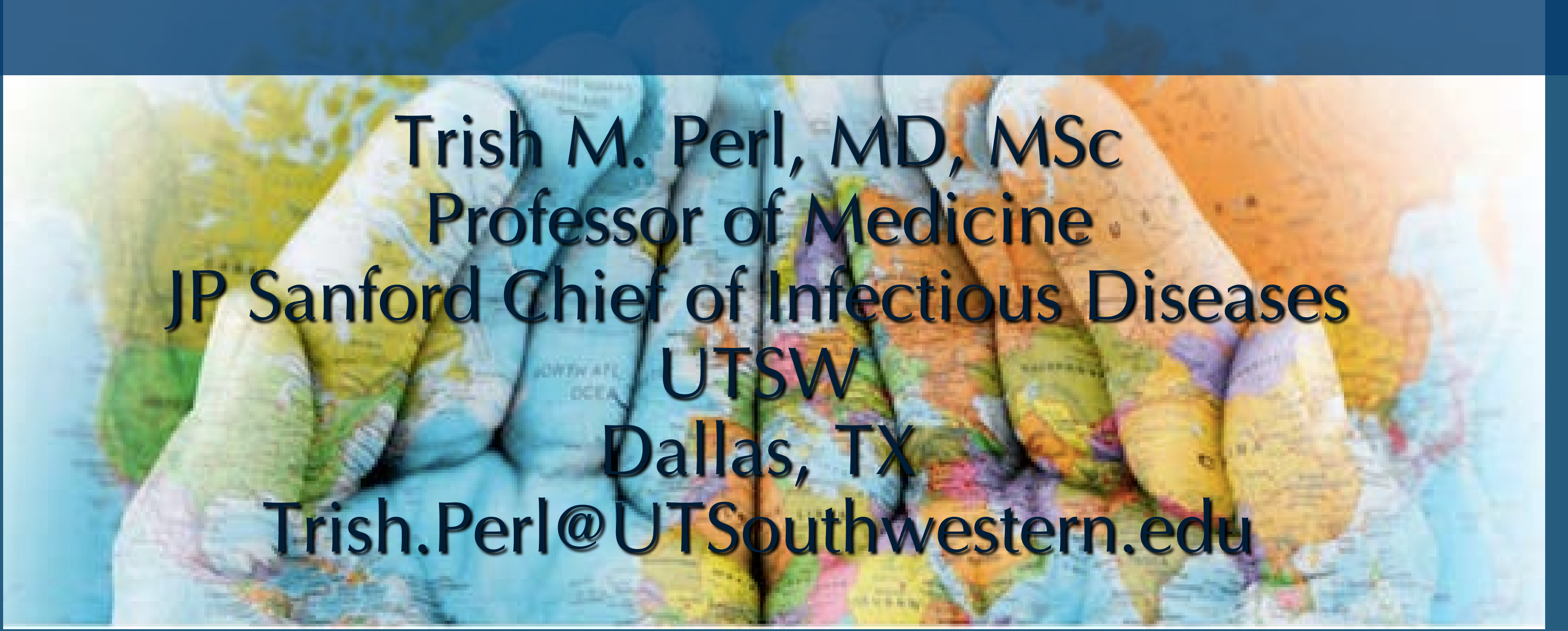
Healthcare Associated Infections - Overview, Surveillance and Prevention



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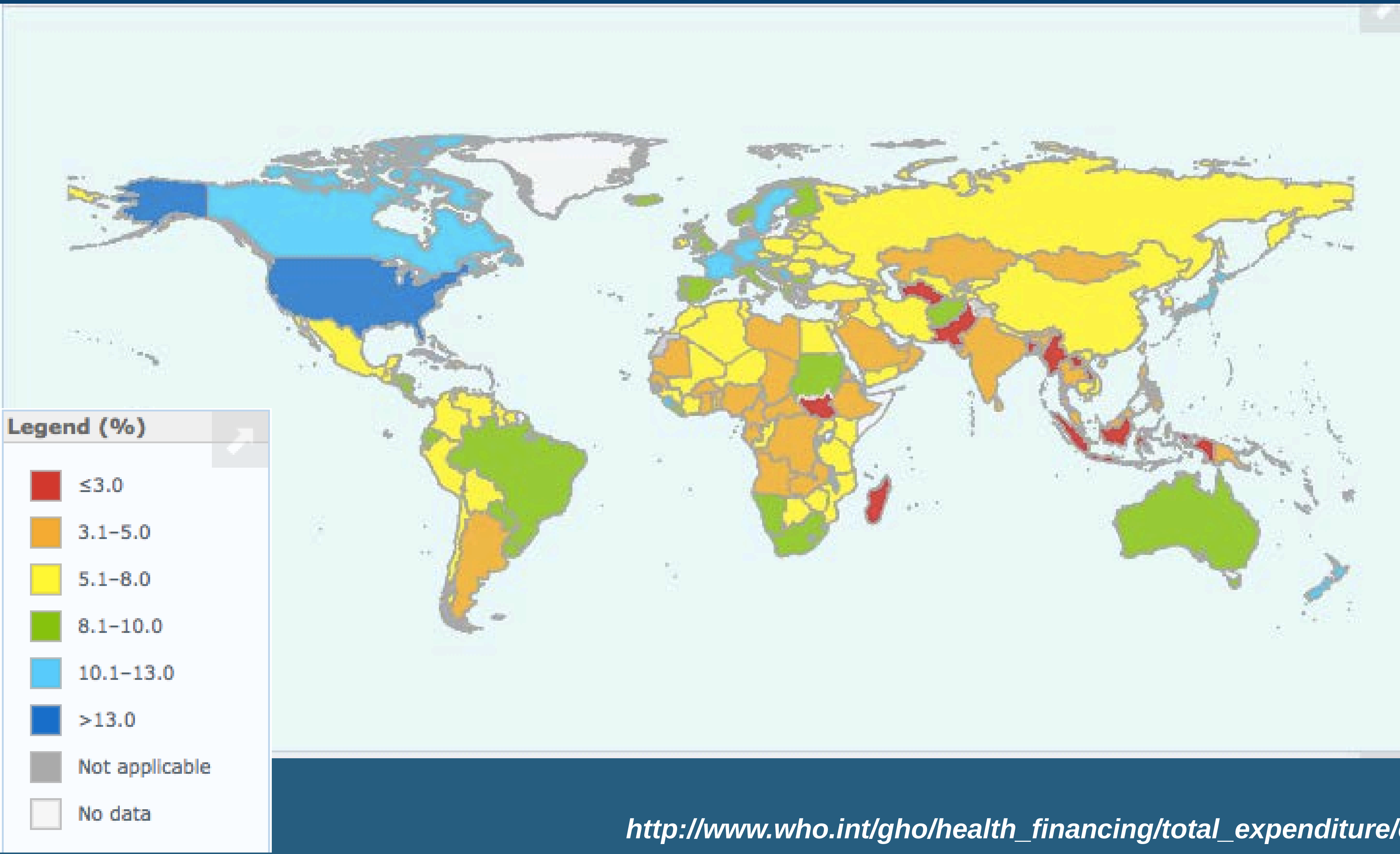
Disclosures:
Medimmunne and VA, CDC & BARDA (grant)

Objectives

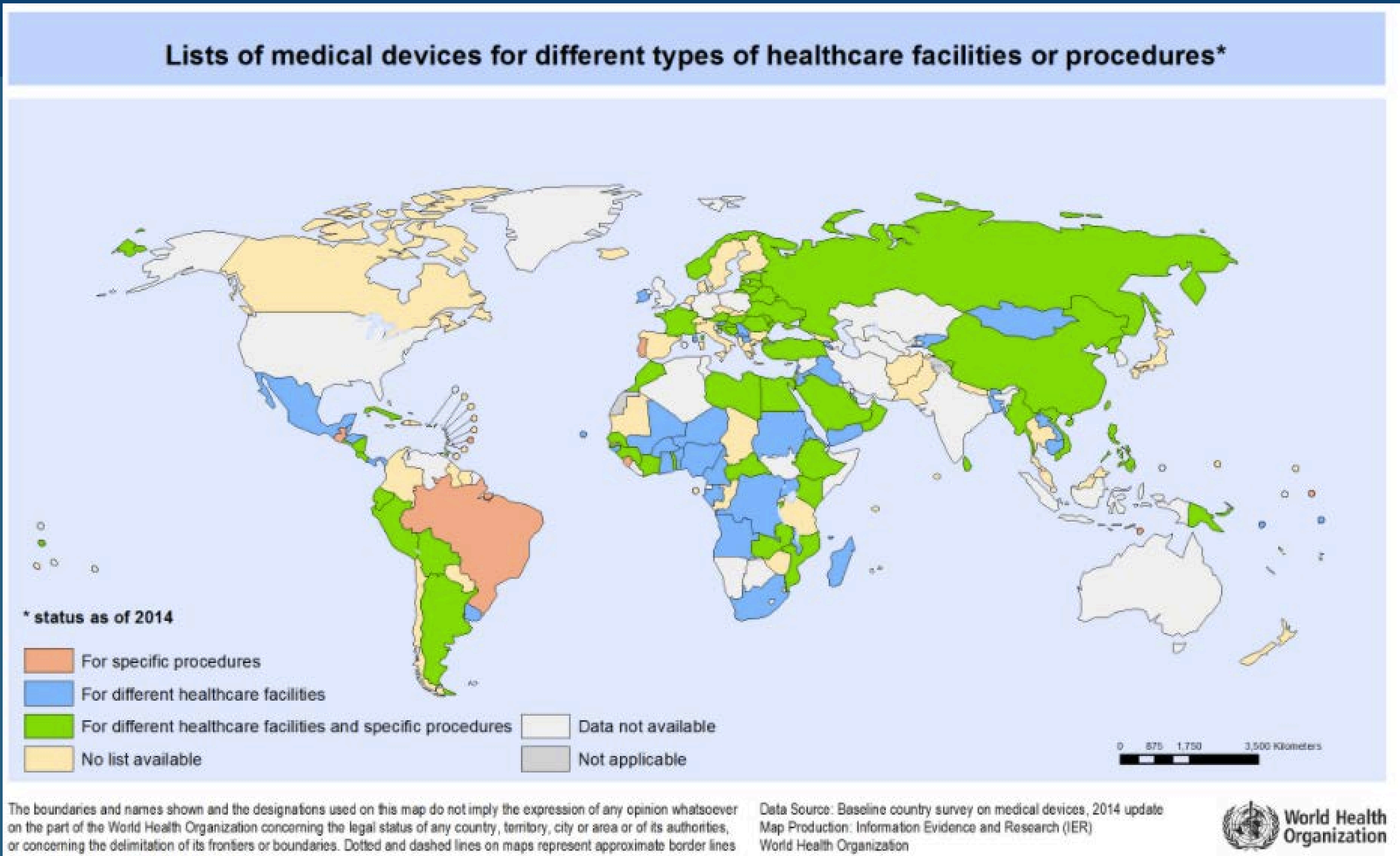
- Review the burden of HAIs/MDROs Worldwide
- Describe surveillance strategies and challenges
- Review general models for interventions
- Provide a framework for diffusion of ideas

Total Expenditure on Health as a Percent of Gross Domestic Product 2017



http://www.who.int/gho/health_financing/total_expenditure/en

Countries that Procure Medical Devices



http://gamapserver.who.int/mapLibrary/Files/Maps/Global_MedicalDevice Lists_availability.png

What Are Healthcare Associated Infections?

- HAIs are infections in patients receiving treatment for medical or surgical care. Infections can be associated with procedures, the processes and the devices used in medical procedures.
- HAIs occur in all types of care settings, including:
  – Acute care hospitals
  – Ambulatory surgical centers
  – Dialysis facilities
  – Outpatient care (e.g., physicians' offices and health care clinics)
  – Long-term care facilities (e.g., nursing homes and rehabilitation facilities)

Healthcare Associated Infections (HAI)

- Three targets
  - ↗ HAIs (acute care, long-term care, surgical centers, rehabilitation facilities, home care, ect…)
  - ↗ Antimicrobial resistant and epidemiologically important organisms
  - ↗ Emerging infections transmitted in healthcare settings
- US: 1.7 million pts/yr with a HAI
  - – 2 - 10% of hospitalized patients develop healthcare associated infections; the rate varies by size of the hospital
  - – Represent a significant portion of adverse events/medical errors
- HAIs= 4th leading cause of death in U.S. behind heart disease, cancer, CVA

The Burden of HAIs

- Systematic review and meta-analysis
- 220 articles included in final analysis
- Prevalence (Overall): 15.5/100 pts (95CI 12.6-18.9)
- Infection density in adult ICU: 47.9/1000 pt days (95CI 36.7-59.1)
- SSI pooled cum incidence: 5.6/100 procedures
- GNR most common nosocomial isolate
- 54% of *S. aureus* isolates resistant to methicillin

Allegranzi et al. Lancet 2011;377:228-241

Studies Reporting HAIs in Developing Countries (WHO)

