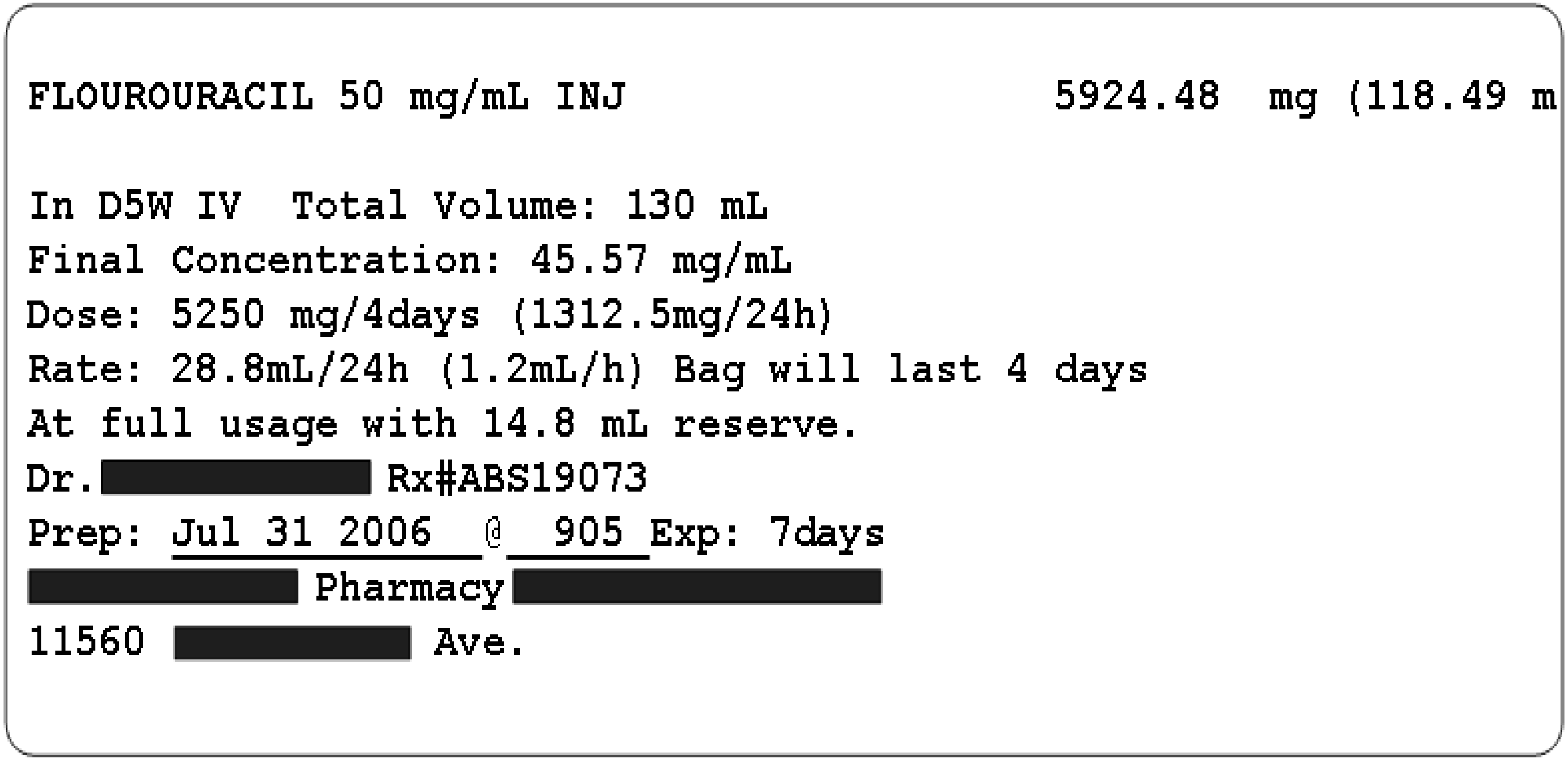
JK / gc

FLUOROURACIL 50 mg/mL INJ 5924.48 mg (118.49 m

In D5W IV Total Volume: 130 mL
Final Concentration: 45.57 mg/mL
Dose: 5250 mg/4days (1312.5mg/24h)
Rate: 28.8mL/24h (1.2mL/h) Bag will last 4 days
at full usage with 14.8 mL reserve.
Dr. [redacted] Rx# ABS19073
Prep: JUL 31 2006 @ 905 Exp: 7days
[redacted] Pharmacy [redacted]
11560 [redacted] Ave., [redacted]

