Electromagnetic Interference From Wireless Devices on Critical Medical Care Equipment

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Wireless technology

- Applications:
  - tracking of patient identity
  - tracking of medical equipment
  - tracking of blood supplies
- Numerous RF devices:
  - cell phones
  - 2-way radios
  - WLAN
  - WPAN
- ***Goal: Asses and classify incidents of electromagnetic interference (EMI) on critical care equipment***

Background

- Radio transmission produce electromagnetic waves which may interfere with the operation electromagnetic devices
- Factors affecting EMI
  - transmission power
  - proximity
  - radio frequency
  - modulation

Device shielding

- EMI requirements for medical devices:
  - IEC 801-x: 3 V/m for 26MHz - 1 GHz
  - IEC 61000-4-3:
    - 3 V/m for 80 MHz - 800 MHz
    - 10 V/m for 800 HMHz - 1 GHz

- These levels of shielding are sometimes insufficient when max. power is used in proximity of medical devices

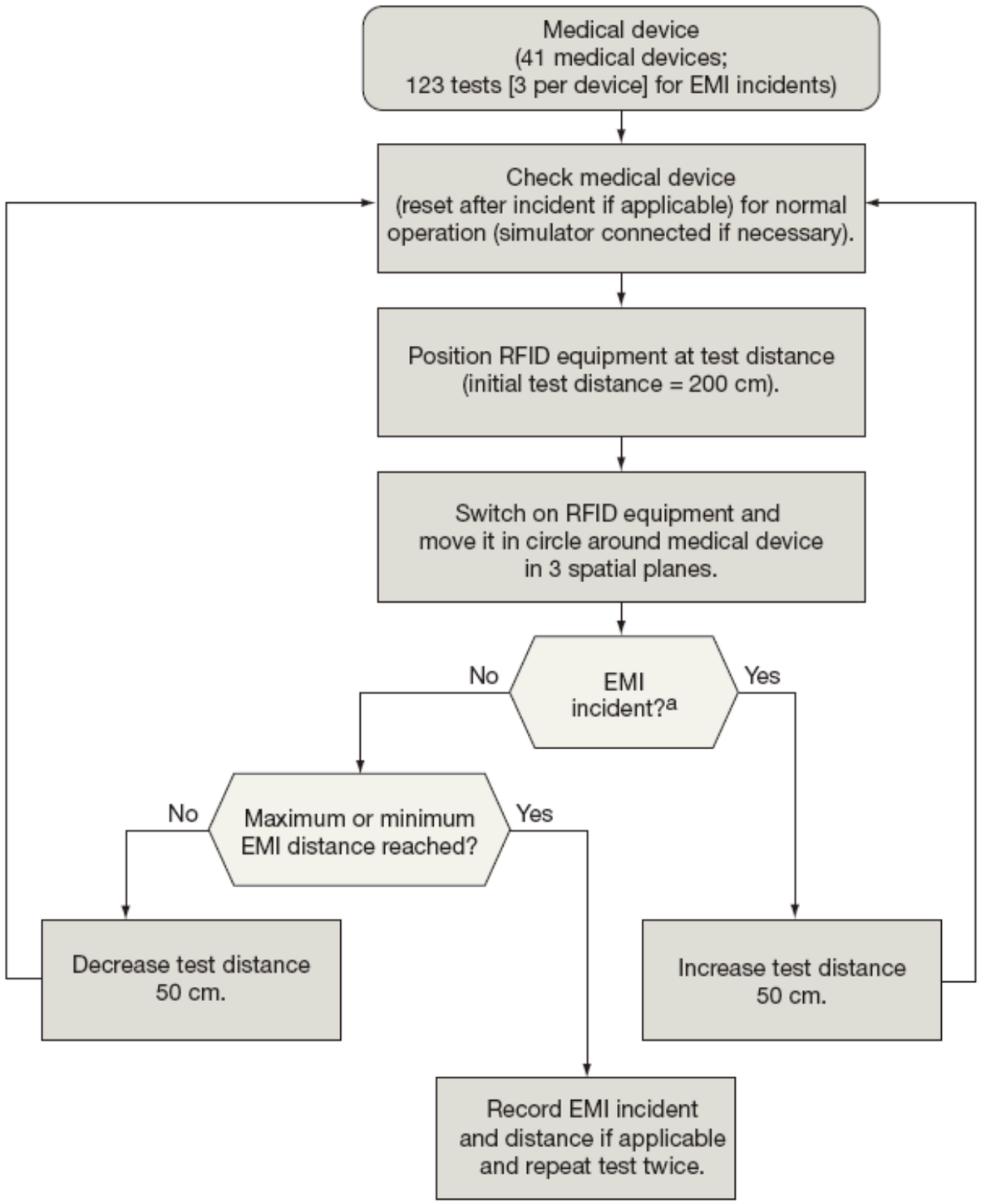
Wireless devices

Device	Passive RFID	Active RFID	UMTS	GPSR	WLAN