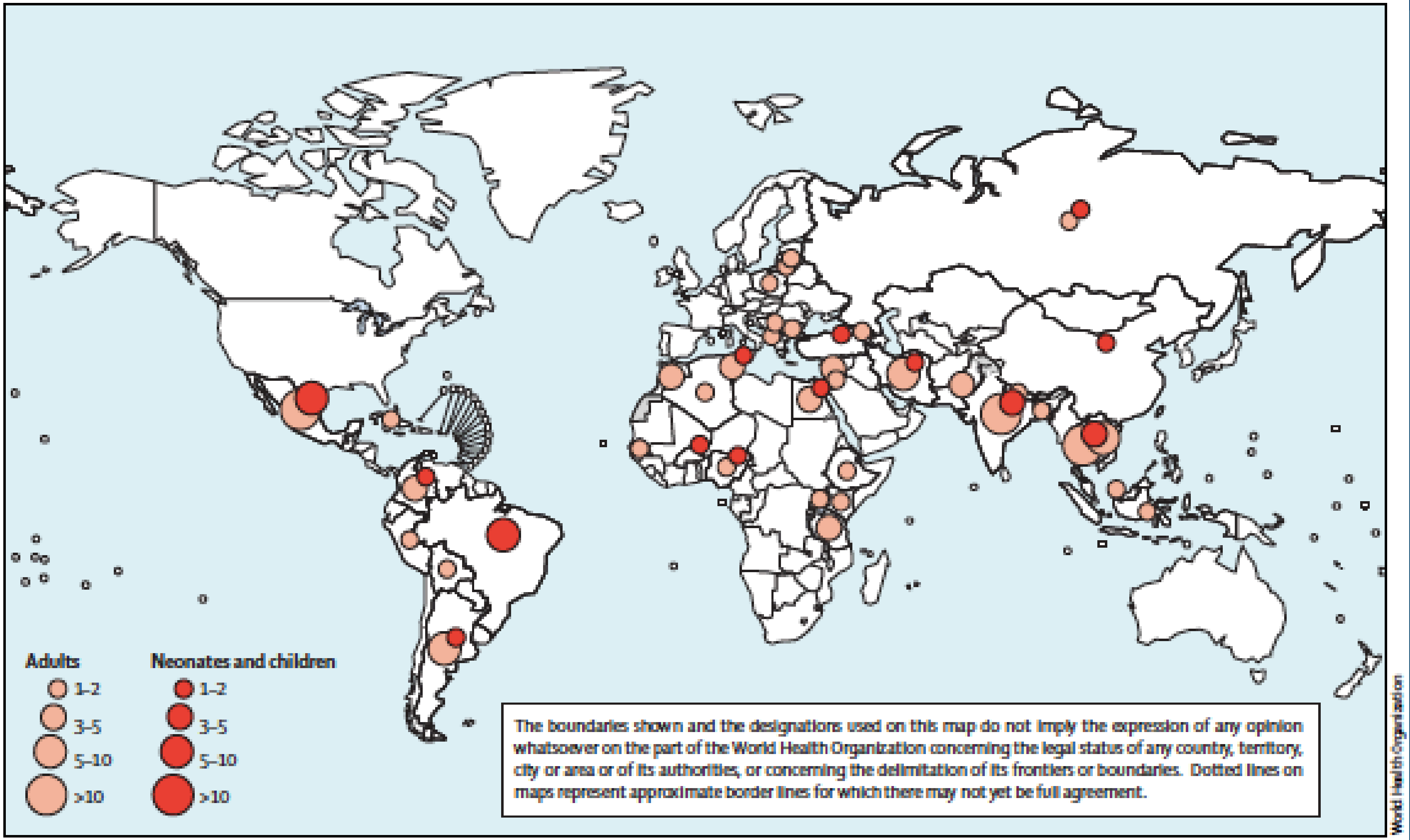
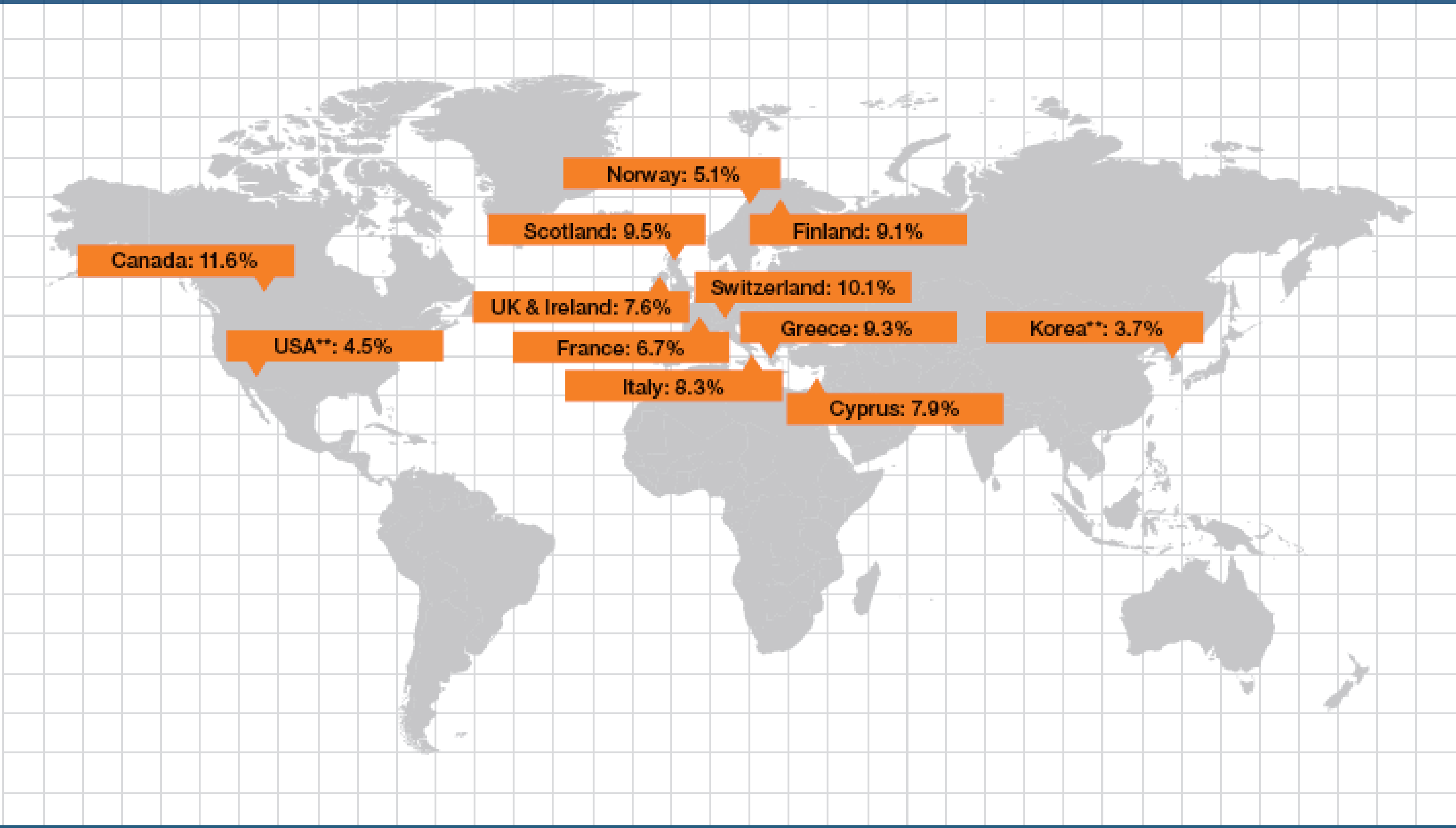


Figure 2: Number of studies reporting health-care-associated infection in developing countries, 1995–2008

Size of dots indicates number of studies. Map created with ARCView (version 9.3.1; ESRI, Redlands, CA, USA), using WHO criteria for official borders and disputed borders.

Allegranzi et al. Lancet 2011;377:228-241

Burden of Healthcare-associated Infections 1995-2008: WHO

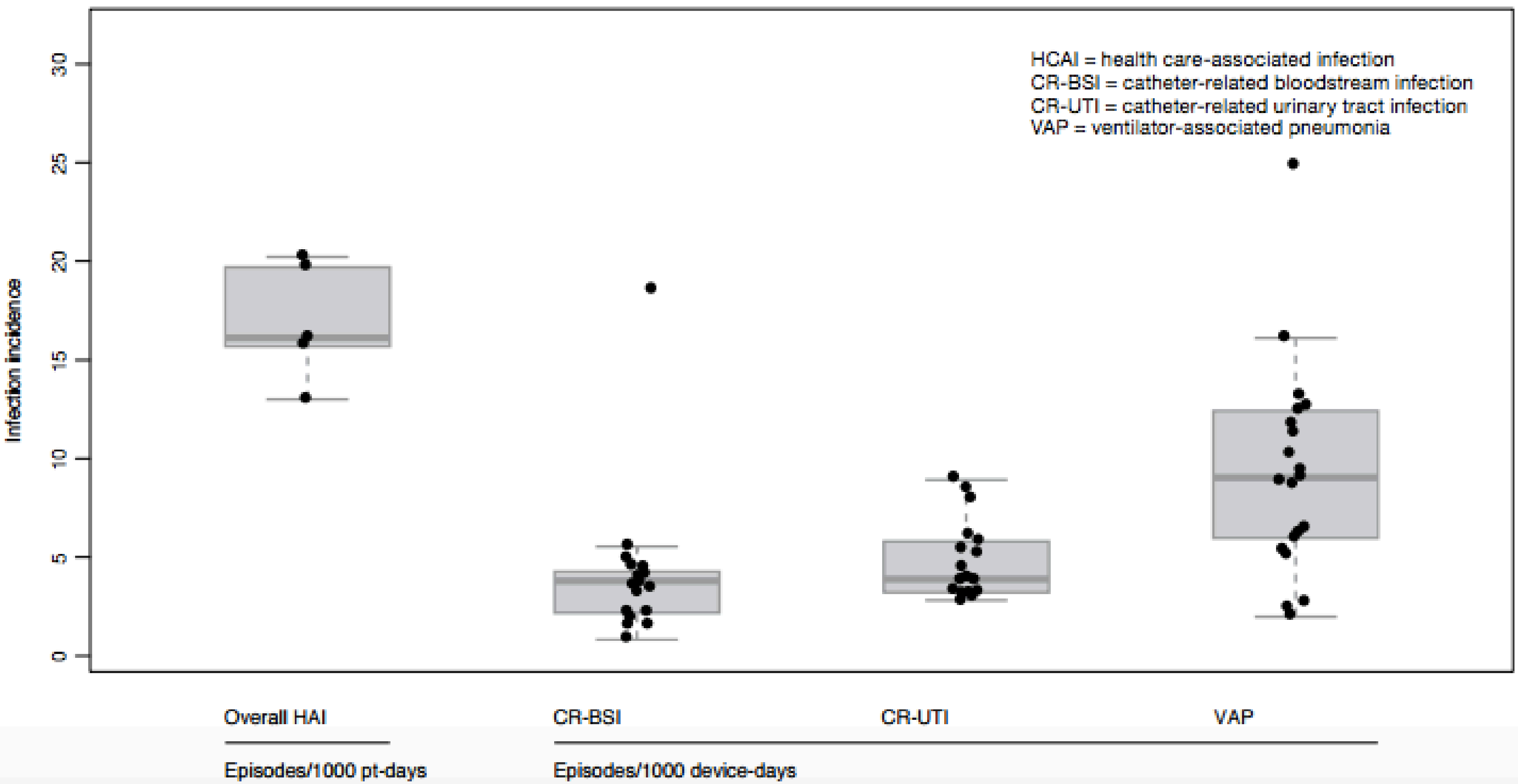


http://www.who.int/gpsc/country_work/summary_20100430_en.pdf

Incidence of and Device Related HAI's: High Income Countries 1995-2010

Figure 3.4

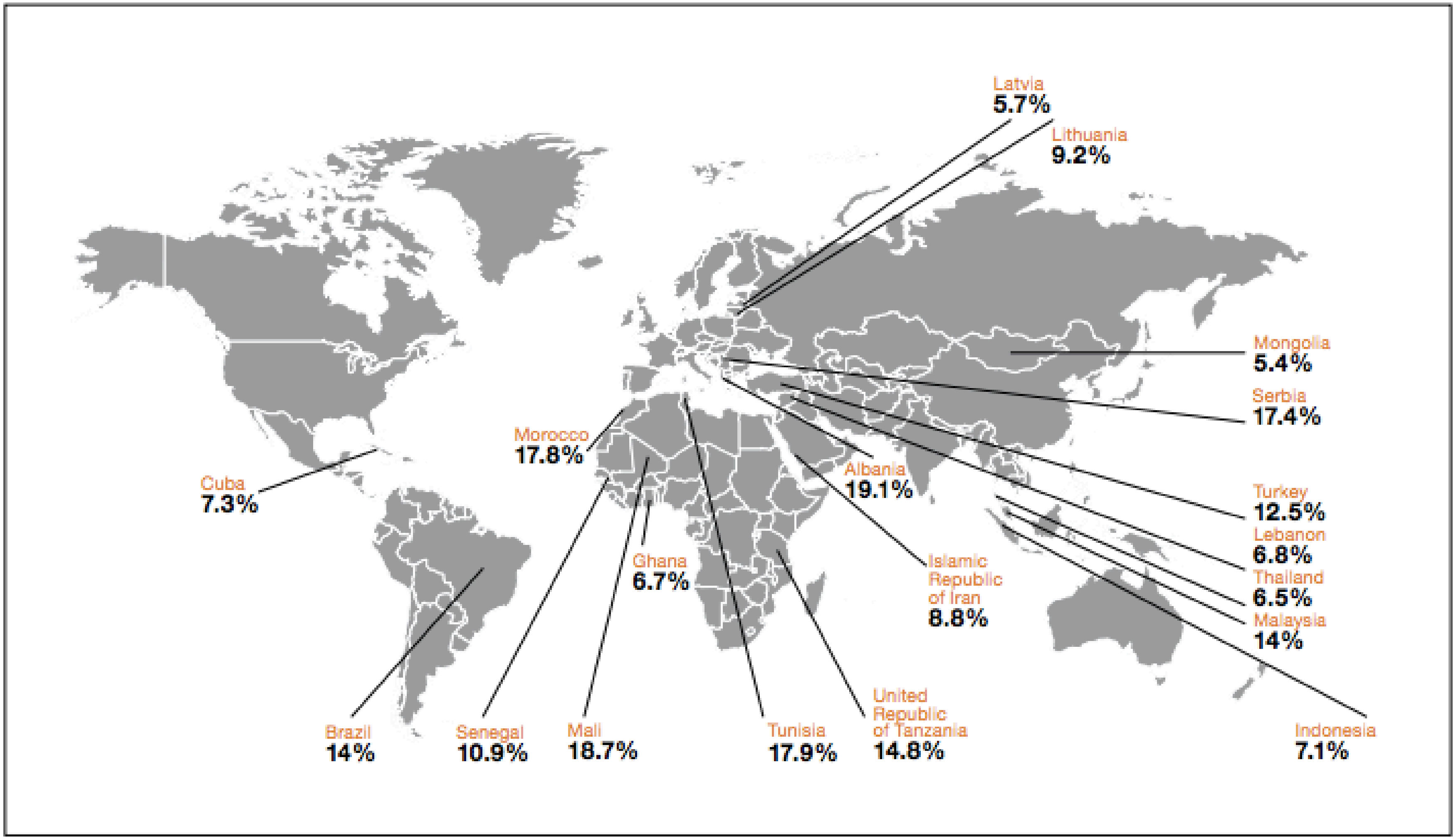
Incidence of overall health care-associated infection and device-associated infection in high-risk adult patients in high-income countries, 1995-2010



http://apps.who.int/iris/bitstream/10665/80135/1/9789241501507_eng.pdf?ua=1

Prevalence of HAI's Low to Middle Income Countries 1995-2010

Prevalence of health care-associated infection in low- and middle-income coutries, 1995-2010



Comparison of HAI Rates

	Number of ICUs	CR-BSI (95% CI)	Catheter-days	CR-UTI (95% CI)	Urinary catheter-days	VAP (95% CI)	Ventilator-days
Developed countries							
NNIS (1995–2003), USA*	85–133†	5·0‡	1 356 490	5·3‡	1 356 490	5·8‡	115 900
NHSN (2006–2008), USA*	89–182†	2·1‡	699 300	3·4‡	546 824	2·9‡	383 068
KISS (1997–2003), Germany	309	1·8‡	1 993 541	..	..	8·0‡	1 177 137
KISS (2004–2009), Germany	514–583†	1·3‡	4 002 108	2·0‡	4 757 133	5·1‡	2 391 381
Developing countries							
INICC (2002–2007), 18 developing countries*§	60	8·9‡	132 061	6·6‡	1030	19·8‡	1802
Argentina (1998–2004; current systematic review)	15	24·7 (7·4–42·0)	9458	17·2 (13·4–21·1)	19 013	48·0 (42·0–54·0)	5777
Turkey (1999–2005; current systematic review)	16	11·0 (2·2–24·3)	23 503	10·8 (4·2–17·4)	36 343	26·0 (20·0–32·0)	39 504
Current systematic review (1995–2008)	226	11·3 (9·0–13·6)	373 848	9·8 (7·7–11·8)	427 831	22·9 (19·1–26·6)	263 027

Data are overall (pooled mean) infection episodes per 1000 device-days. ICUs=intensive-care units. CR-BSI=catheter-related bloodstream infection. CR-UTI=catheter-related urinary-tract infection. VAP=ventilator-associated pneumonia. NNIS=National Nosocomial Infection Surveillance. NHSN=National Healthcare Safety Network. KISS=Krankenhaus Infektions Surveillance System. INICC=International Nosocomial Infection Control Consortium. *Medical or surgical ICUs in major teaching hospitals. †Range reported because number of ICUs included in data pooling varied according to the type of device-associated infection. ‡95% CI not reported. §Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Nigeria, Peru, Philippines, Turkey, Uruguay.

