



Centers for Disease Control and Prevention

# Infection Concerns and Solutions in the Endoscopy Suite

43<sup>rd</sup> Annual Seminar for GI Nurses and Associates

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# Disclosures

- Boston Scientific – Clinical Education Training

# Agenda Slide

Introduction

Sources of risk in the GI lab

Multifactorial cause of endoscope infection

“Low-tech” and “High-tech” solutions

Summary and recommendations

# Introduction

# The problem is real, and is on the public's mind

## *These Medical Are Inserted Into Patients Each Year Are Tough to*

Duodenoscopes have sickened hundreds of patients in hospital outbreaks. Now some experts are calling for the devices be redesigned or taken out of use.

ars TECHNICA    BIZ & IT    TECH    SCIENCE    POLICY    CARS    GAMING & CULTURE    STORE

FARM-RAISED INFECTIONS —  
**Deadly superbug outbreak in humans linked to antibiotic spike in cows**  
Use of certain antibiotics in cattle increased 41% just before the outbreak.  
BETH MOLE - 8/23/2019, 2:15 PM



Enlarge

82

A deadly outbreak of multi-drug resistant *Salmonella* that sickened 225 people across the US beginning in 2018 may have been spurred by a sharp rise in the use of certain antibiotics in cows a year earlier, infectious disease investigators reported this week.



bladder. An endoscope tube runs to the lower left. Science Source

NYTimes.com , accessed 8/6/19  
Arstechnica.com , accessed 8/25/19

# BUT, endoscope infections are not new!

1993, Pseudomonas /  
Klebsiella, defective AER

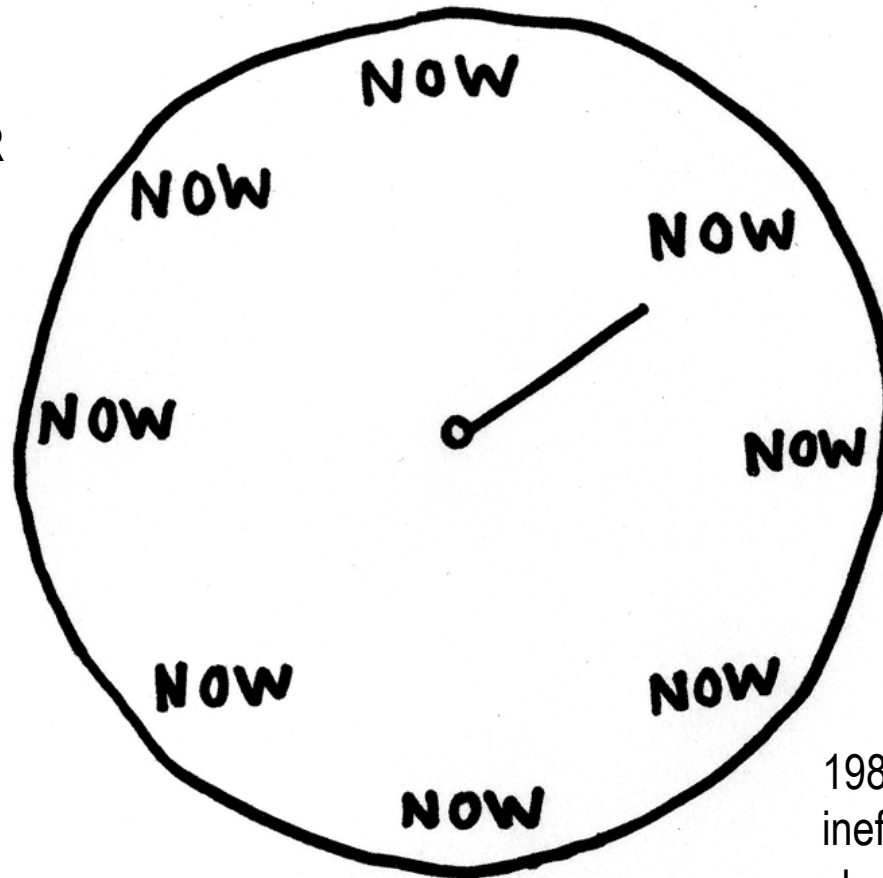
1988, Pseudomonas,  
contaminated lens  
wash bottle / basin, no  
drying

1985, Pseudomonas,  
ONLY tap water flush  
between cases!