Frequency	125 KHz	868 MHz	1952 MHz	1802 MHz	2.4-2.5 GHz
Power	2-4W	2uW	250mW	1W max 500mW avg	100mW
Transmission			5 MHz bandwidth	pulse freq. 217 Hz, 200 kHz b-width	DSSS

Methods - Medical equipment

- 41 medical devices (different types, different manufacturers)
  - no patient connected
  - simulated input (i.e., cardiogram sim, artificial lung)
  - examples:
    - infusion/syringe pumps
    - external pacemakers
    - mechanical ventilators
    - ...

Test method (ANSI C63.18)



Incidents

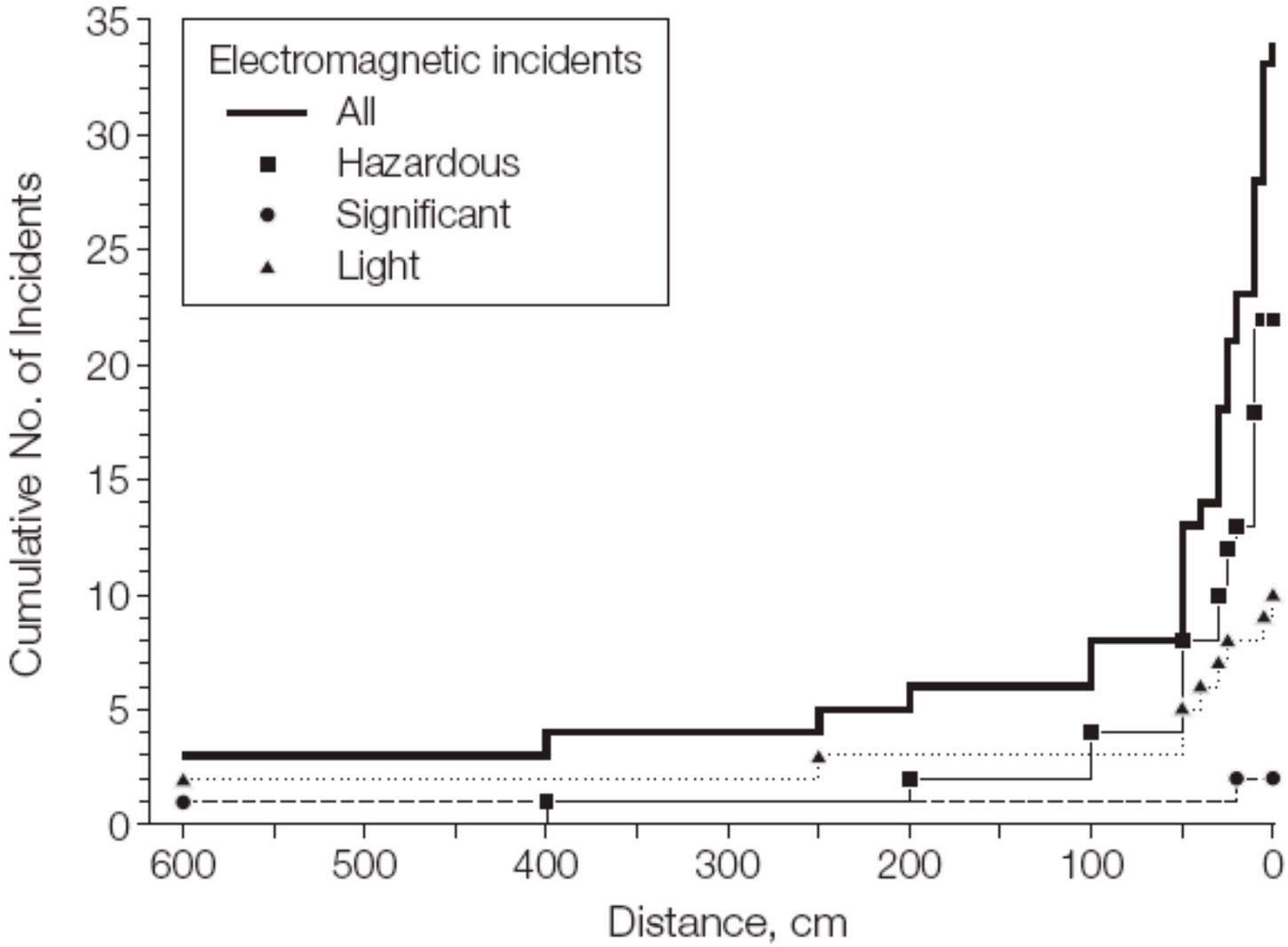
- incident = every unintended change in function of a medical device
- 5 intensivists classified the incidents independently
  - hazardous - direct physical influence on patient by unintended change in equipment function
    (e.g., stop of a syringe, incorrect pacing)
  - significant - influence on monitoring with sufficient level of attention needed to distract from patient care
    (e.g., incorrect alarm, incorrect blood pressure)
  - light - influence on monitoring without level of attention needed
    (e.g., disturbed display)