Table 2: Comparison of device-associated infection densities in adult ICUs from developed and developing countries, 1995–2008

Allegranzi et al. Lancet 2011;377:228-241

To Recapitulate

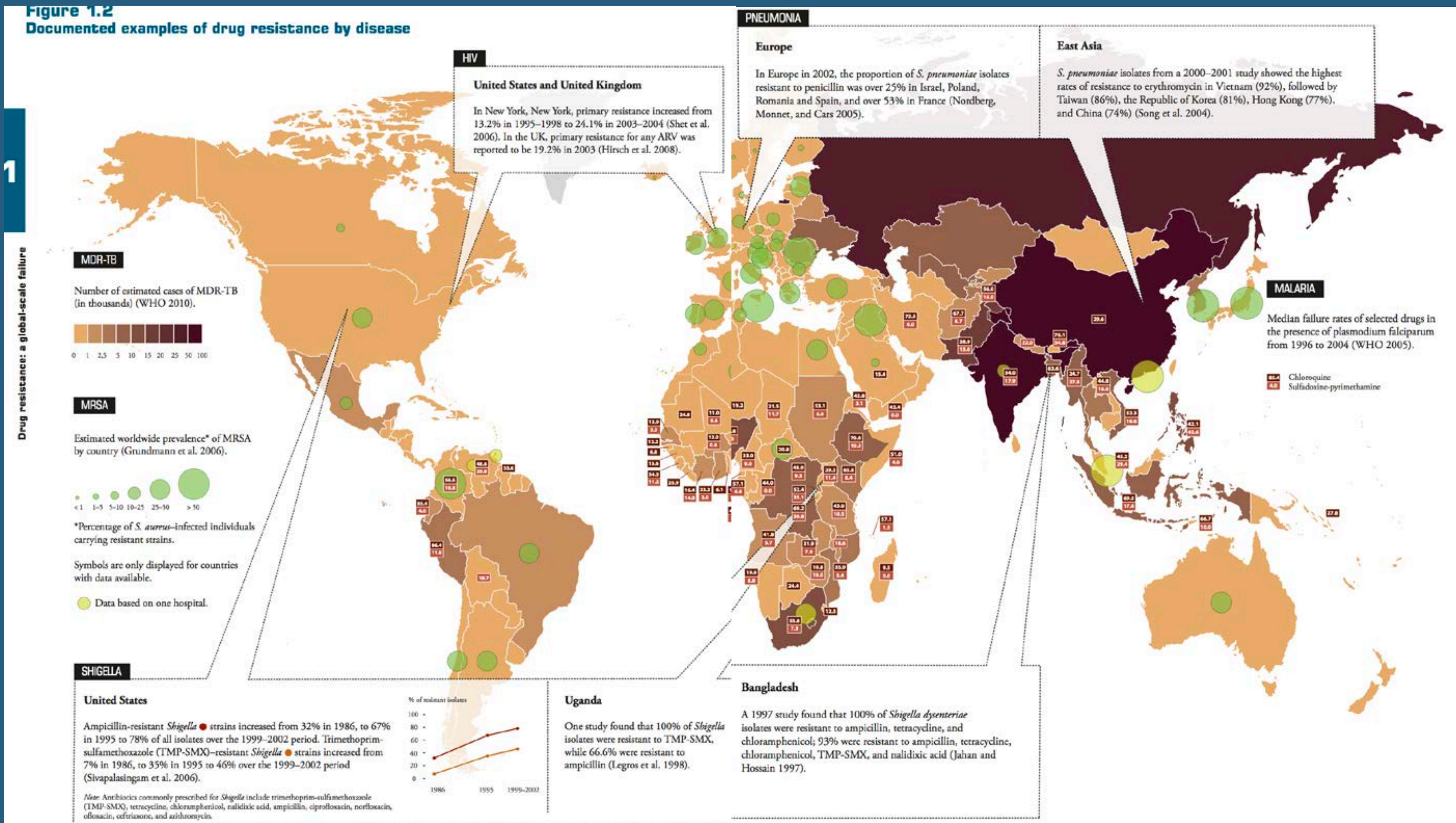
- 23 developing countries (23/147 [15.6%]) reported a functioning HAI surveillance system in 2010
- No published data on HAI endemic burden from 66% (97/147) of developing countries
- HCAI pooled prevalence in mixed patient populations in low- and middle-income countries: 10.1%. In high-quality papers, prevalence: 15.5%.
- SSI is the most frequent HAI hospital-wide in low- and middle-income countries with a pooled incidence of 11.8/100 pts

Healthcare Associated Infections: HK

- 20,355 patients surveyed, 637 had HAIs and 13 patients had >1 HAI.
- Overall prevalence of HAIs was 3.1% (95% CI: 2.9%-3.4%).
  - pneumonia 0.93% (95% C.I.: 0.80%-1.07%),
  - urinary tract infection 0.57% (95% C.I.: 0.48%-0.69%),
  - SSI: 0.52% (95% C.I.: 0.42%-0.62%), skin & soft tissue infection: 0.36% (95% C.I.: 0.28%-0.45%)
  - BSI: 0.33% (95% C.I.: 0.26%-0.42%).

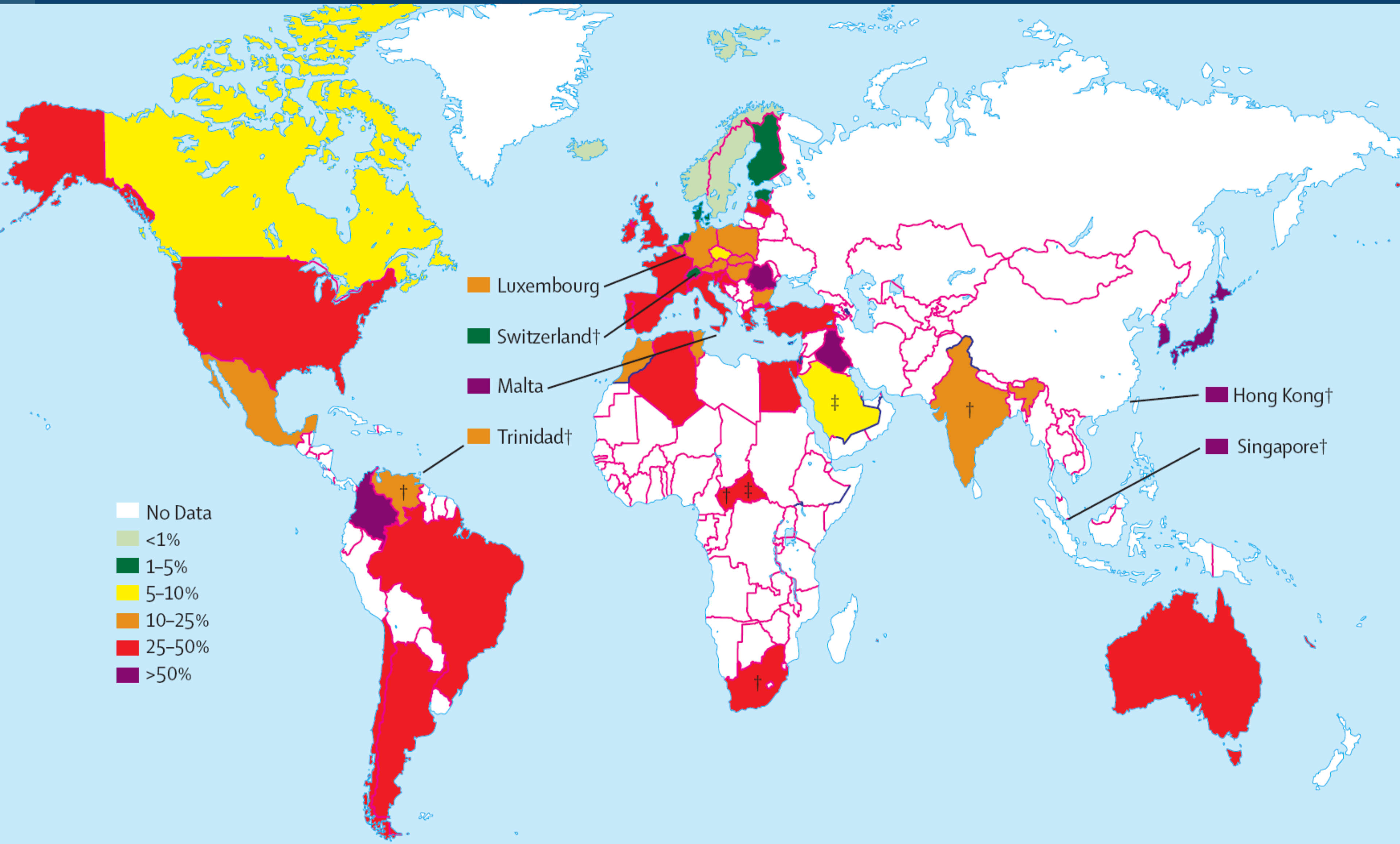
2010 Prevalence Survey of Infections; Report Hospital Authority of Hong Kong

The World of Antimicrobial Resistance



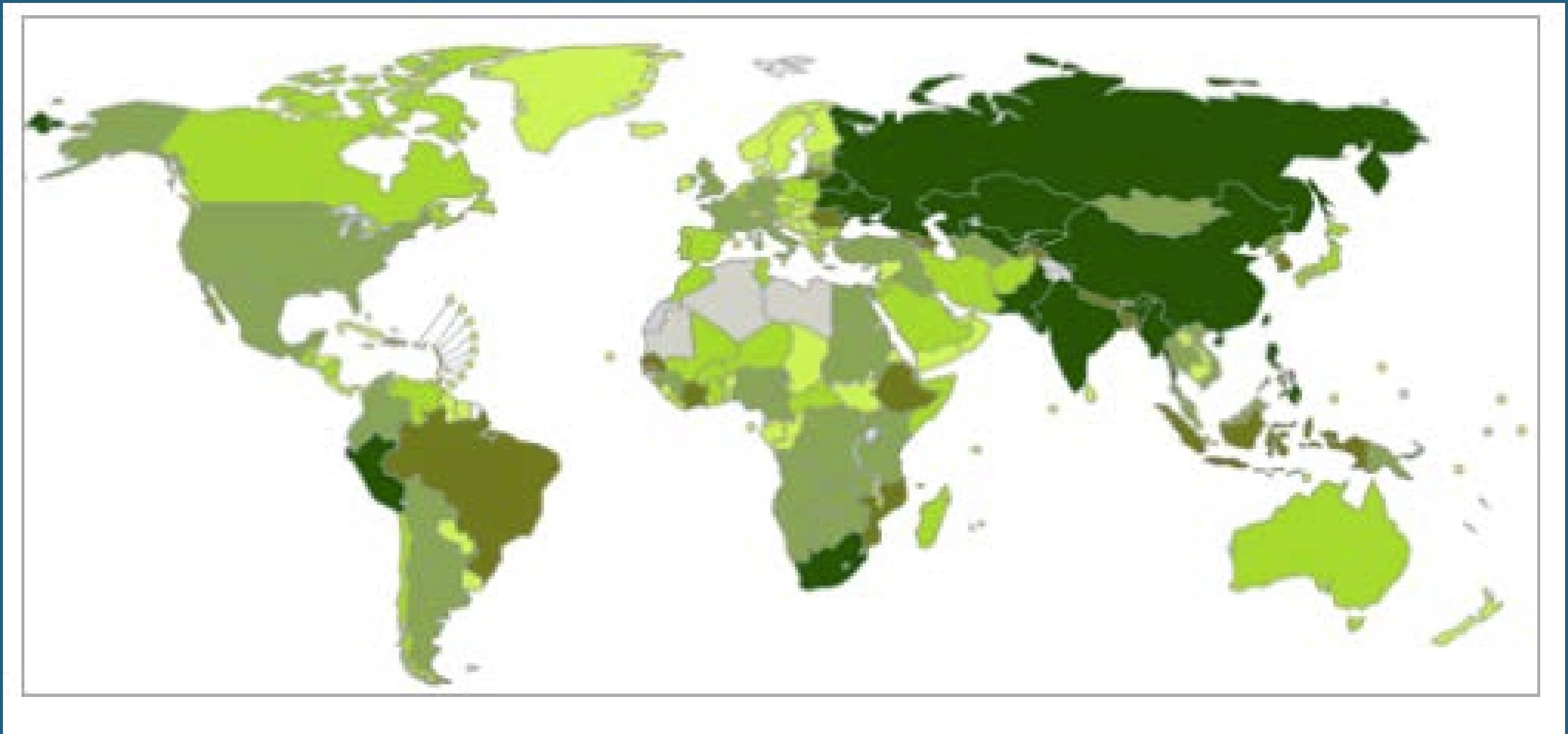
https://www.cgdev.org/files/1424207_file_CGD_DRWG_FINAL.p