Elson 1975  
Low 1980

Cryan 1984  
Earnshaw 1985

Struelens 1993  
Image: giphy

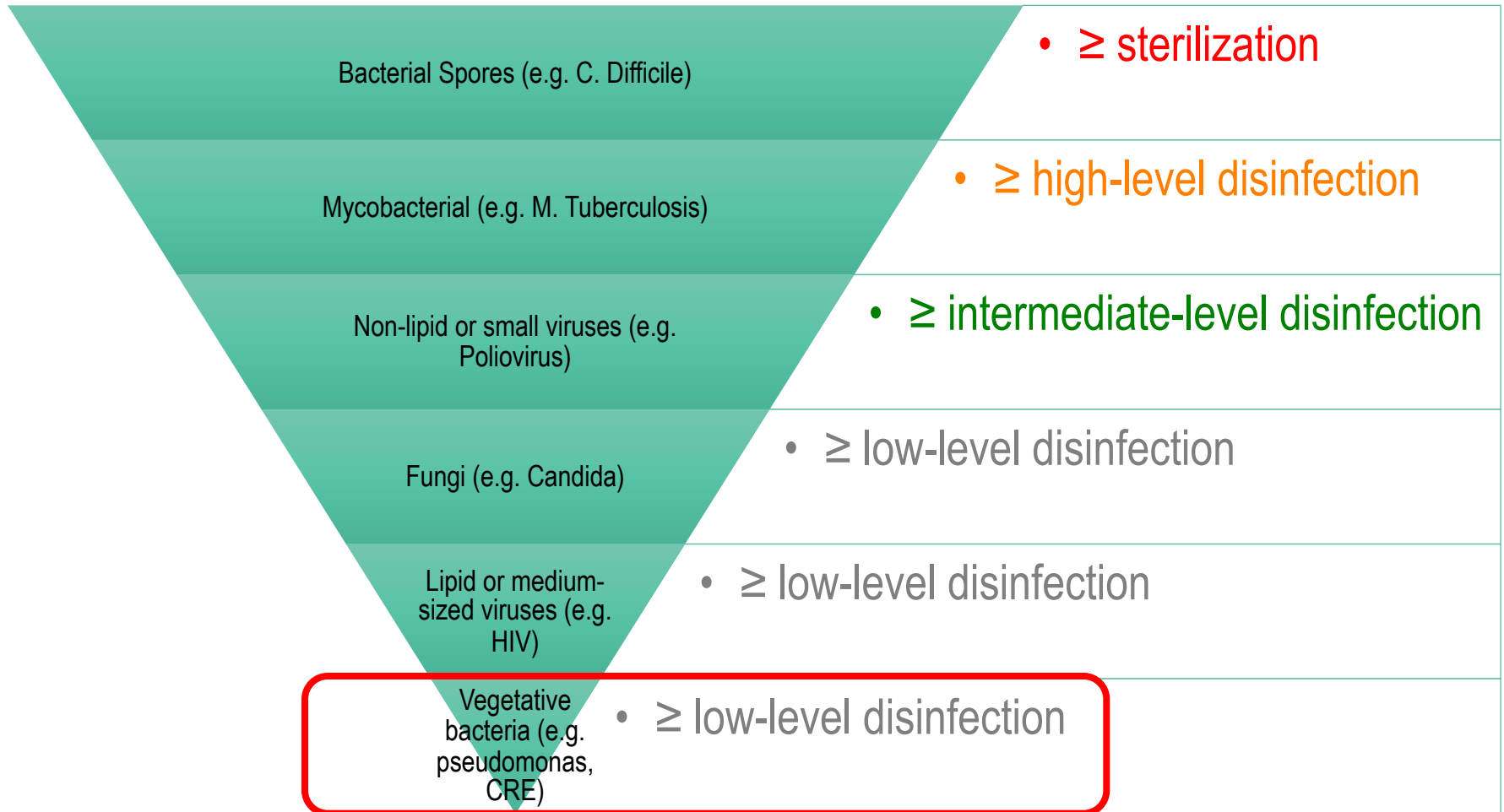


1975, Pseudomonas,  
ineffective disinfectant

1980, Pseudomonas,  
ineffective disinfectant /  
no brushing

1984, Pseudomonas,  
ineffective disinfectant & A/W  
channel not washed

# Resistance to biocides (most to least)



Adapted from Endoscopy Handbook 2<sup>nd</sup> Ed, p12

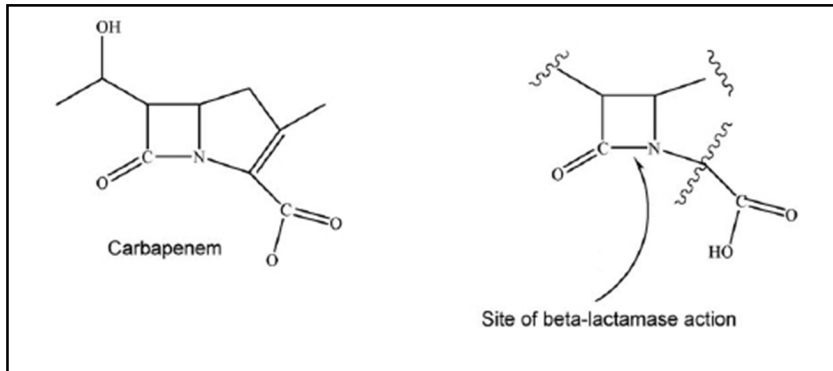
# What is Enterobacteriaceae? (CRE)

- Family of 70 commonly-found GUT flora
- Opportunistic infections
  - Asymptomatic CRE colonization can occur
  - Immunocompromised state increases risk of active infection
    - Bone Marrow Transplant
    - Hematology-oncology wards

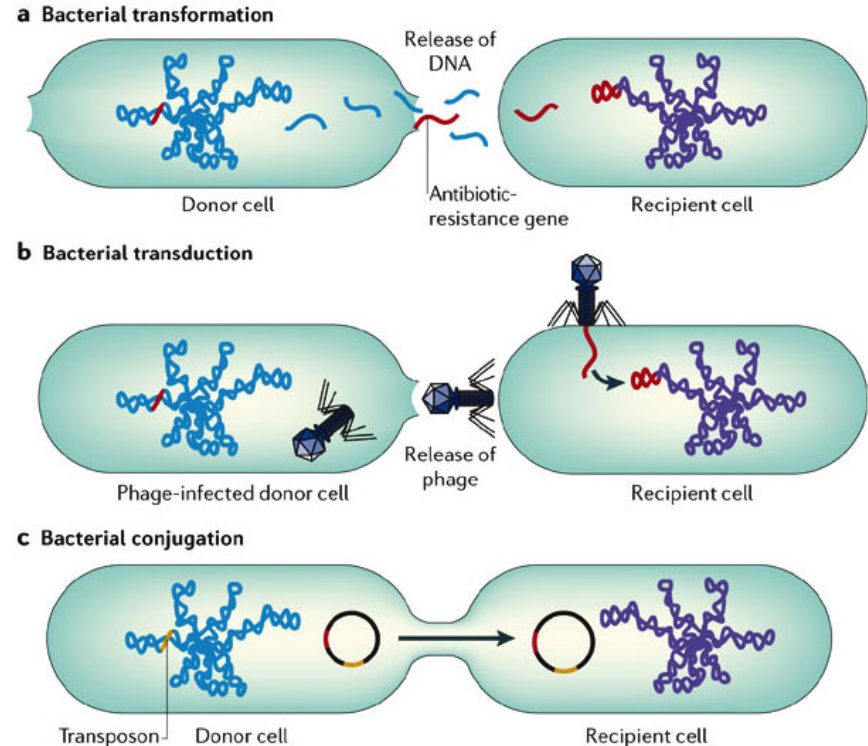
Oren 2013  
Muscarella LF 2014



# Carbapenem resistance (CRE)



- Carbapenem – beta lactam ring (similar to penicillins)
- Resistance may occur through
  - Antibiotic resistance gene transfer (right)
  - active drug removal
  - alteration of bacterial target, etc