CHEMOTHERAPY
DISPOSE OF PROPERLY

Information on the bag label



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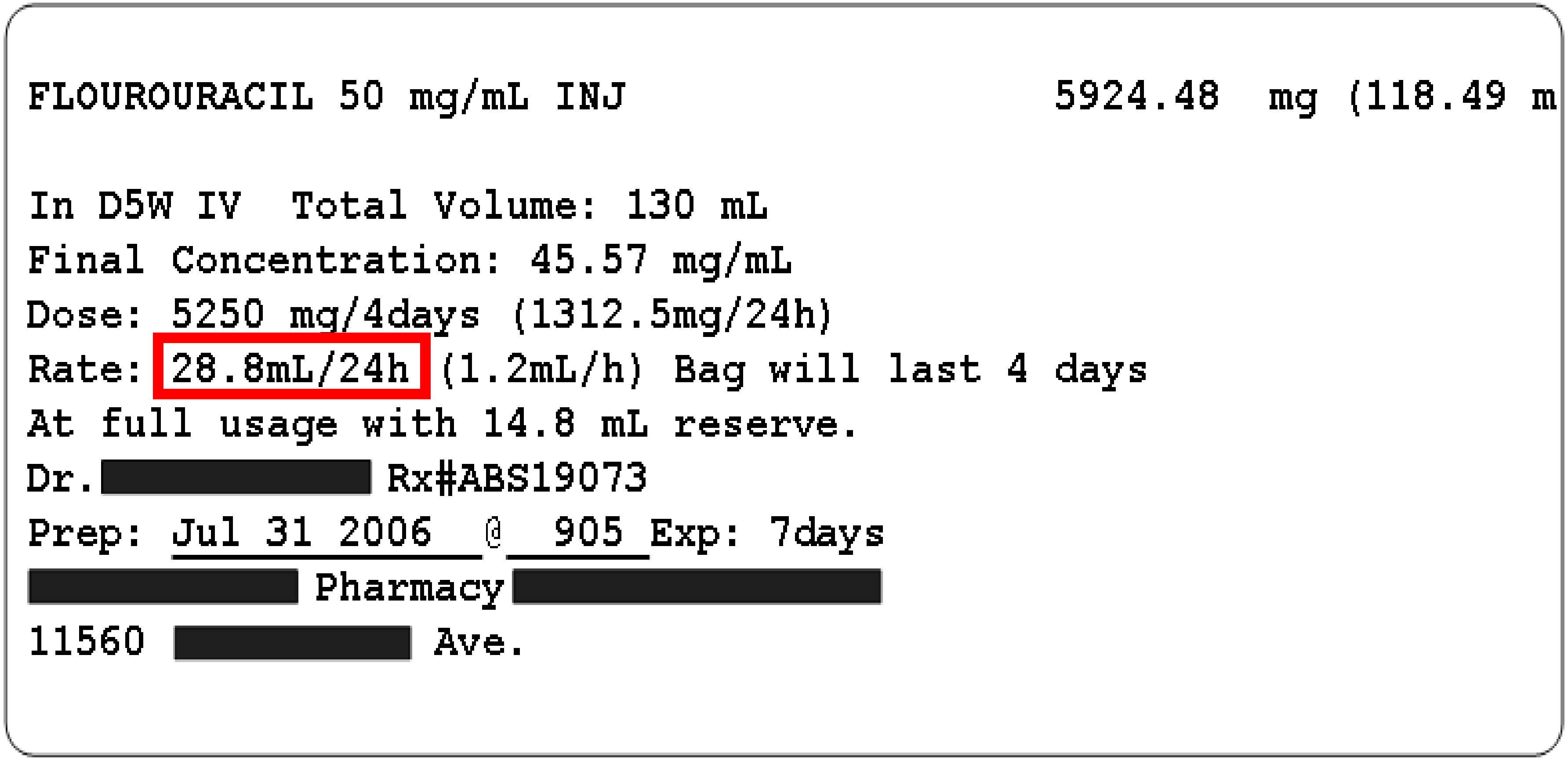