Worldwide Prevalence of MRSA



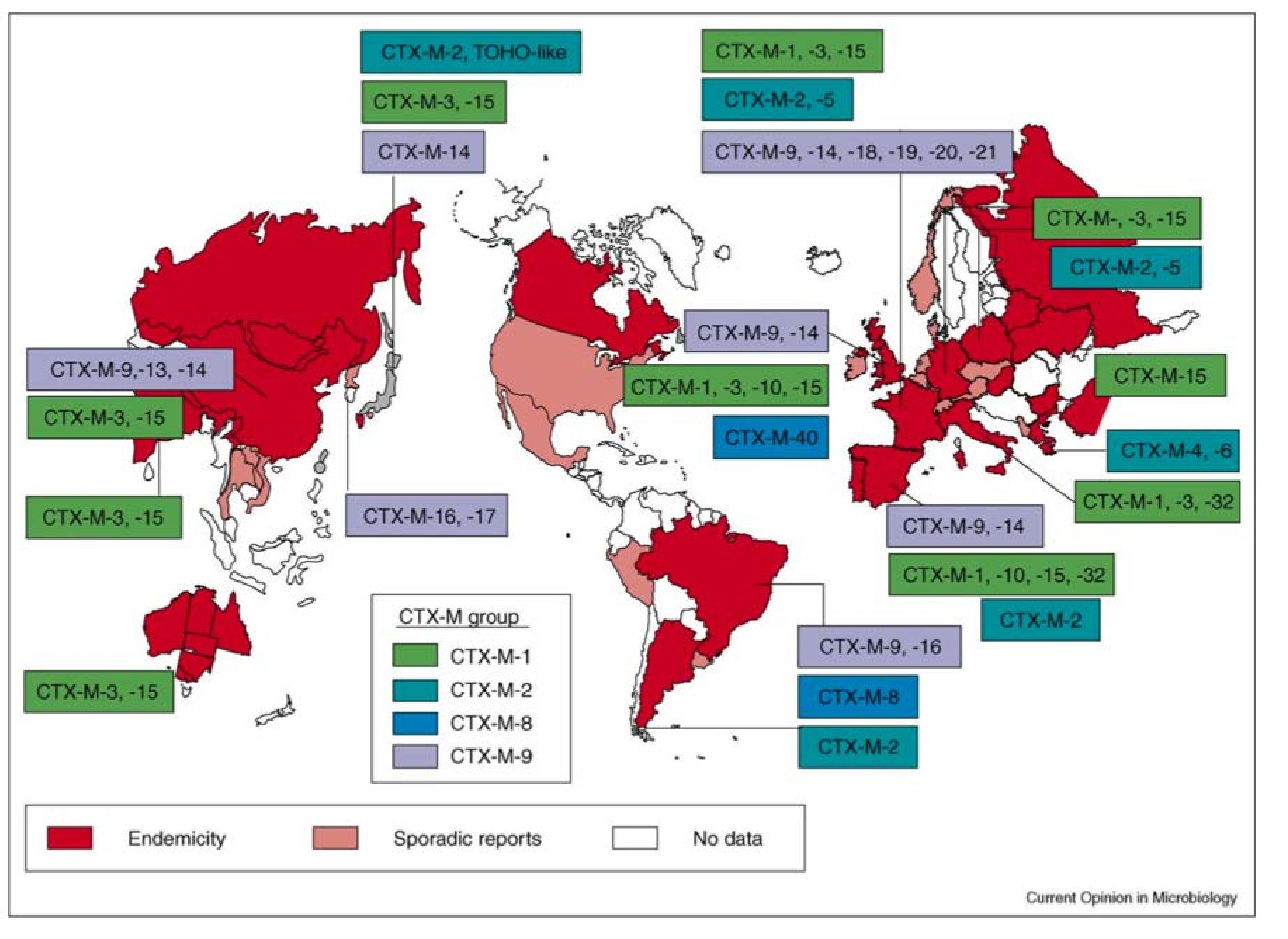
Grundmann et al. Lancet 2006; 368: 874-85

MDR TB



http://www.who.int/tb/areas-of-work/drug-resistant-tb/global-situation/en/

CTX β-lactamase Pandemic



Canton et al. Current Opinion Micro 2006;9:466-75

Spread of KPC-containing *Klebsiella pneumoniae*: Global Travel

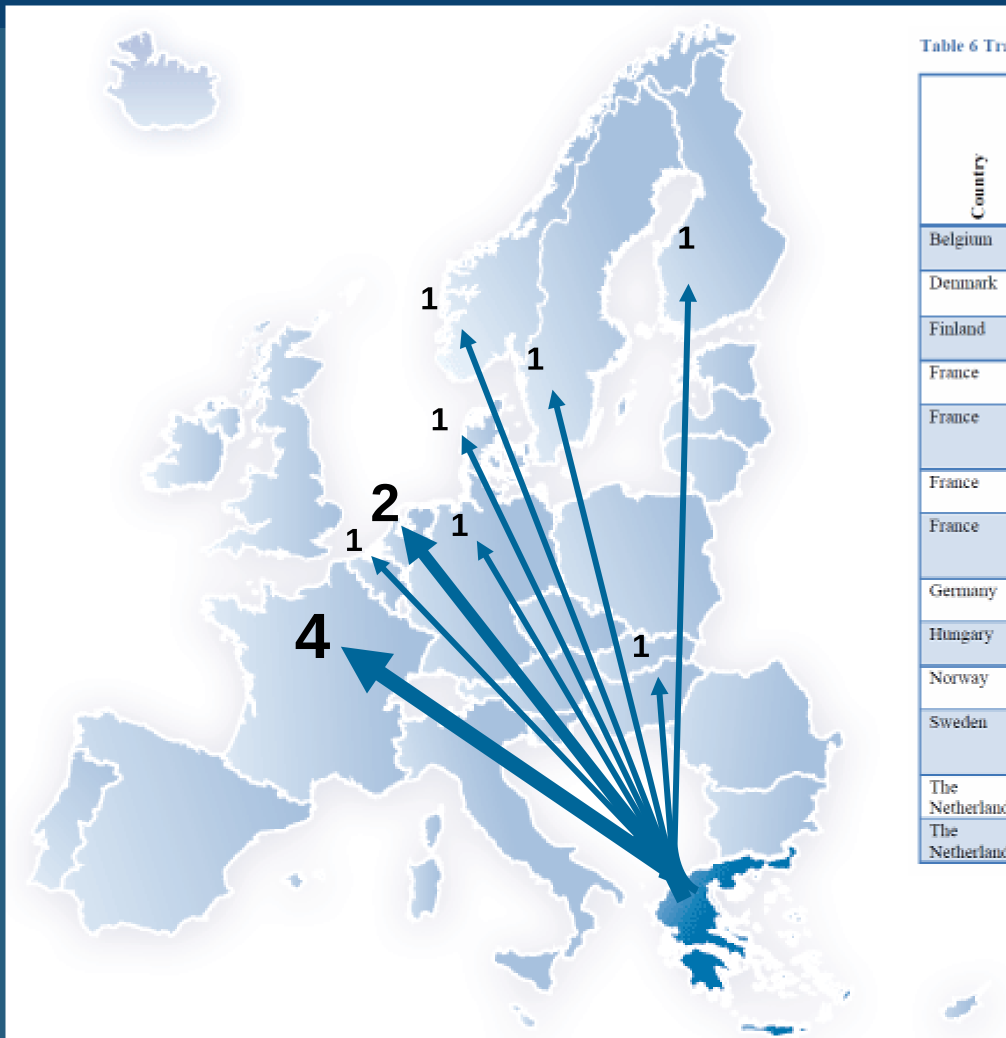


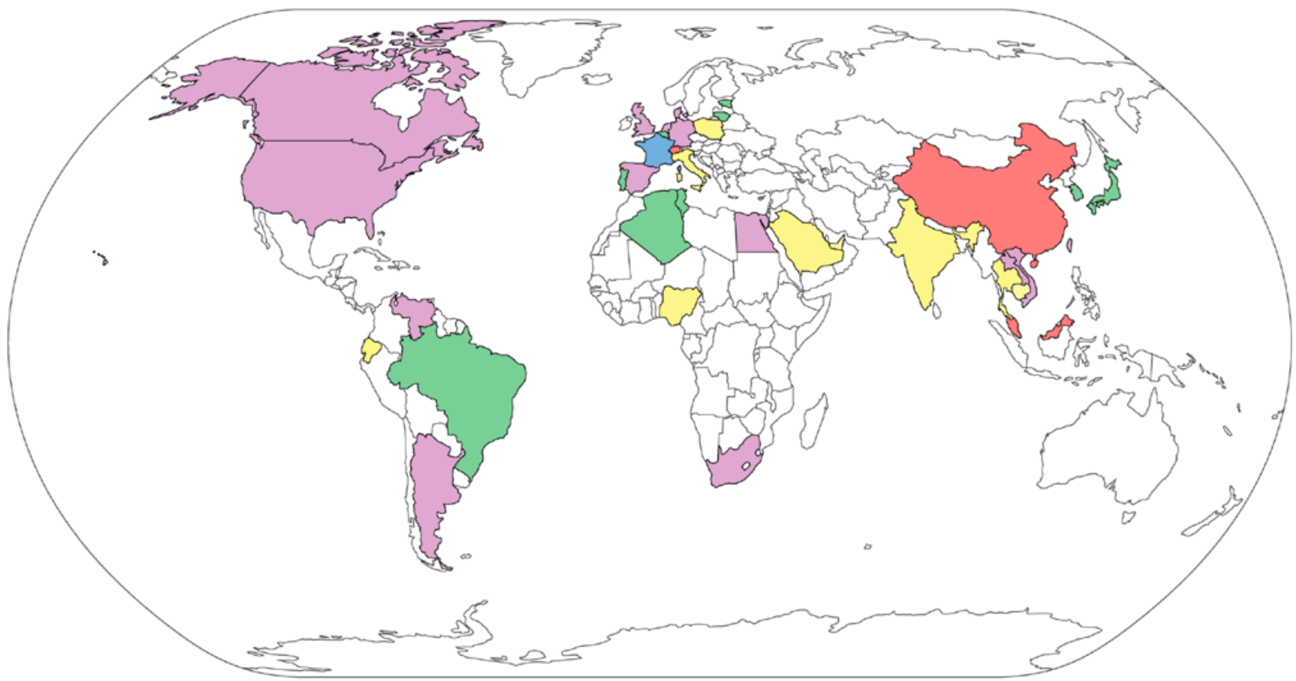
Table 6 Transmission of KPC-Kp from Greece to other countries

Country	Year	Total Number of patients	Data about Greek origin	Further transmission	probability of the Greek Origin	References	Mechanisms of resistance
Belgium	2009	3	3 patients transferred from Greek hospital	0	Confirmed	Bogaerts *et al.* 2010 (144)	bla_{KPC-2}
Denmark	06/2009	2	2 patients transferred from Greek hospitals	0	Confirmed	Hammerum *et al.* 2010 (145)	No data
Finland	06/2009	1	1 patients transferred from Crete	0	Confirmed	Osterblad *et al.* 2010 (146)	bla_{KPC-2}
France	No data	8	1 patient transferred from Chania, Crete	7	Confirmed	Naas *et al.* 2010 (147)	bla_{KPC-2}
France	10/2007	1	1 patient transferred from Heraklion hospital	0	Confirmed	Cuzon *et al.* 2008 (137)	bla_{KPC-2}
France	04/2009	1	1 patient transferred from Greek hospital	0	Confirmed	Barbier *et al.* 2010 (126)	bla_{KPC-2}
France	07/2009	4	1 patient transferred from a Greek hospital	3	Confirmed	Kassis-Chikhani *et al.* 2010 (148)	bla_{KPC-2}
Germany	2007-2008	9	1 patient treated in Greece	8	Hypo-thetical	Wendt *et al.* 2010 (149)	bla_{KPC-2}
Hungary	09/2008	7	1 patient transferred from Greek hospital	6	Confirmed	Tóth et al. 2010 (150)	bla_{KPC-2}
Norway	11/2007	6	4 patients transferred from Greek hospital	2	Confirmed	Samuelson *et al.* 2009 (151)	bla_{KPC-2}
Sweden	No data	1	1 patient transferred from Greek hospital	0	Confirmed	Tegmark Wisell *et al.* (152)	bla_{KPC-2}
The Netherlands	No data	14	African immigrants travelling via Greece	No data	Hypo-thetical	Messen *et al.* (153)	No data
The Netherlands	No data	1	1 patient transferred from Greek hospital	No data	Confirmed	Cohen Stuart *et al.* (154)	bla_{KPC-2}

Wernli D et al. PLoS Medicine 2011

The New Kid on the Block

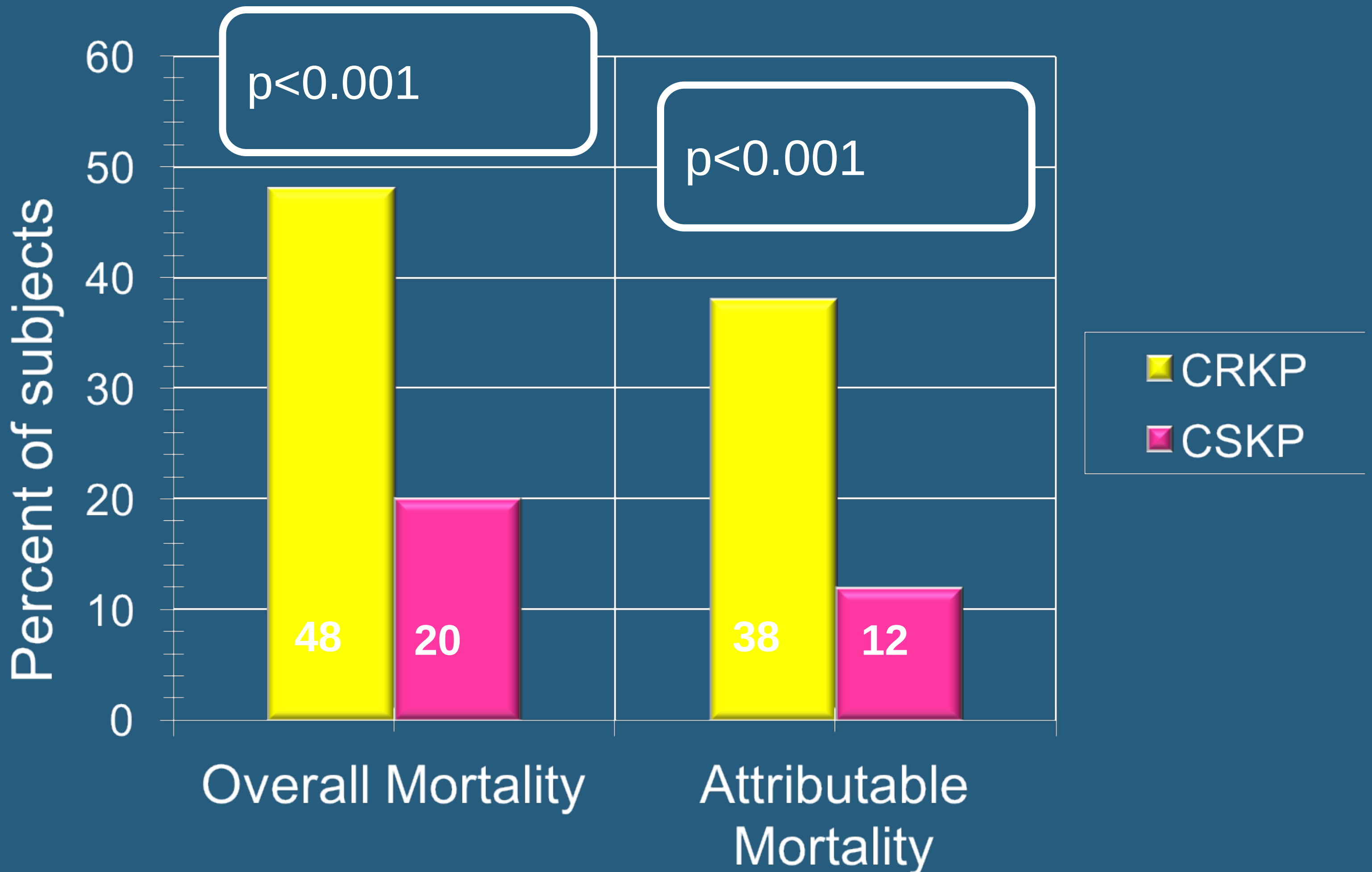
Countries reporting plasmid-mediated colistin resistance encoded by *mcr-1*