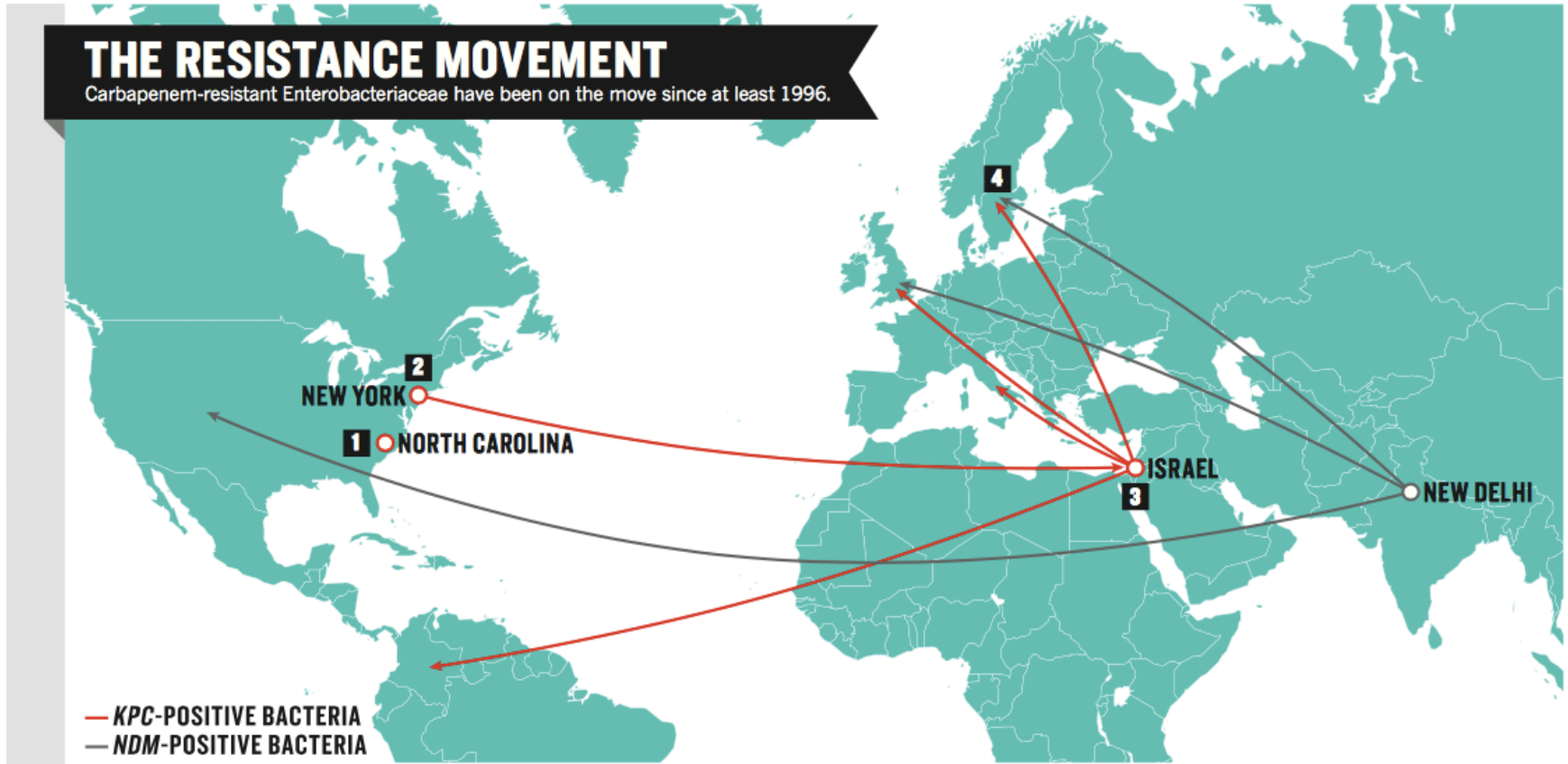


Copyright © 2006 Nature Publishing Group  
Nature Reviews | Microbiology

Wikipedia  
Muscarella LF 2014

Furuya EY 2006

# The rise of CRE



1. '96, NC ICU – KPC resistance gene
2. '03, spread thru NYC; '07, 21% KPC gene

3. '05, Israel, UK, Sweden, Italy, Columbia
4. '08, Sweden discovers new gene, NDM

Adapted from McKenna M, 2013

# Sources of risk in the GI lab

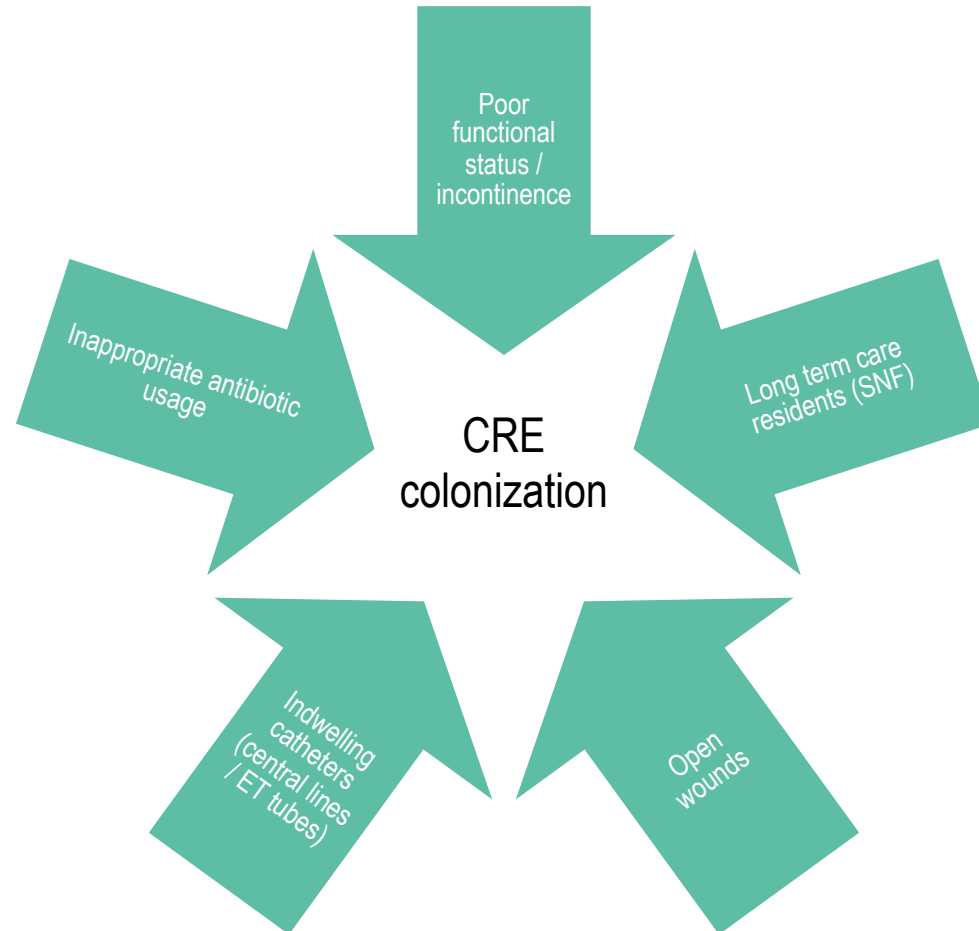
# Where is the possible source of infection risk?



Answer:  
**ALL OF THE ABOVE**

Image: maniladoctors.com.ph

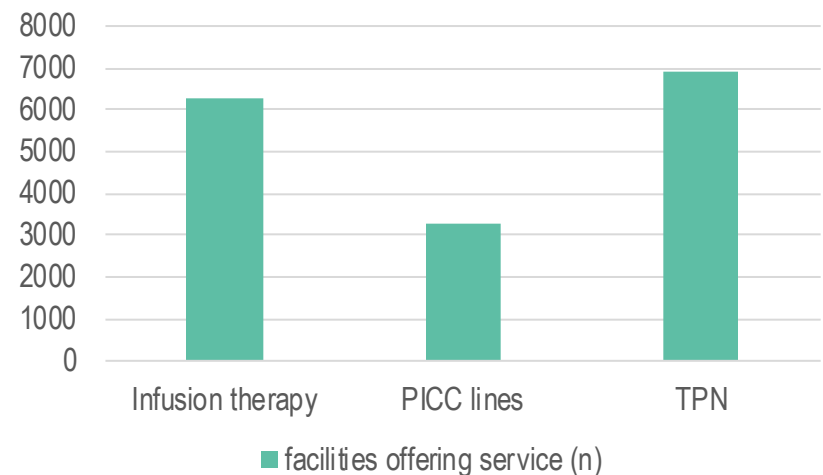
# 1. Source of risk – patient (“people”)



# Long term care pts (lines, incontinence, etc.)

- T cell function decreases among the elderly
- PLUS multi-hit hypothesis
  - Malnutrition, chronic illness, Functional impairments
    - reduced continence, cough reflex
  - ~ 50% of LTC patients with assistive needs (graph)
  - “Sicker patients, sooner”
    - Higher rates of antibiotic usage

Survey of 15k LTC facilities ('04)



Smith 2008

# Inappropriate antibiotic use / resistance



## Overuse – farm

80% of US rx – farming

Feed, to soil, to  
processor, to you

Consumer Reports, 2015

## Overuse – Doctor's office

80% of EU rx – URI

US MD – Patient  
Satisfaction Scores?