Results - RFID

123 tests => 34 EMI incidents

Device Category[b]	No. of Devices		Distance, Median (Range), cm	No. of Incidents by Type		
	Tested	Demonstrating EMI		Hazardous[c]	Significant[c]	Light[c]
Infusion/syringe pumps	9	8	30 (0.1-100)	6	Not applicable	3
External pacemakers	3	3	25 (5-30)	5	Not applicable	Not applicable
Mechanical ventilators	4	2	20 (5-400)	2	1	Not applicable
Hemofiltration/dialysis devices	2	2	15 (10-20)	2	Not applicable	Not applicable
Pacemaker programmers	2	2	150 (25-600)	3	1	Not applicable
Intra-aortic balloon pumps	3	1	50[d]	1	Not applicable	Not applicable
Fluid warmer	1	1	50[d]	1	Not applicable	Not applicable
Cardiopulmonary bypass device	1	1	10[d]	1	Not applicable	Not applicable
Autologous blood recovery device	1	1	5[d]	1	Not applicable	Not applicable
Anesthesia devices	4	1	325 (25-600)	Not applicable	Not applicable	2
Defibrillators	3	2	303 (5-600)[e]	Not applicable	Not applicable	2
12-lead ECG device	1	1	138 (25-250)[e]	Not applicable	Not applicable	2
Monitors	3	1	50[d]	Not applicable	Not applicable	1