Data source: Al-Tawfiq, J. A., Laxminarayan, R. & Mendelson, M. How should we respond to the emergence of plasmid-mediated colistin resistance in humans and animals? Int. J. Infect. Dis. (2016). doi:10.1016/j.ijid.2016.11.415

CDDEP The Center for Disease Dynamics, Economics & Policy
WASHINGTON DC • NEW DELHI

Mortality Carbapenem Sensitive vs Resistant *Klebsiella pneumoniae*

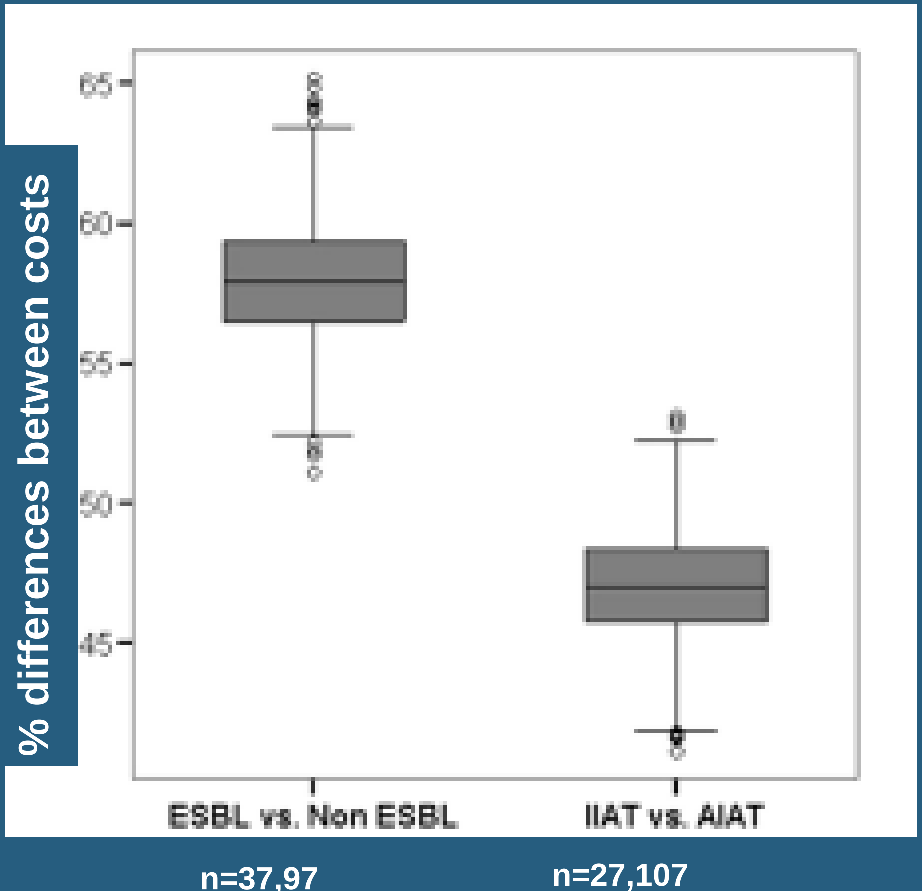


OR 3.71 (1.97-7.01)

OR 4.5 (2.16-9.35)

Hospital costs from *E. coli* BSIs Increased by ESBL Production

- Economic impact of
  - ESBL production
  - Inadequate initial antimicrobial treatment
- ESBL: longer (7d) and more costly (56.5% to 59.4%↑) post-BSI-onset hospital stays
- IIAT: longer (6d) and more costly (45.7% to 48.4%↑) post-BSI-onset hospital stays



IIAT: inadequate initial antimicrobial treatment
AIAT: adequate initial antimicrobial treatment

Tumbarello M. Antimicrob Agents Chemother. 2010 Oct;54(10):4085-91.

The SENIC Study: Is HAI Surveillance Efficacious?

Infection	% prevented
SSI	20 - 35
UTI	38
BSI	15 - 35
Pneumonia	15
Medical	27
Surgical	13

Surveillance is Difficult: Case Finding

- Follow cases as identified systematically—ICD-9 or ICD-10 codes
- Reporting mechanisms
  - Surgeons and OR Staff; ICU personnel
  - ID consults
- Microbiology reports
- Readmissions/Re-operations
- Pharmacy records for ABX use
- Post-discharge surveillance
- Machine learning algorithms

Surveillance Methods

- 100% Chart Review
- Targeted SSI Surveillance: 100% Chart Review for Selected Procedures
- Targeted SSI Surveillance: 100% Chart Review of Patients at High Risk
- Selective Chart Review
- Sampling of patient records and chart review
- Postdischarge Surveillance
- Use of electronic Data Surveillance alone or with "human" surveillance

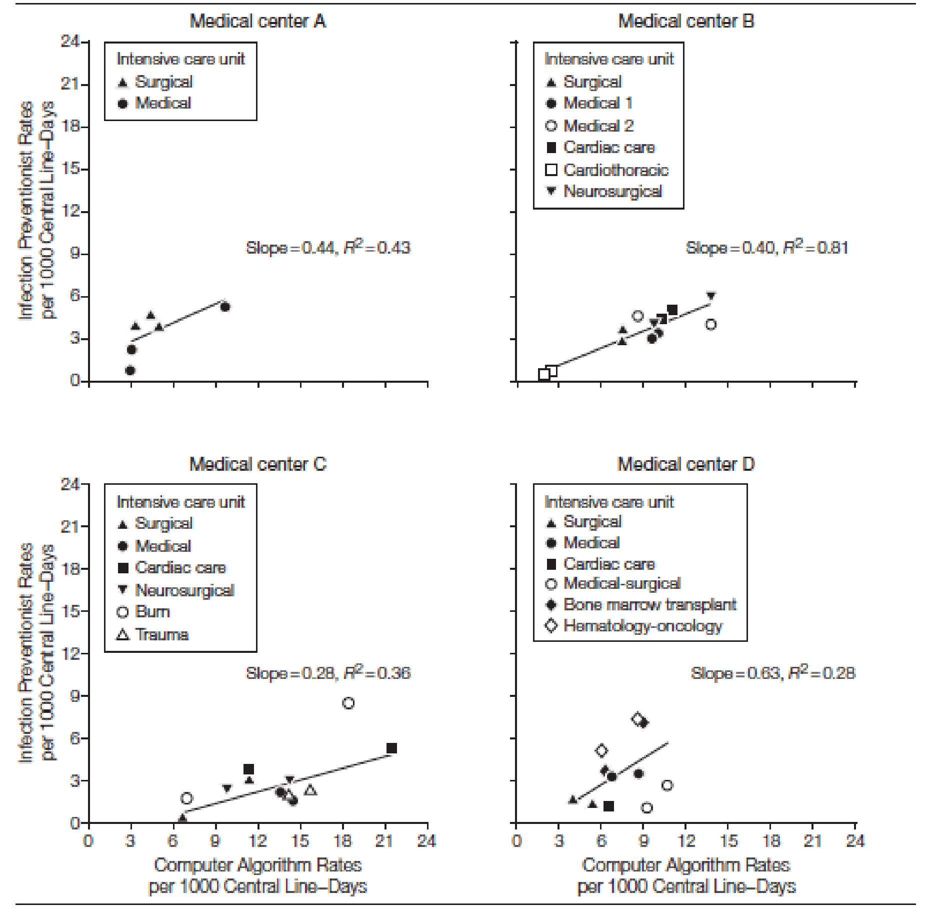
Challenges

- 100% Chart Review
  - Not practical & feasible in large hospitals
  - Take IP away from educational activities
  - The ICP identified 84% of SSIs noted by the hospital epidemiologist
  - Quality depends on completeness of medical records & on the reviewer's experience

How Do You Define a CLABSI: Traditional vs Computer Surveillance

- 241,518 pt days and 165 963 CLdays. Median IP CLABSI 3.0 (2-4.5) vs Computer CLABSI 9 (6.3-11.3)
- Correlation between IP and computer algorithm 0.34

Figure 2. Linear Regression of Rates of Central Line–Associated Bloodstream Infection



Lin et al JAMA 2010:304; 2035

How Do We Find Cases--Can Administrative Data Identify HAI Accurately?

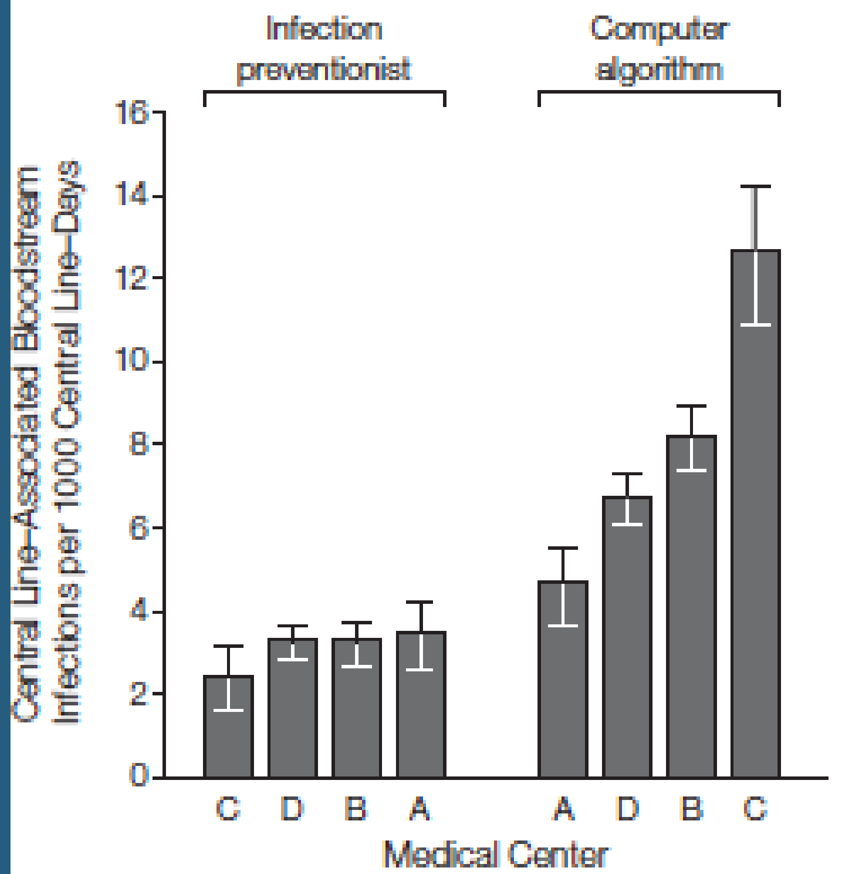
- Cross sectional prospective study--over 9 months 2004--CHOP
- Cases (“true”) met NNIS definitions of HAI
- Determined sensitivity/specificity of identifying HAI by use of administrative data or targeted surveillance

	Sens	PPV	NPV
Cases identified by administrative data	61	20	99
Cased identified by targeted surveillance	76	100	99

Sherman et al. 2006 ICHE:17 (4); 332

Comparison of Traditional and Computer Surveillance

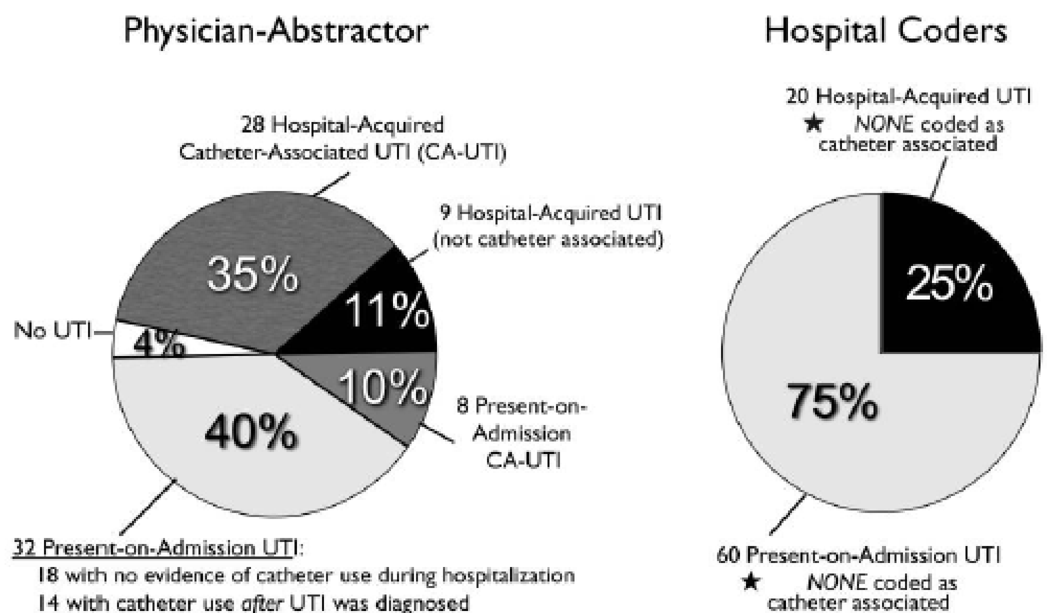
Figure 4. Relative Ranking of 4 Medical Centers