European CDC, 2014

## Overuse – hospital

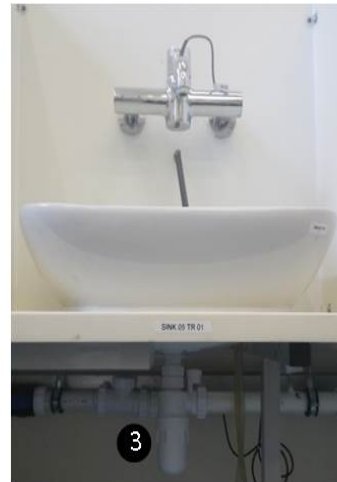
30-60% of ICU rx  
unnecessary, not  
appropriate, suboptimal

Luyt CE 2014

## 2. Source of risk – environment (“places”)

- Sink Drain Design Can Directly Impact CRE dispersal
- Slow drain ( $\geq 10$  sec) & drain opening directly underneath faucet opening: significant dispersal of CRE up to 1m ( $p < 0.001$ )

A2



A3

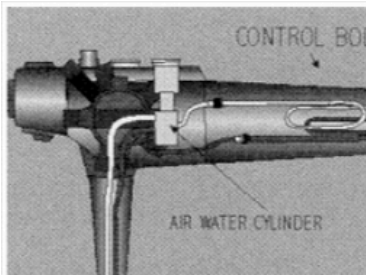


Aranega-Bou 2019

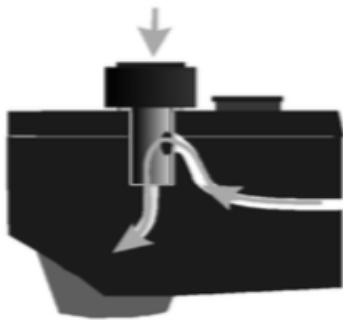


# 3. Source of risk – endoscope (“things”)

## Forward viewing scopes



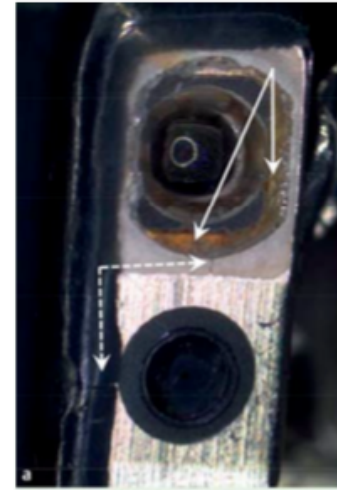
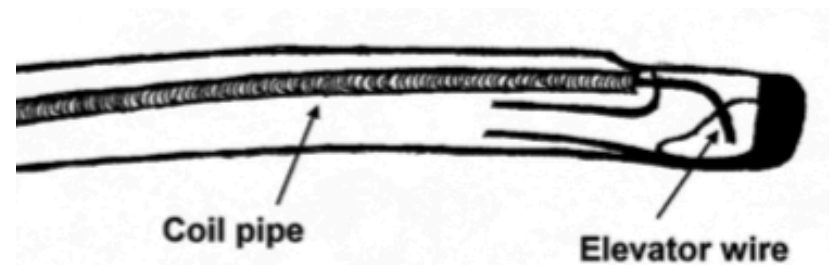
- Air/water
- 1.5mm diameter



- Suction
- Up to 3.7mm diameter
  - BUT >90° at valve

Holland 2000

## ERCP / linear EUS scopes



- Elevator wire / sus pipe (coil pipe)
- 0.185mm diameter
  - “SEALED” optics / elevator wires: fault tolerance?

Holland 2002  
Verfaillie 2015

# **Multifactorial causes of endoscope infection**

# Multifactorial causes of endoscope infection

Complex instructions /  
complex design

Human factors

Biofilm

CRE infection

# Complex instructions: Reprocessing steps / use

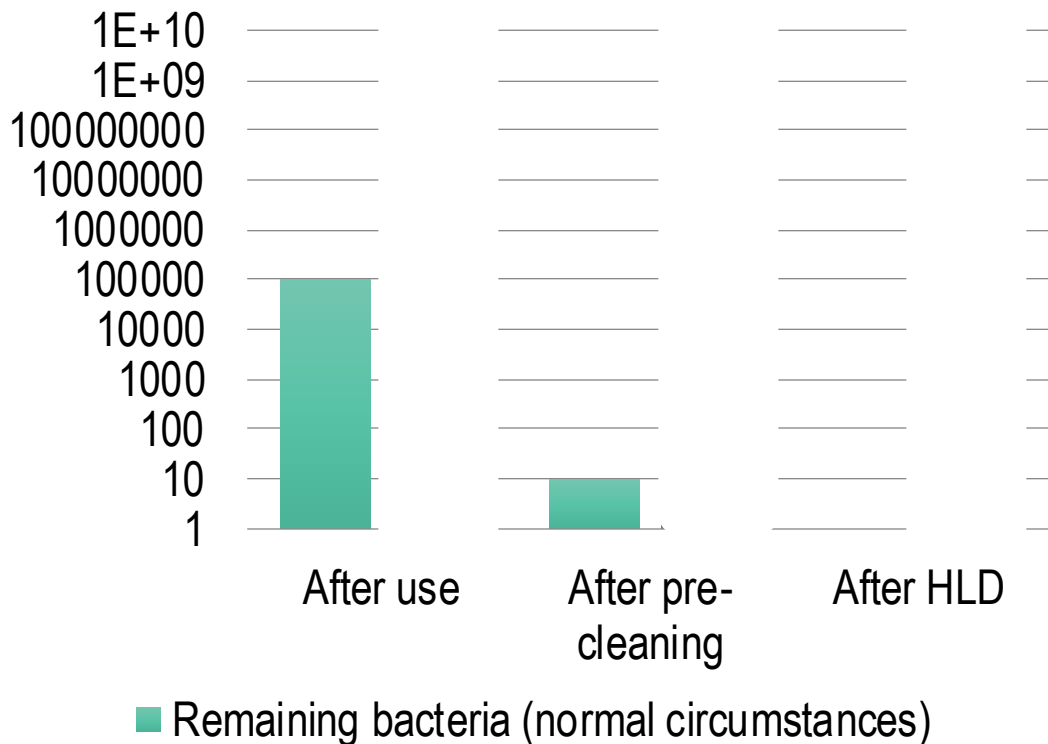


- 2013, WA: 3% persistent duodenoscope infection despite exceeding reprocessing guidelines
- 2015, CA: CRE transmission through duodenoscopes (culture negative)