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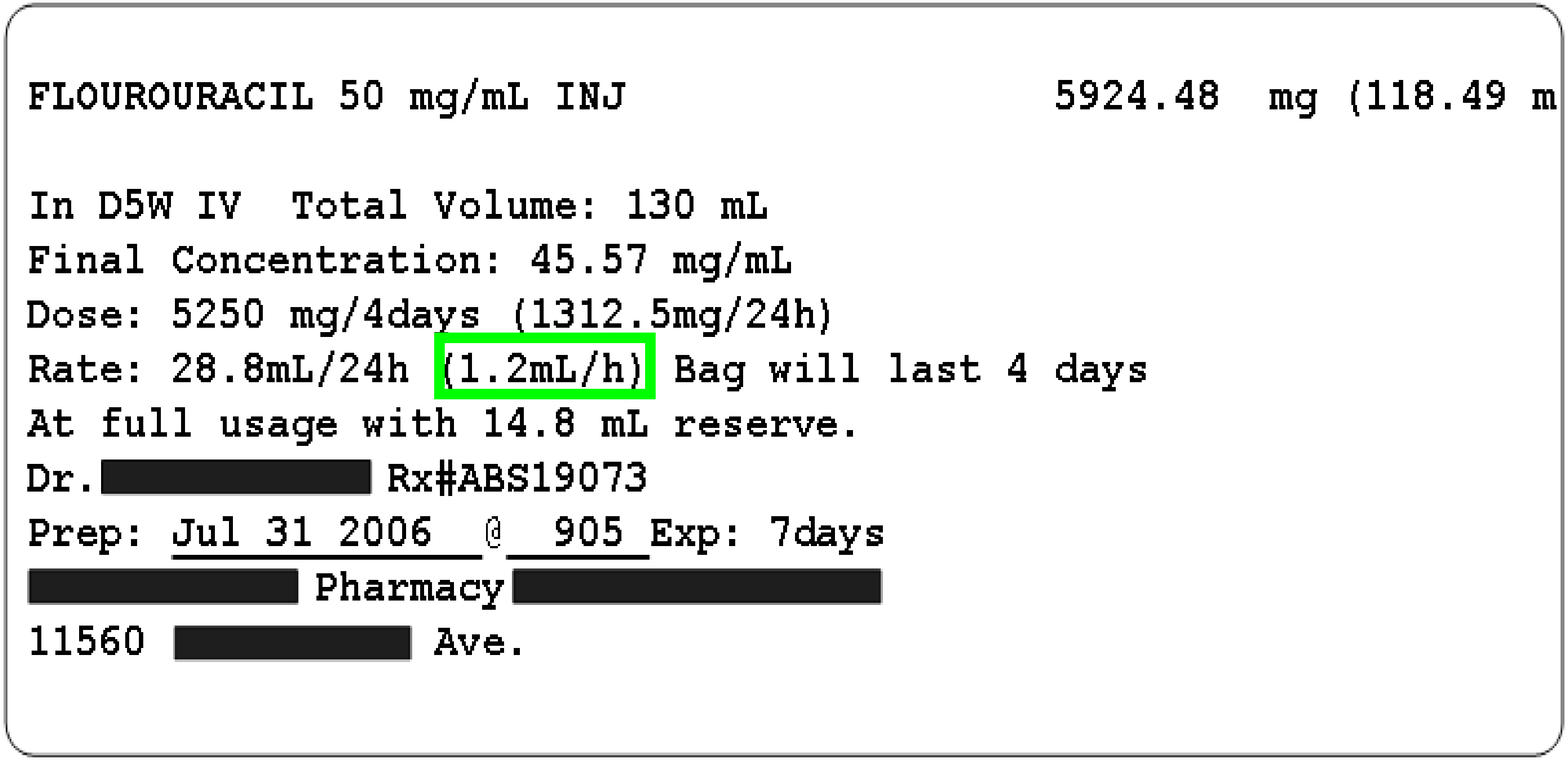

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Using the type-checking mechanism of PVS to support the analysis of information resources

Example: entering the rate

- Specification

```
enter_rate(rate: label_th.rate_type): pump_th.rate_type
    = val(rate)
```

- Proof obligation automatically generated by PVS

```
enter_rate_TCC: OBLIGATION
   FORALL (rate: label_th.rate_type):
      val(rate) >= 0 AND val(rate) <= max_rate;
```

Unfinished proof obligations

- Mathematically trivial issues can highlight implications for the incident that are potentially significant
- When a proof obligation cannot be discharged,
  a situation is found that may warrant further investigation
- Example of questions stimulated by **`enter_rate_TCC`** :
  - What are the actual constraints of the infusion rate on the bag label?
  - What is the actual procedure when the rate value printed on the label cannot be entered in the pump?

Conjectures about the use of information resources

Can be embedded in the specification with sub-typing

Example:

```
{ r: rate_type | safe_rate?(r, drug_name) }
```

- Proof obligation automatically generated by PVS when instantiating the bag label

```
fluorouracil_bag_label_TCC: OBLIGATION
        safe_rate?(mL_Xh(28.8, 24), fluorouracil);
```

- The obligation cannot be discharged with the given information
  - The bag does not report safety limits
  - Neither the pump does!

Summary

A relatively simple use of PVS informed with a distributed cognition can help raise systematic questions about systemic system failures

These questions can lead to insights that would guide an incident investigator while reconstructing facts & events

The ultimate aim is to provide tool support for reasoning about how to re-design a socio-technical system so as to avoid the recurrence of similar accidents

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Long-term aim: to transform the design and use of medical devices so as to help clinicians avoid and recover from human error

Combining a variety of approaches

- Contextual studies in hospitals
- Understanding manufacturer’s context
- Lab-based experiments
- Device design
- Formal modelling
- Public engagement

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