Lin et al JAMA 2010:304; 2035

Insights From CAUTI

- Retrospective chart review of 80 records comparing coders
- to MD abstractors
- Coders identified 20 HA UTI (25%) and no CA UTI versus 37 (45%) & 36 CAUTI among MD abstractors; 8 were present on admission



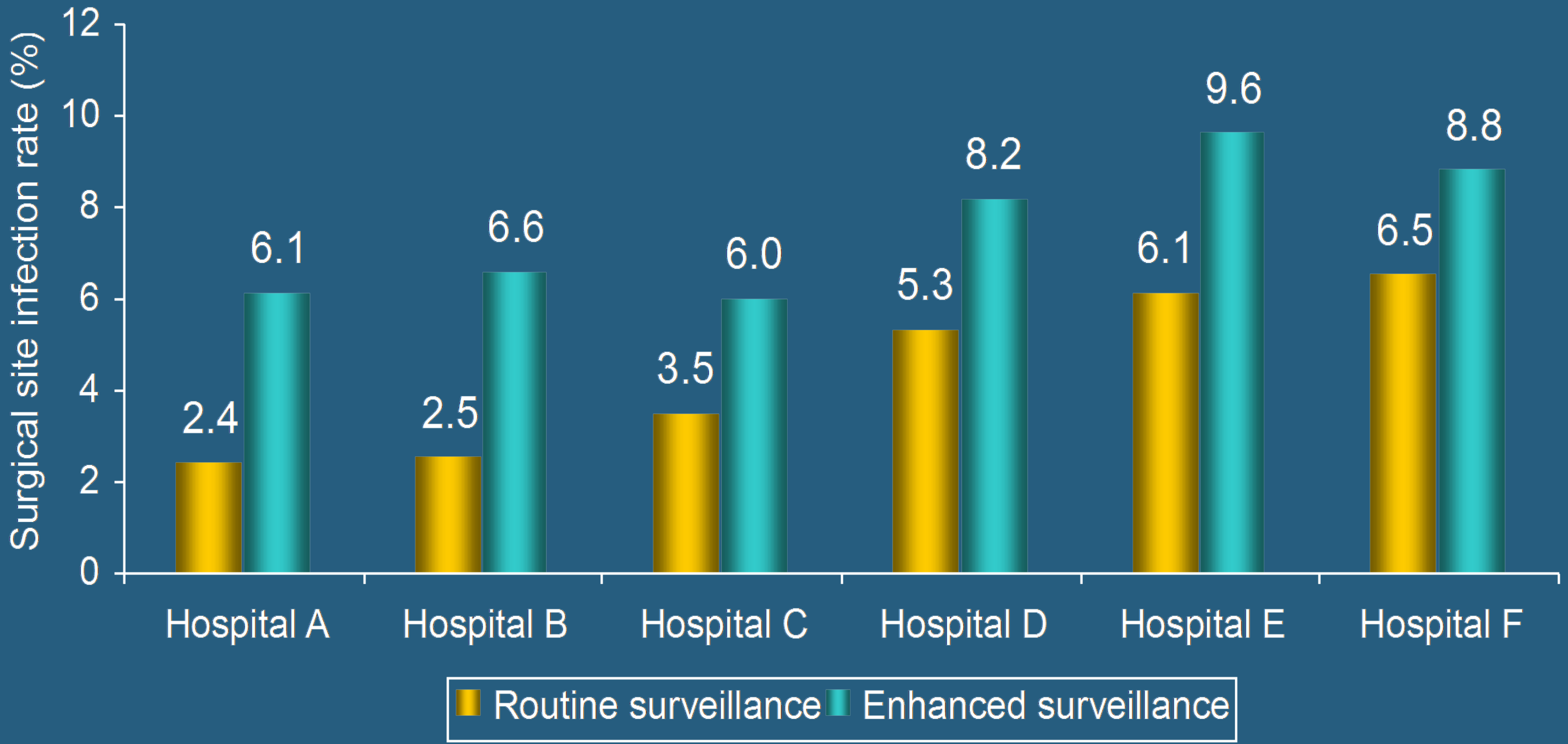
Meddings et al ICHE 2010: 31(6):627-33

Post-discharge SSI Surveillance

- 501 randomly selected surgeries
- 38% contacted by telephone
- 89% reported no complications
- 1% reported no complications and had documented SSI while in hospital
- 9.5% had symptoms: pus, pain, fever
- 89% of patients with symptoms had seen an MD and no MDs reported an SSI
- Required 15 minutes per patient

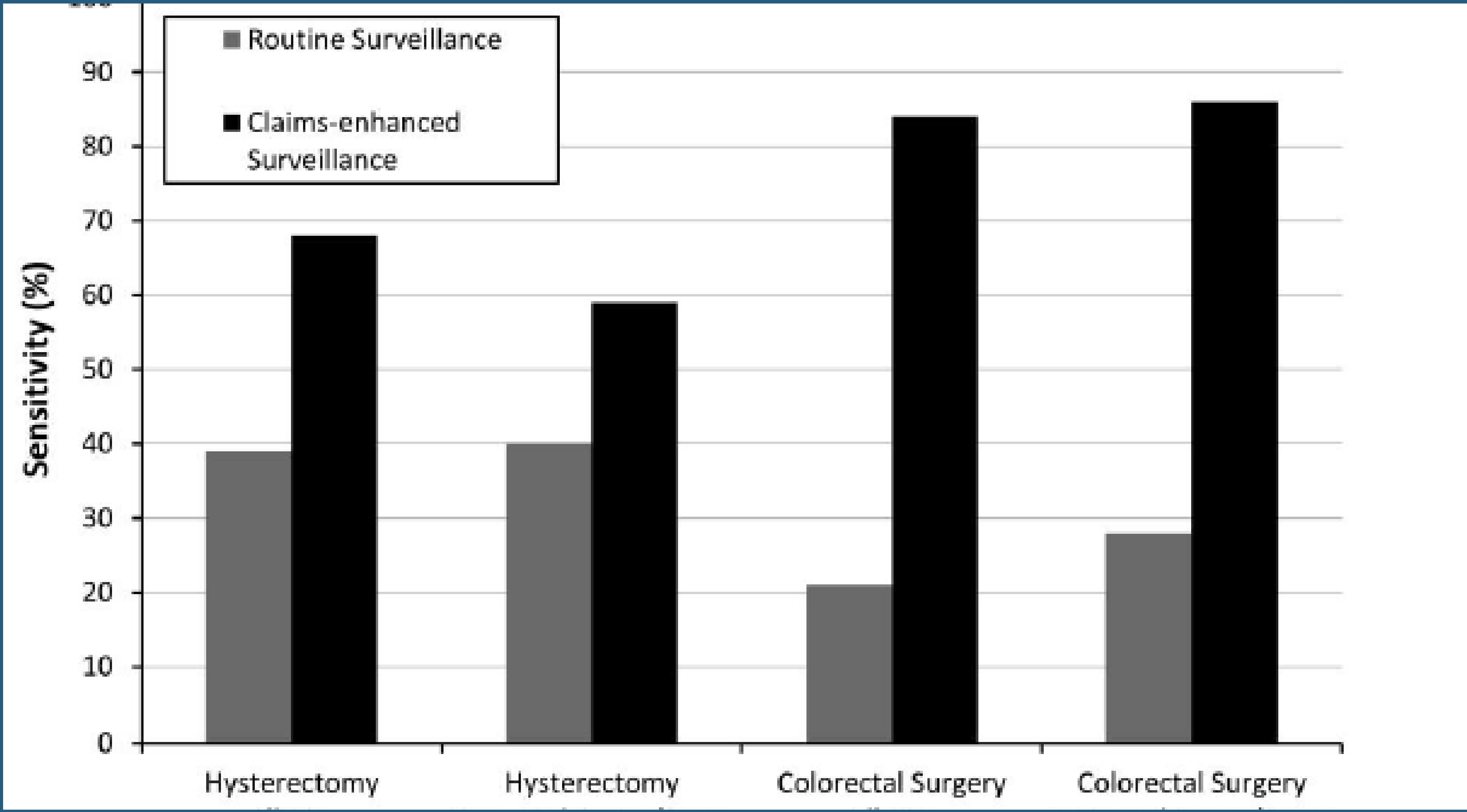
Manian ICHE 1993

SSI Rates
Routine vs Enhanced Surveillance

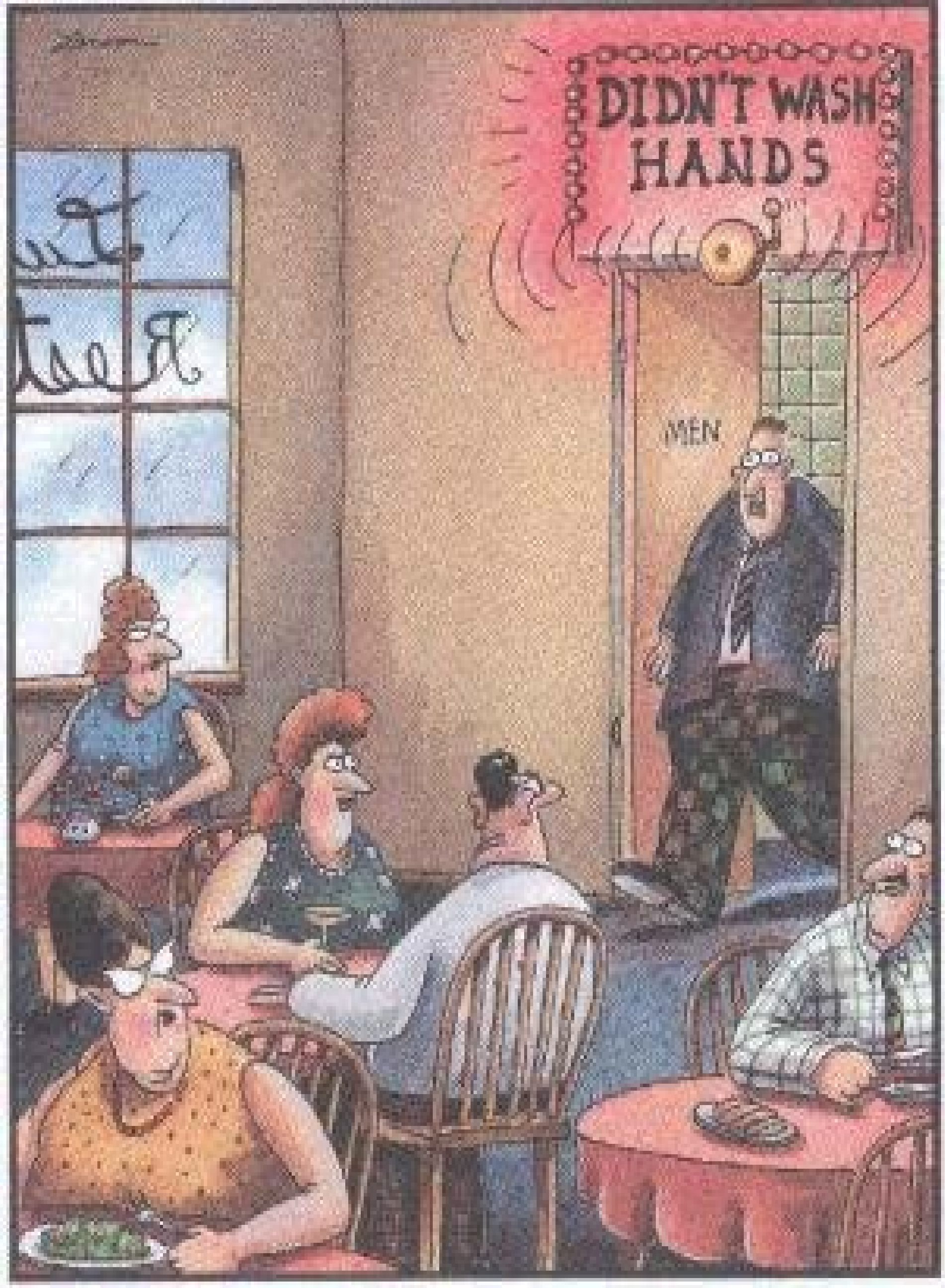


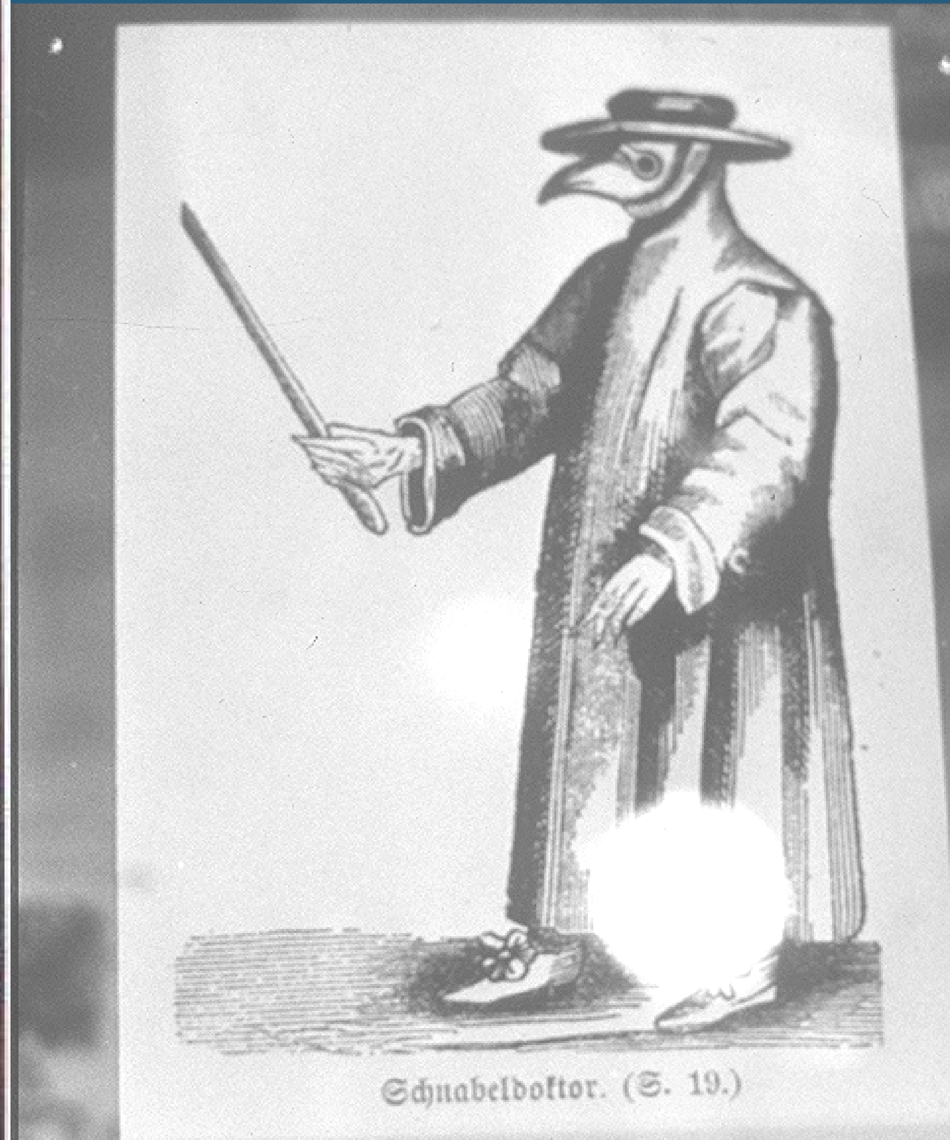
Yokoe. Emerg Infect Dis 2004;10:1924-30.