Wendorf 2015  
Kim 2016

Image: Unicode / Apple

# Complex design: Very narrow margin of safety



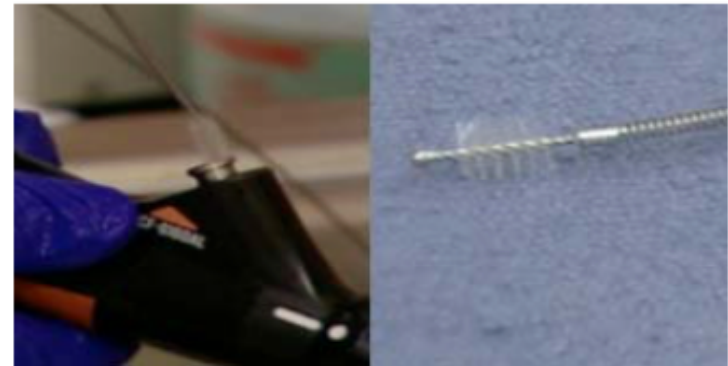
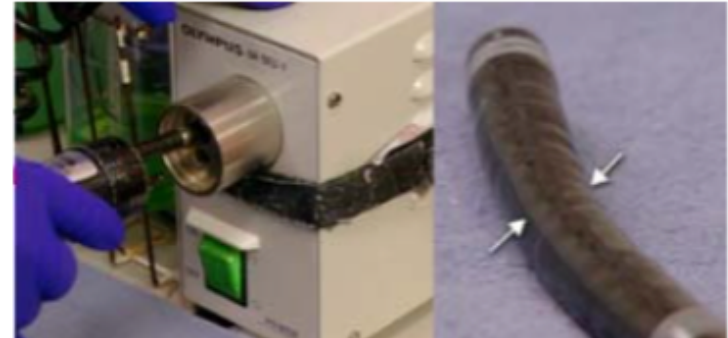
- Assumes EVERY step properly performed!
- **Meticulous Pre-cleaning is essential**
  - Germicide contact time to kill
    - 10 bacterial spores: 30 minutes
    - 100,000 bacterial spores: **3 hours**

Rutala 2008  
Kovaleva 2013

Isaacson WHO 2009

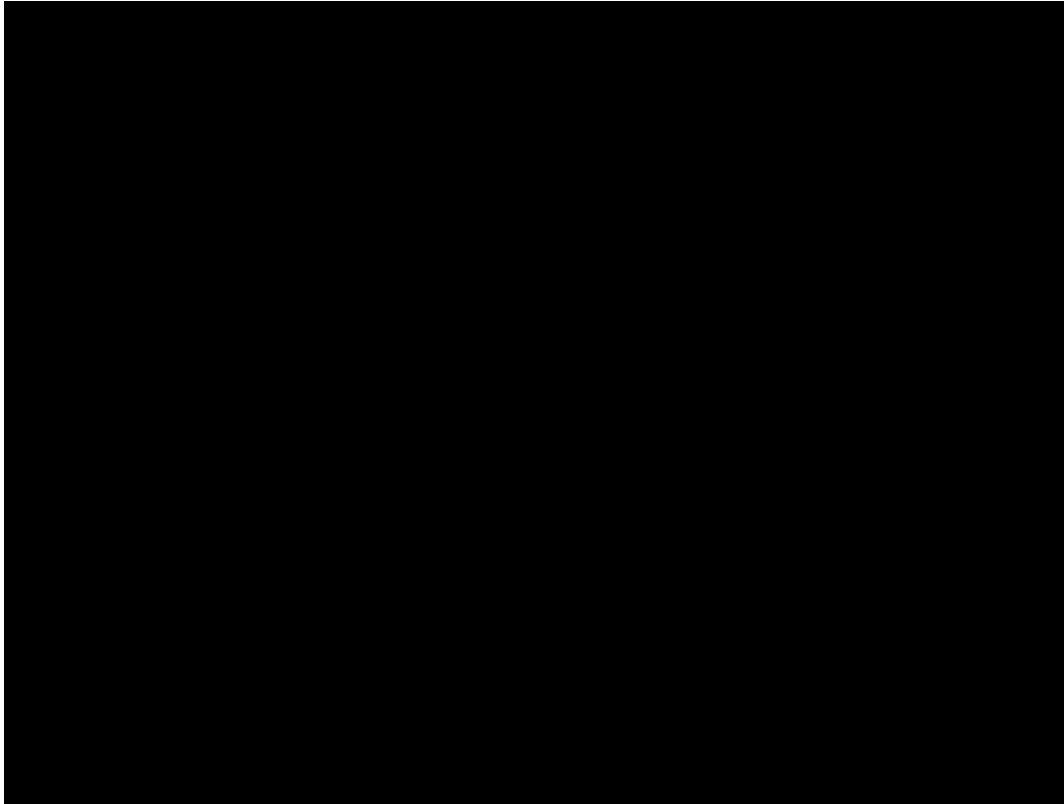
# Human factors: heuristic analysis

- **75% feel pressure to work quickly**
  - Physicians rushing the staff washers → rush & skip steps
- Top 3 violations in endoscope reprocessing
  - Feedback
  - Visibility
  - Memory



Ofstead 2010  
Hildebrand 2010

# Human factors



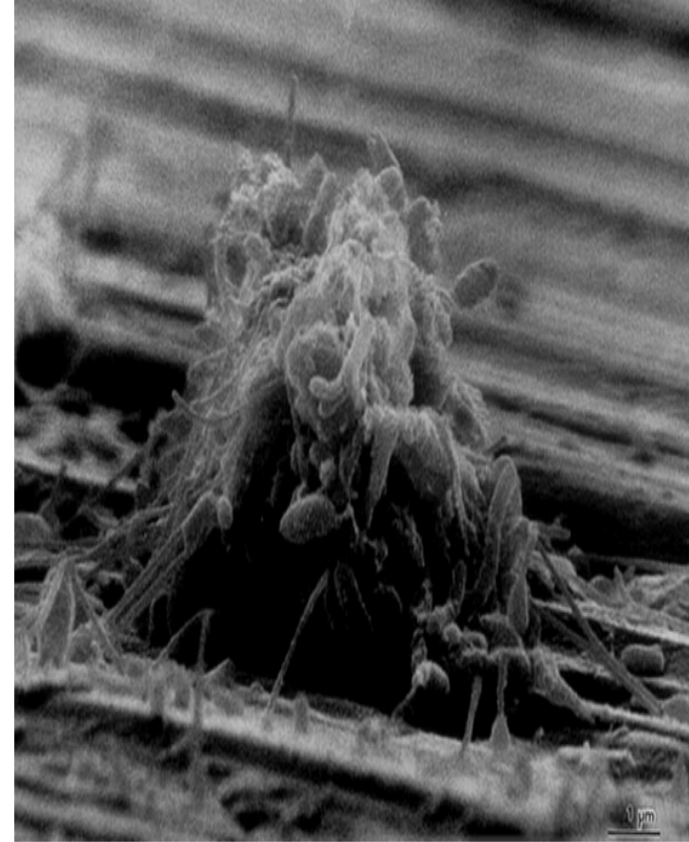
- Improper elevator position (open instead of 45° closed)
  - After only 1 round of reprocessing, viable bacteria remains under the elevator

Alfa 2018

Video: youtube

# Biofilm

- Bacteria can be planktonic (free floating), but prefer to be assembled in biofilm
  - Can occur in any surface, from water supply systems, to paper mills, to endoscopes
- Confers survival advantage
  - 1000-fold resistance to chemicals / antibiotics
- Changes in growth rate and gene transfer (e.g. antibiotic resistance genes) can occur



Kovaleva J 2013  
Donlan RM 2002



# ERCP transmission of CRE: Swiss cheese model

Index patient has CRE (1.4 per 100,000 patient days)