Results - RFID



Results - RFID

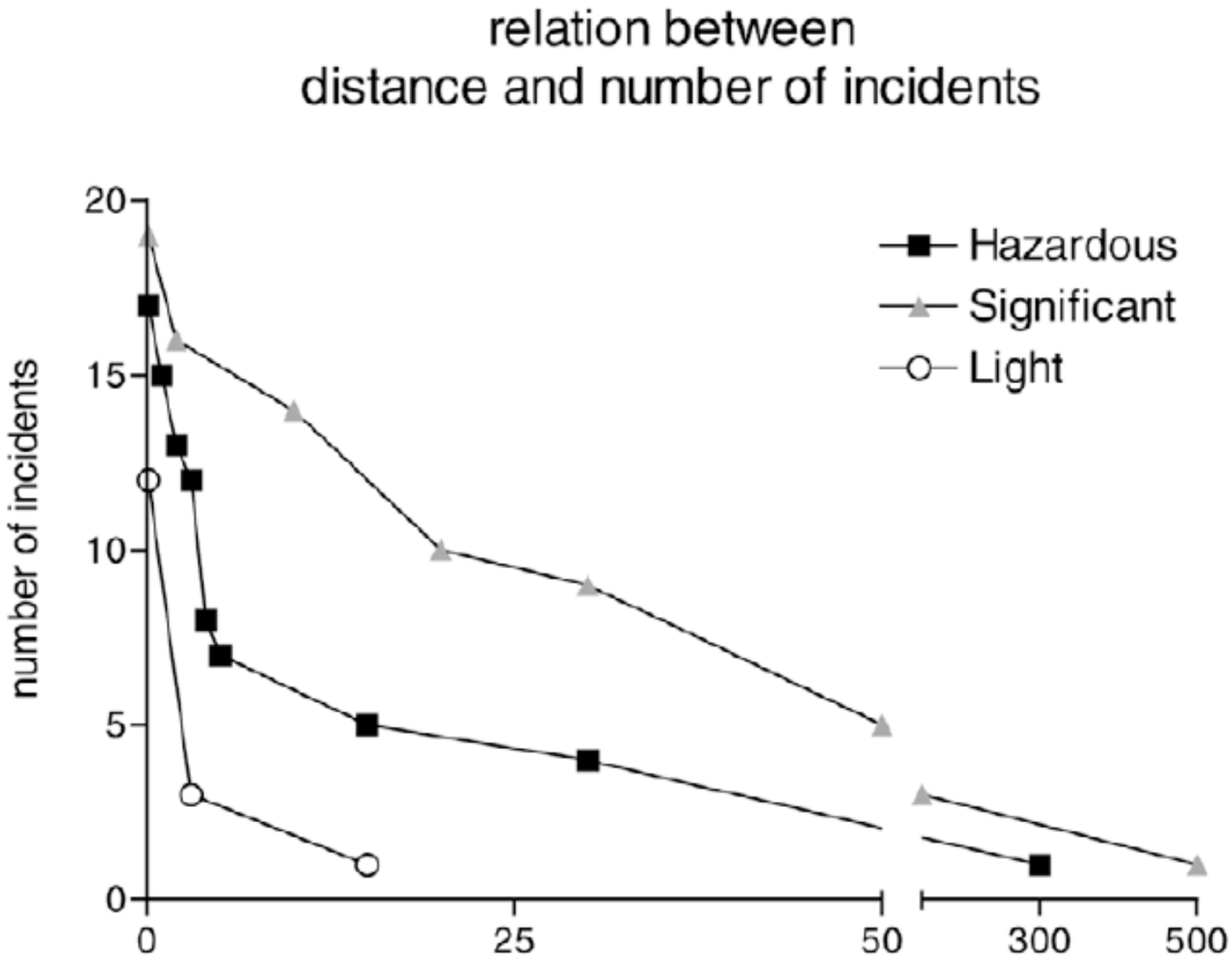
	Distance, Median (Range), cm	RFID Signal, No. of Incidents	
		868 MHz	125 kHz
Hazardous incidents	25 (5-400)	17	5
Significant incidents	310 (20-600)	1	1
Light incidents	45 (0.1-600)	8	2
All incidents	30 (0.1-600)	26	8

passive active

- the majority of the incidents were reported when the passive RFID is used => due to higher transmission power

Results - phones

- Contradictory results:
  - Wallin et. al. - 85% of tested devices were immune
  - van Lieshout et. al - 57% of tested devices were immune



Results - WLAN

- Two empirical studies => small number of EMI incidents

Remarks

- the study shows that RF signals can impact operation of critical medical devices
- the degree of interference reduces with transmission power and distance
- no systematic analysis of the root cause of the RF interference and its impact
  (e.g. frequency, signal strength, modulation)

MHRAI EMI mitigation recommendations

EMI Risk	Type of Communication System	Recommendation
High	Analogue emergency service radios	Use in hospitals only in an emergency, never for routine communication.
	Private business radios (PBRs) and PMR446 e.g. porters' and maintenance staff radios (two-way radios).	Minimise risks by changing to alternative lower risk technologies
Medium	Cell phones (mobile phones) TETRA (Terrestrial Trunked Radio System) Laptop computers, palmtops and gaming devices fitted with GPRS* and/or 3G HIPERLAN**	• A total ban on these systems is not required and is impossible to enforce effectively. • Should be switched off near critical care or life support medical equipment • Should be used only in designated areas • Authorised health and social care staff and external service personnel should always comply with local rules regarding use
Low	Cordless telephones (including DECT)*** and computer wireless network systems except HIPERLAN and GPRS e.g. WLAN**** systems and Bluetooth®	These systems are very unlikely to cause interference under most circumstances and need not be restricted.

Consequences

- safety should be the driver in picking RF technology
  - low-power radios are safer to use
  - higher density of nodes is required
  - better understanding of what characteristics of wireless signals on EMI