SSI Detection: Claims Data



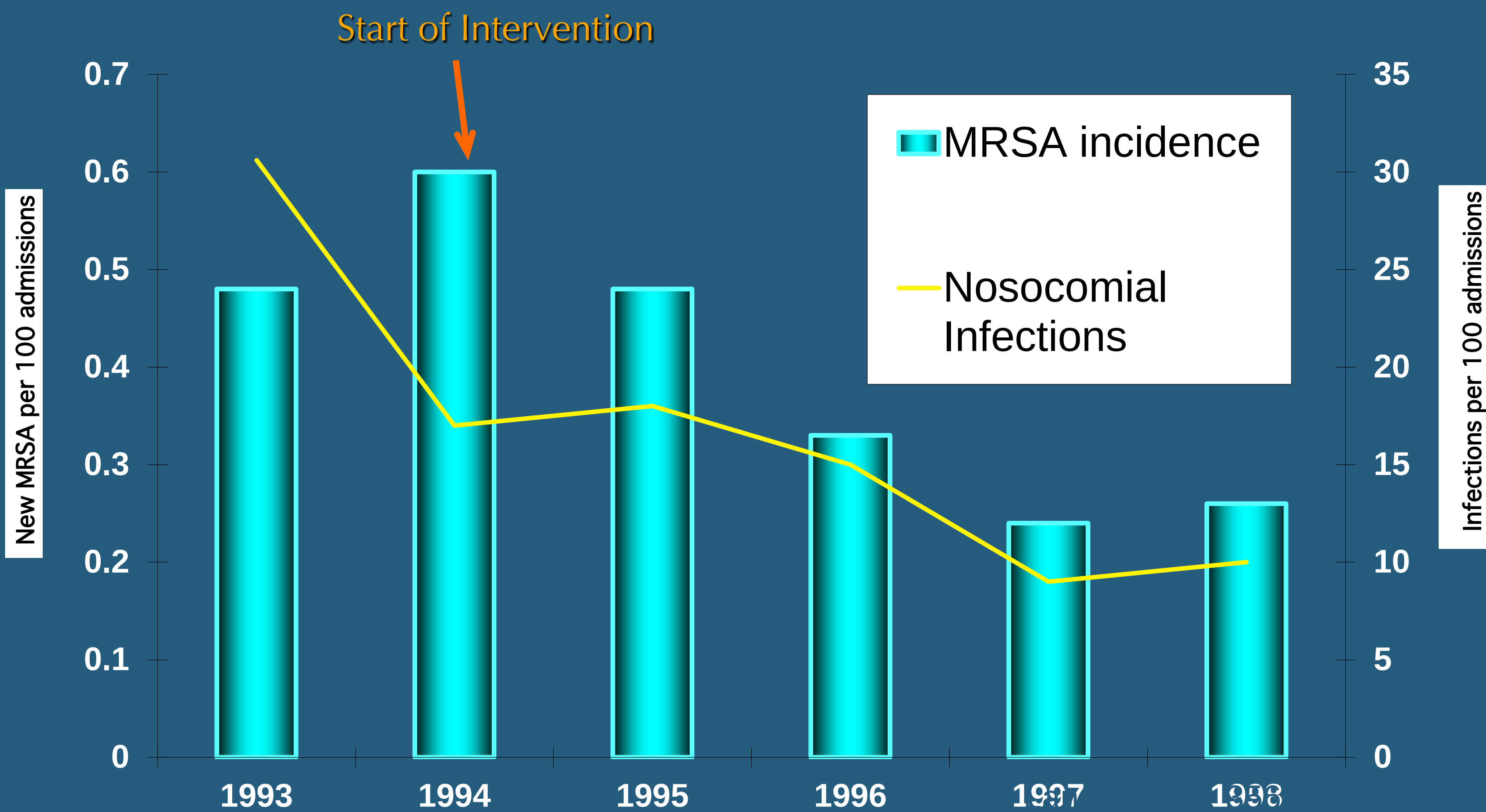
LeTourneau etal. ICHE 2013;34:1321-3.

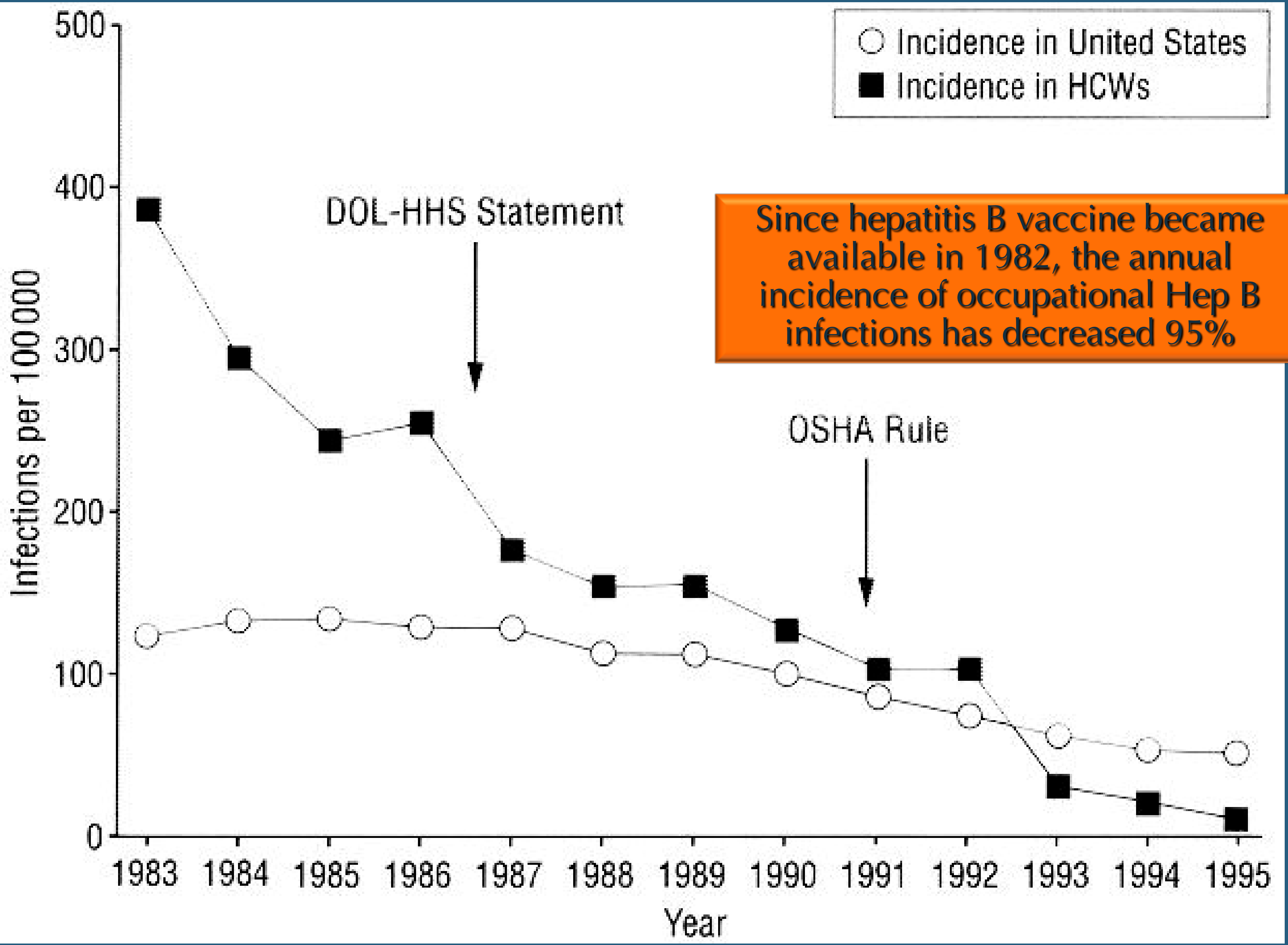




"Schnabeldoktor": Protective clothing against pestilence, from the
tury. From: Schimmer, Karl Eduard: "Alt und Neu Wien."
Vienna and Leipzig, 1904, vol. 2, p. 22.

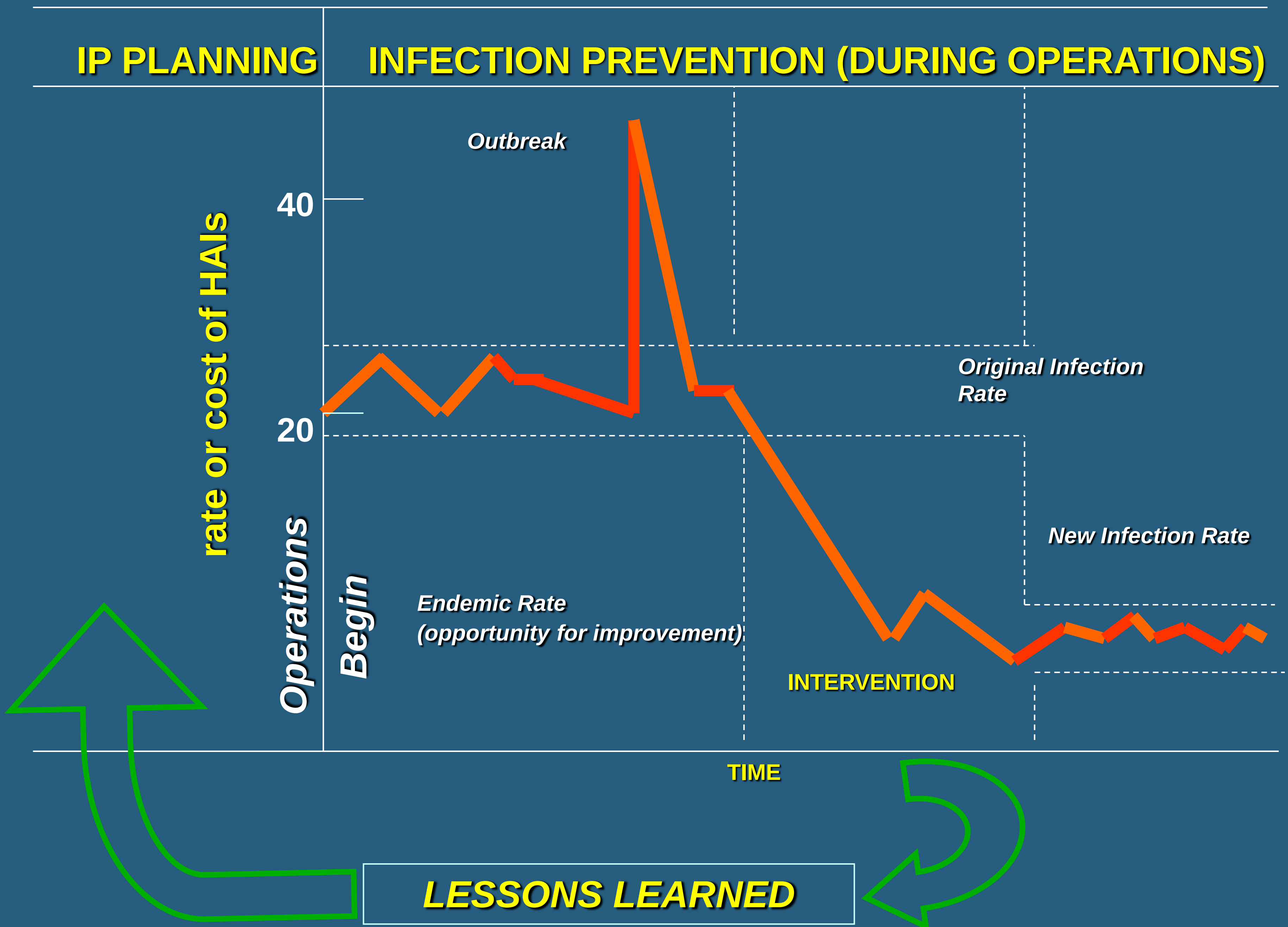
Does it Matter if We Clean Our Hands?