**Hazards**

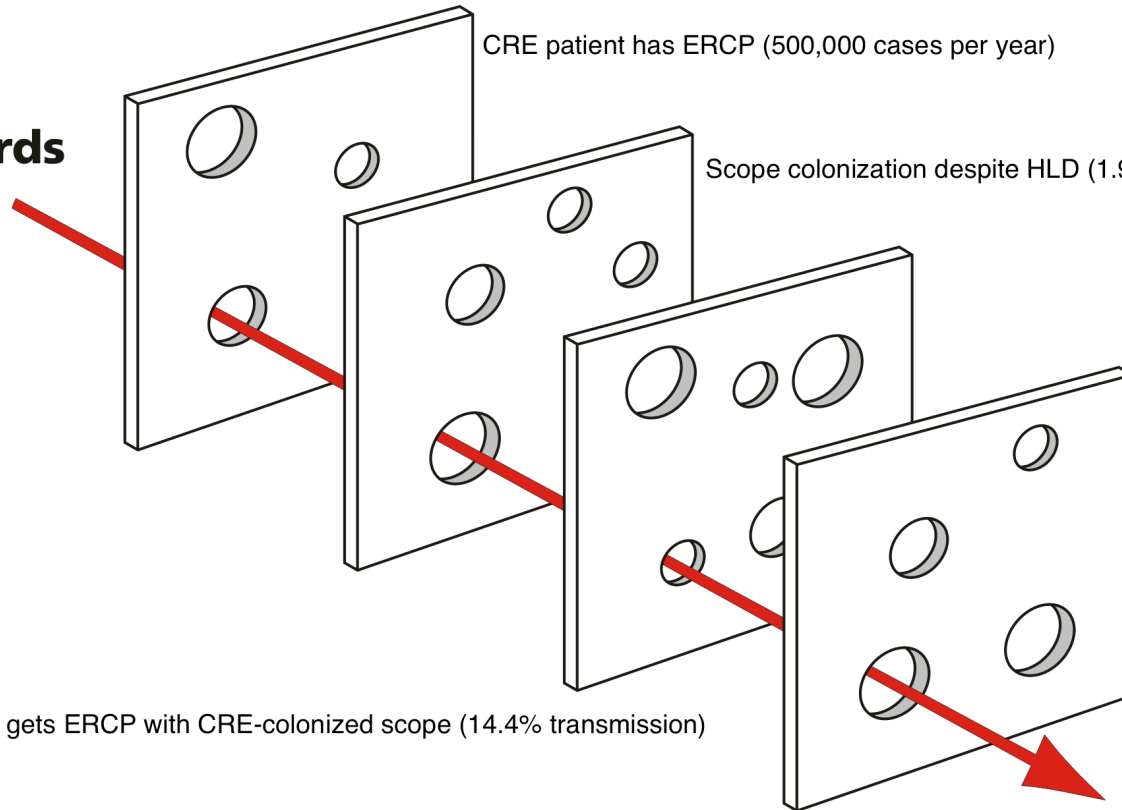
CRE patient has ERCP (500,000 cases per year)

Scope colonization despite HLD (1.9% risk)

Pt gets ERCP with CRE-colonized scope (14.4% transmission)

Colonized pt actively gets CRE (53.3% attack rate)

**Losses**

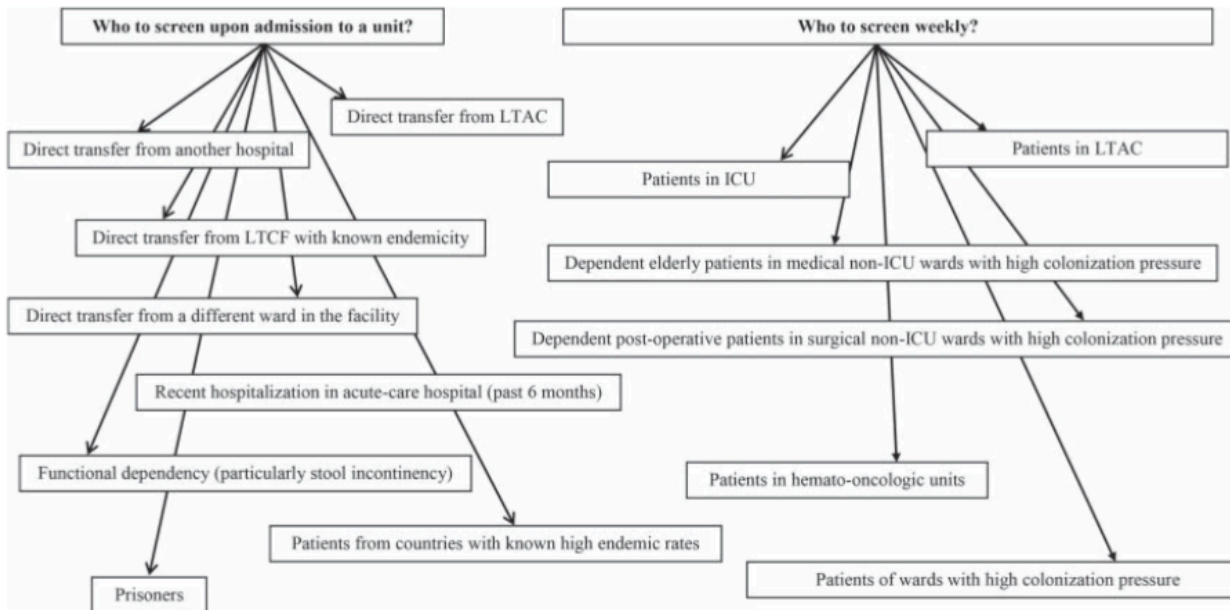


Data adapted from Kim 2016

Image: (CC BY-SA 3.0). Modified from original by David Mack

**“Low-tech” and “High-tech” solutions**

# Low tech: Screening for CRE?



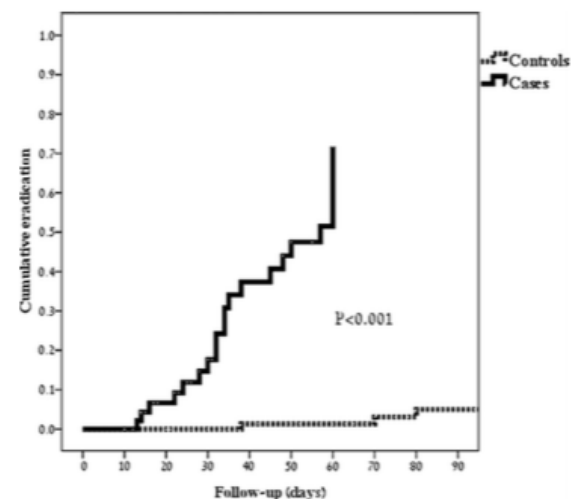
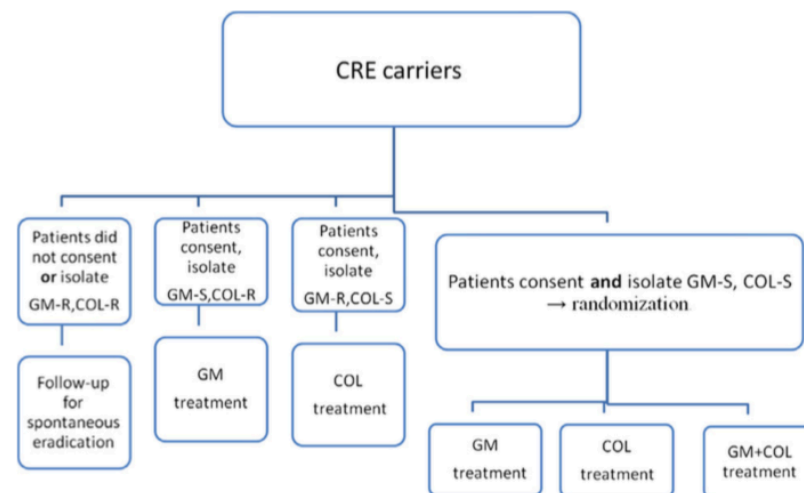
- Rectal (peri-rectal) swab culture
  - 83.8% sensitivity, 89.2% specificity (meta-analysis 28 studies)

- Culture vs PCR?
  - Culture: ~96h turnaround, \$22k / yr
  - PCR: ~24h turnaround, \$224k / yr

Richter 2017

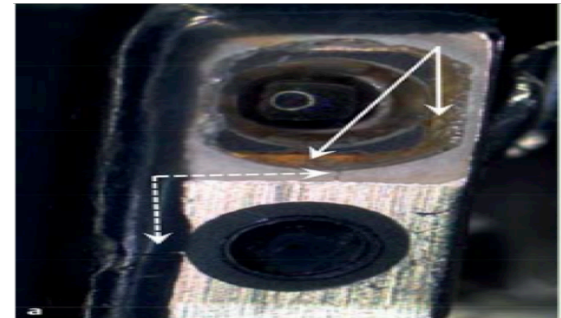
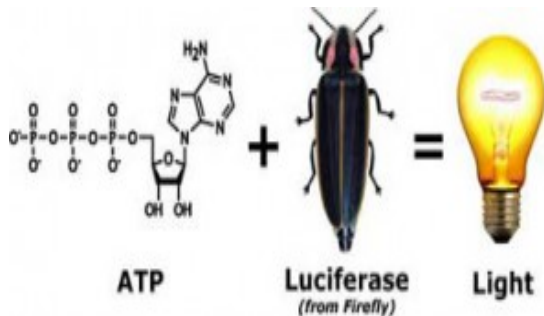
# Low tech: Decontaminate the Gut?

- CRE colonizes the gut
- Chemotherapy -> mucositis -> recurrent bloodstream infection
- 152 consecutive patients, randomized into 1, 2, or both drugs (see flowchart)
- If eradicated, 17% mortality; if FAILED eradication, 49% mortality ( $p = 0.002$ )



Oren 2013

# Low tech: “Do More”?



ATP < 200 RLU?

Proper technique (maybe)  
 Poor correlation between  
 RLU and “cleanliness”

Sethi 2017  
 Visrodia 2017

Ofstead 2017  
 selectech.co.za

FDA guidance – 4 options

FDA 522: 7.5x more infx  
 RCT of 1/2/EtO: no  
 difference in >10 CFU

Accessdata.FDA.gov  
 Snyder 2017

Post-Disinfection Tests

GNR enzyme activity  
 PCR  
 CDC culture protocol?

Lichtenstein and Alfa 2019  
 Gazdik 2016

# “If 1 is good, 2 must be better... right?”

- Randomized control trial of single HLD, double HLD, or EtO gas sterilization
- 516 washes
- Study terminated after 3 months due to futility (no MDRO detected)
- **No difference among the 3 arms for culture positivity**

Trial arm	N	≥ 1 MRDO	>0 CFU <sup>a</sup>	≥ 10 CFU <sup>b</sup>
sHLD	174	0	28 (16.1%)	4 (2.3%)
dHLD	169	0	27 (16%)	7 (4.1%)
HLD/ EtO	173	0	39 (22.5%)	9 (4.2%)
Total	516	0	94 (18.3%)	20 (3.9%)