Since hepatitis B vaccine became available in 1982, the annual incidence of occupational Hep B infections has decreased 95%

Mahoney FJ et al Arch Internal Med 1997;157:2601+


IP PLANNING
INFECTION PREVENTION (DURING OPERATIONS)
Outbreak
40
rate or cost of HAIs
Original Infection Rate
20
New Infection Rate
Operations
Begin
Endemic Rate
(opportunity for improvement)
INTERVENTION
TIME
LESSONS LEARNED

Anatomy of an Intervention

Predisposing f
Knowle
Attitu
Beli

Enabling f
Skills
Equipment
Facilities

Reinforcing factors
Feedback
Peer/supervisor support
Patient participation
Link to changes in infection rates

revention of
CA-BSI

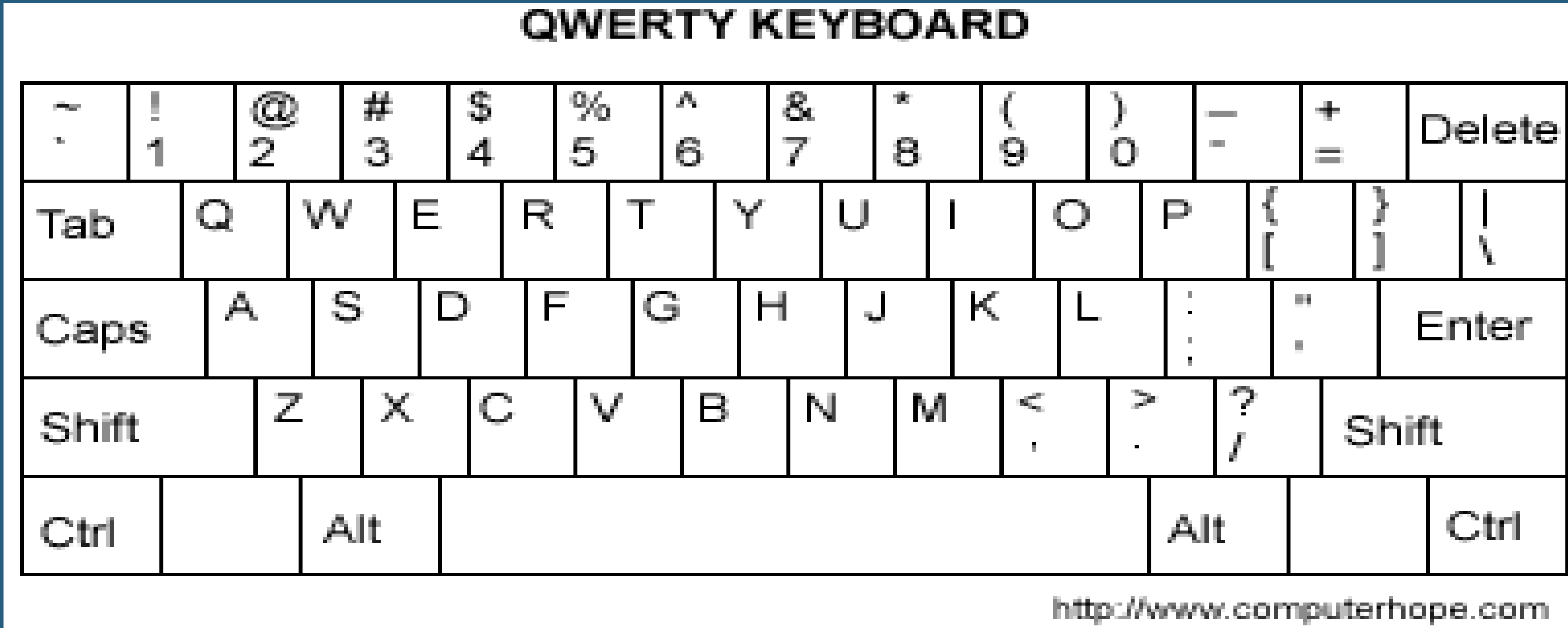
Positive Deviance
CUSP
Other methods or frame works of organizational implementation

How Does Innovation Disseminate?

- Most innovations diffuse at a disappointingly slow rate
- 1497 - Vasco de Gama's voyage around the Cape of Good Hope: 100/160 crew members died of scurvy
- 1601 – James Lancaster (English captain): quasi-experimental study of 4 ships to India.
  - Sailors on 1 ship received lemon juice (3 tsp/d); sailors in other 3 ships got nothing
  - "Lemon" ship = all healthy; control ships = 110/278 died

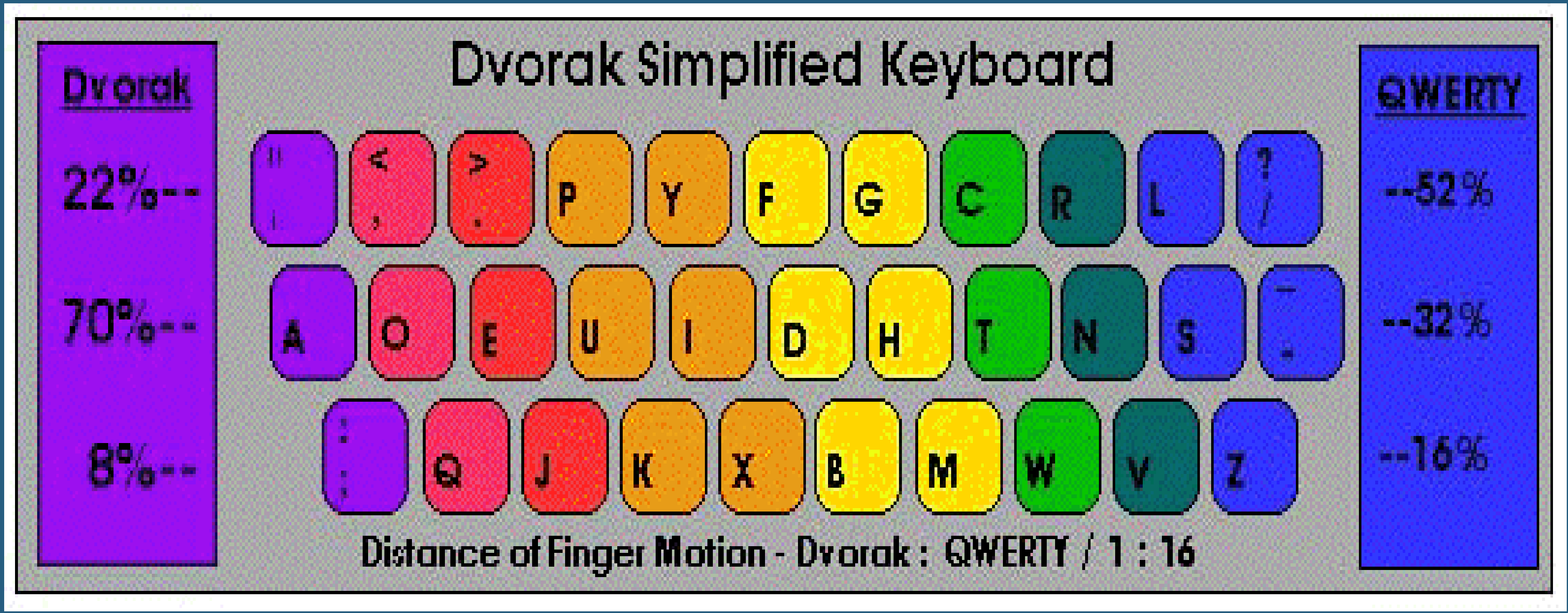
And Then!

- British Navy should adopt citrus juice for scurvy prevention given these findings, correct?
- 1747 - James Lind (British Navy physician): confirmed Lancaster's findings from 150 years earlier
- 1795 – British Navy adopted this innovation and scurvy eradicated (48 years after Lind's study)
- 1865 (70 years later) – this innovation adopted in the British merchant marine
- Does this type of delay (non-diffusion) happen *today*?



- QWERTY keyboard invented in 1873; intentionally <u>inefficient</u>

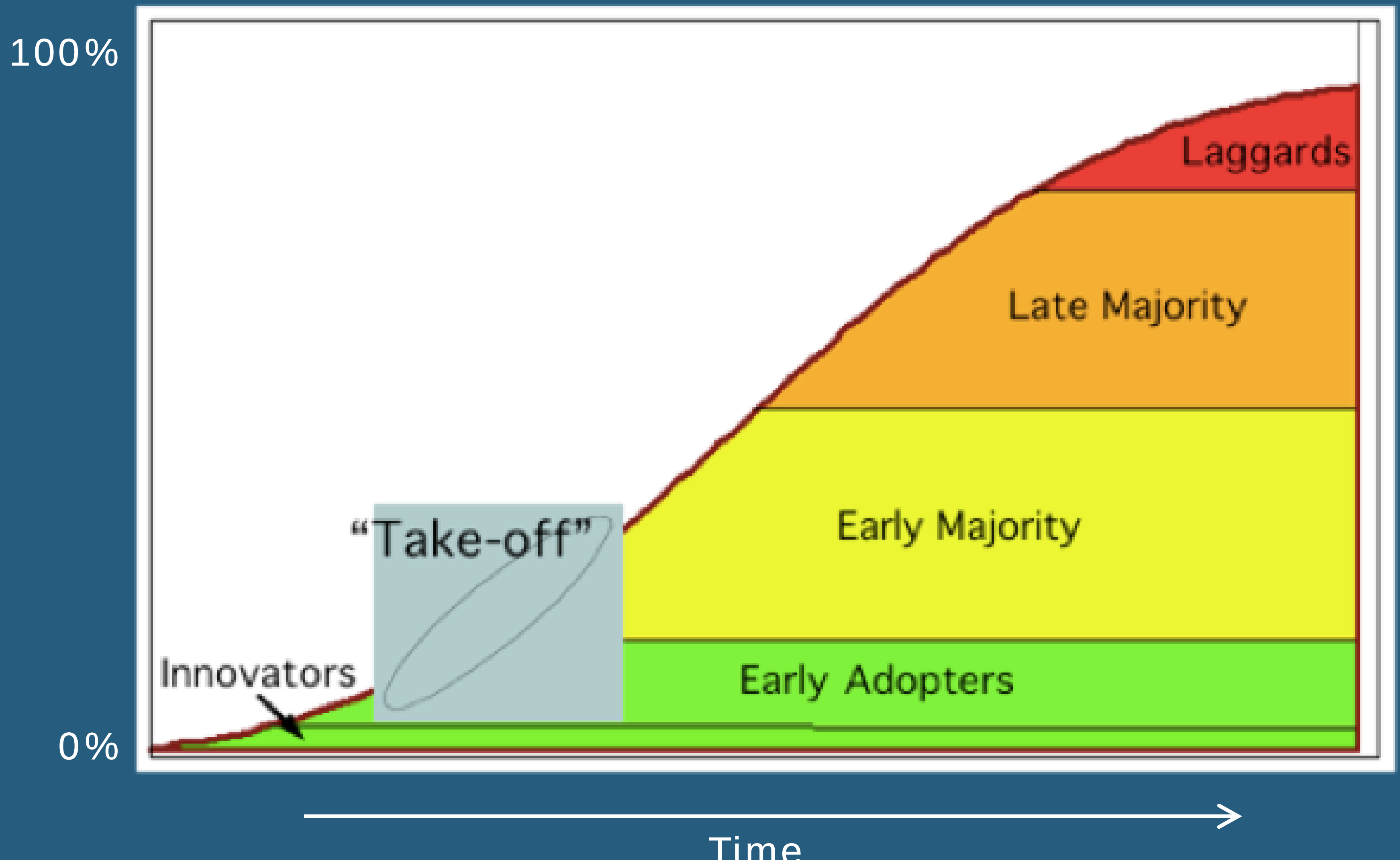
Is there a better keyboard?



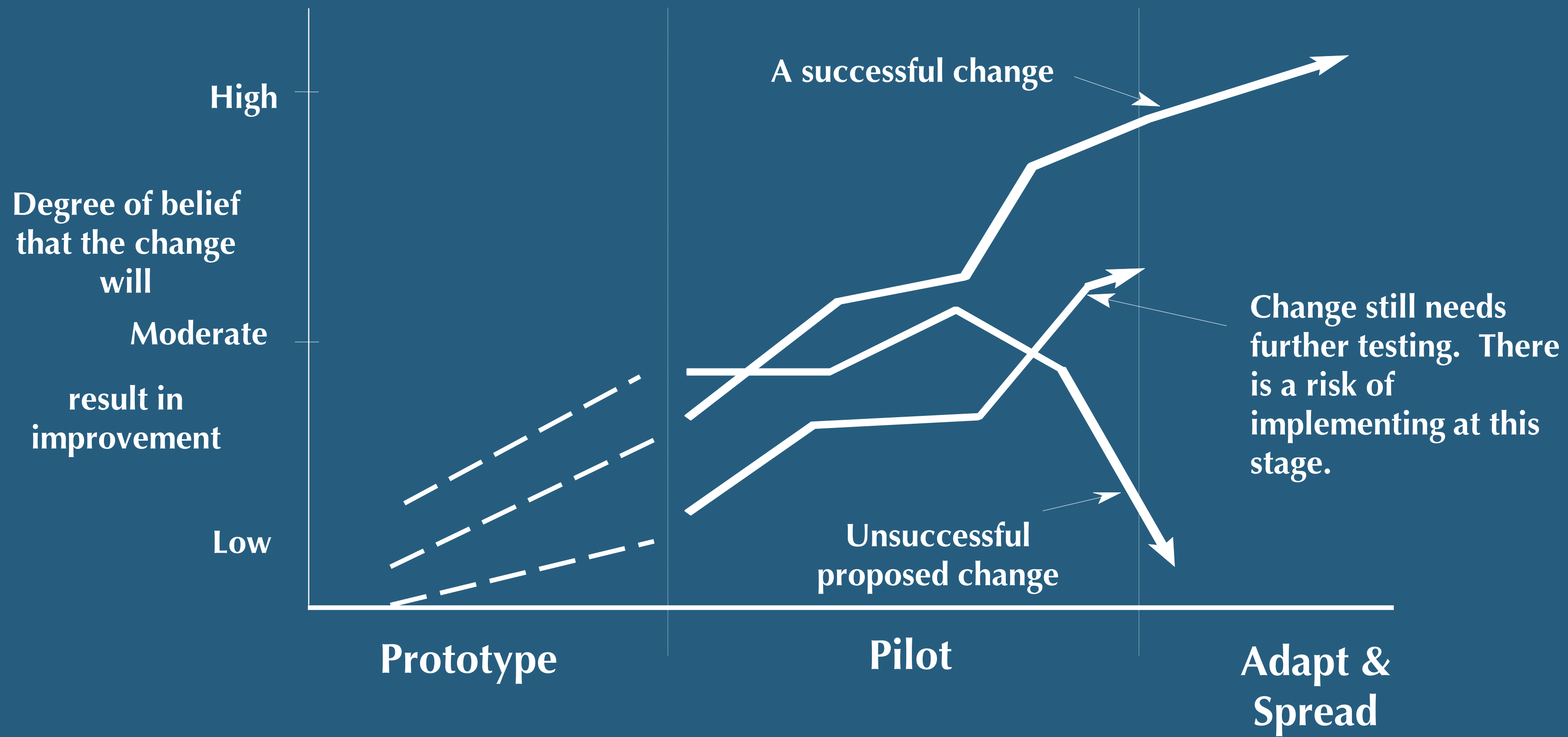
- Dvorak (1932): a new keyboard based on time-motion studies
- Each finger's work is proportionate to its skill & strength
- National organizations: approved this keyboard as an alternative
- Despite obvious advantages: >90 years w/out much use

The 'Take Off' Point

The Majority Engages, Adoption Becomes Irresistible



Building Confidence, Implementing Change



Conclusion

- HAI's and antimicrobial resistance remain significant causes of morbidity and mortality.
- Surveillance is a tool which has helped define the impact of HAIs but now must innovate to help channel resources elsewhere.
- Implementation of simple prevention strategies will generate improved patient safety and visibility at the institution.
- Ultimate patient and healthcare worker safety will require healthcare innovation.
- The components and paradigm in healthcare requires evidence based practices & implementation of social theory change.