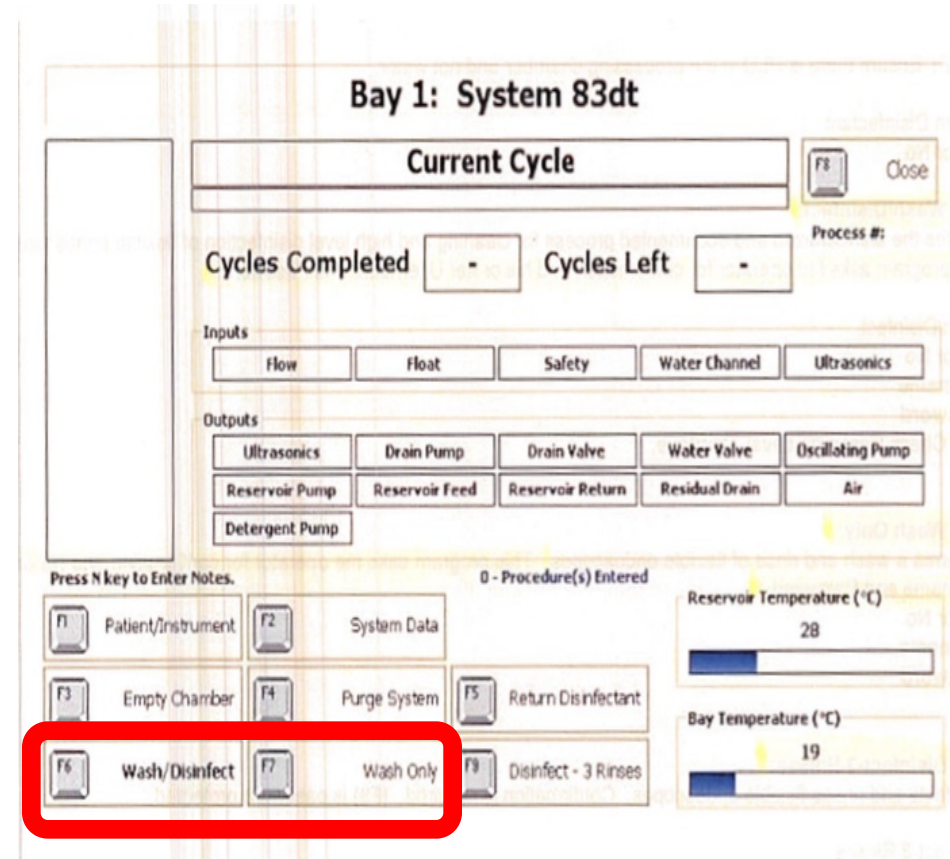
<sup>a</sup> p = 0.21

<sup>b</sup> p = 0.36 by Fisher exact test

Snyder 2017

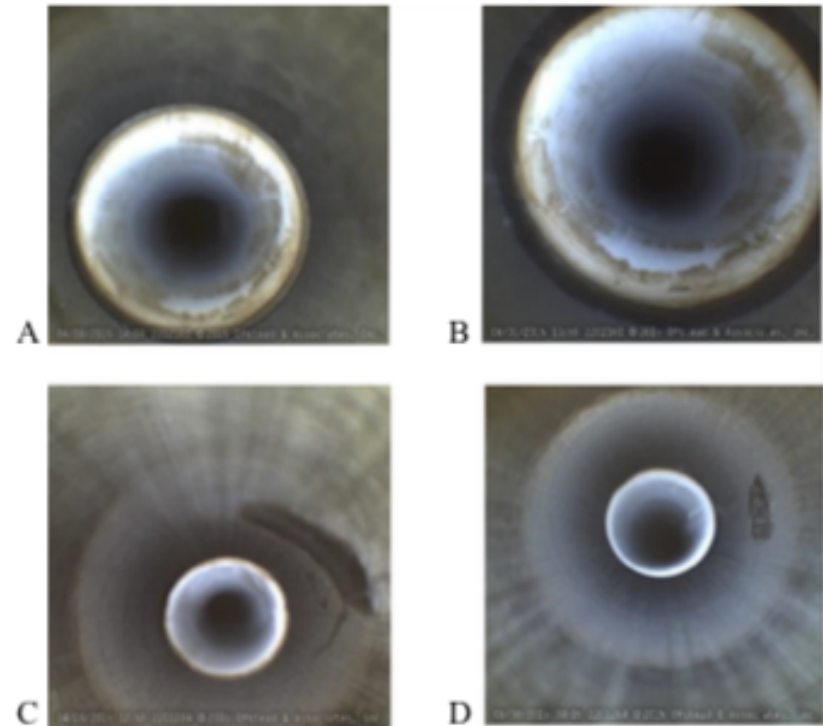
# ポカヨケ (“Poka-yoke”)

- System designed to be error proof
- Pioneered by Industrial Engineer Shideo Shingo (Toyota)
- GOOD: depress brake pedal before shifting from park
- BAD: An example how NOT to design a system (image)



# Low tech: Is there utility of Borescope exam?

- Control arm: preclean, manual brush, AER with 2.5% glutaraldehyde
- Intervention arm: preclean, manual brush, ATP (with more brush as needed), AER with peracetic acid
- Findings
  - ATP gastroscopes > colonoscopes ( $p = 0.001$ )
  - Biopsy port ATP > suction-biopsy channel ATP ( $p = 0.005$ )
  - Intervention arm cleaner but significance? (two variables changed)
  - **Unknown: value of borescope? (clinical relevance?)**



A, B: control arm t=0 and 2mo  
C, D: intervention arm t=0 and 2mo

Ofstead 2016



# Low tech: Disposable buttons / caps

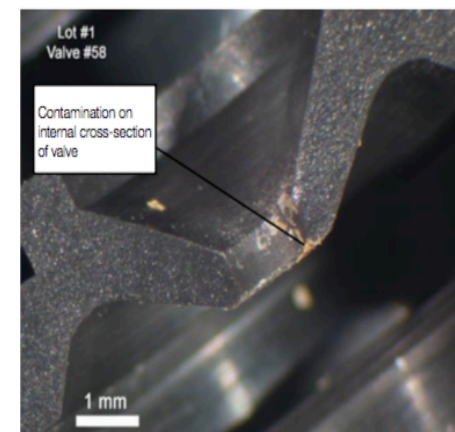
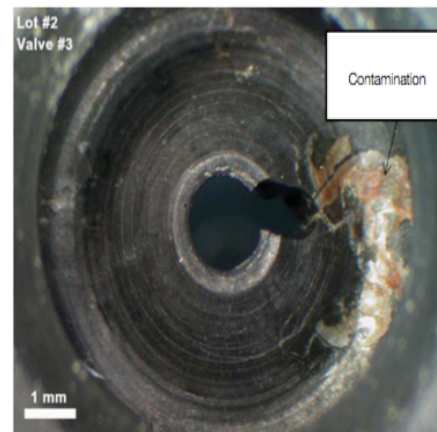
- FDA recommendation 2016 allows either reprocessed valve or single-use valve / caps
- Reusables **HARD TO CLEAN**
- Infection can be transmitted!
  - M tuberculosis (contaminated bronchoscopy valves)



Air / Water Valves



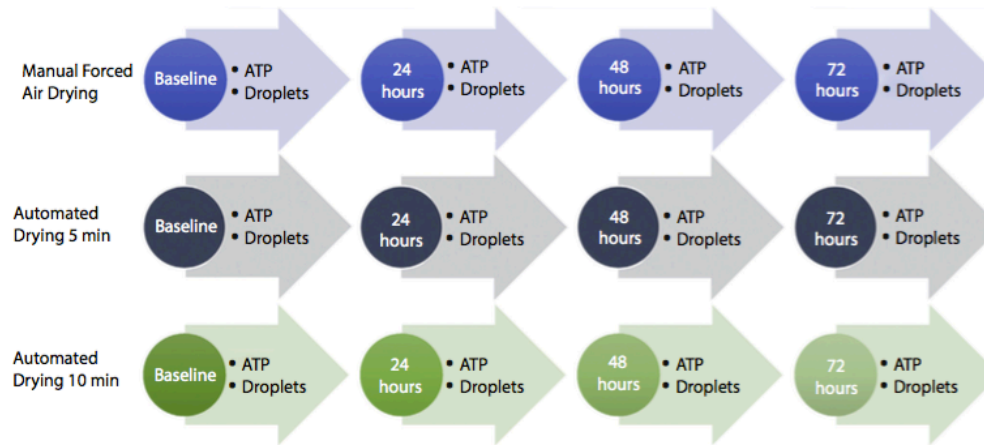
Suction Valves



Images: Parente 2009, Ackert-Burr 2015 (APIC)

Kovaleva 2013

# Low tech: Timed Drying



- 23 total scopes (FWD & Elev)
- 3 arms
  - Manual (10 min, air gun)
  - Automated (5 min)
  - Automated (10 min)
- Results
  - Dryness: auto (10) > auto (5) > manual (10, air gun) ( $p < 0.01$  for group)
  - Lower ATP levels after 48h: auto (10) > auto (5) > manual ( $p < 0.001$ )
  - **Addresses human factor (inattentive blindness / lack of concentration)**

Barakat 2019

# High tech: Single-use?

## Duodenoscope cap

- Released December 2017
- Intent: makes cleaning easier
- But: more acute angles & crevices?



Pentaxmedical.com

## ENTIRE DUODENOSCOPE

- FDA 510k approval (K173085) for upper / lower endoscopes in September 2017
- Duodenoscope market release anticipated 2020
- Well-known GI consumables market vendor also testing

Ambu.com

Clinicaltrials.gov (NCT03701958)

# High tech: Plasma-activated argon gas

- Activity is through reactive Oxygen & Nitrogen species
  - Works against MDRO, spores, biofilm, fungi; bacteria cannot develop resistance
- 120cm & 220 cm long tubes
- PAG exposure time to completely eradicate biofilm at distal end (furthest away from plasma gas), for 24h biofilm – see table
- No visible PTFE tube damage on SEM

Organism	120cm tube	220 cm tube
<i>E coli</i>	1 min	5 min
<i>P aeruginosa</i>	2 min	9 min
<i>MRSA</i>	1 min	9 min

- Not yet commercially available
- But, per authors
  - Materials cost \$2000
  - Pathway for 510k (maybe)

Bhatt 2019

# Summary and Recommendations

# 5 Do's and Don'ts to prevent endoscope infections

## DO'S

## DON'TS

“Poka-Yoke”



Forced air drying



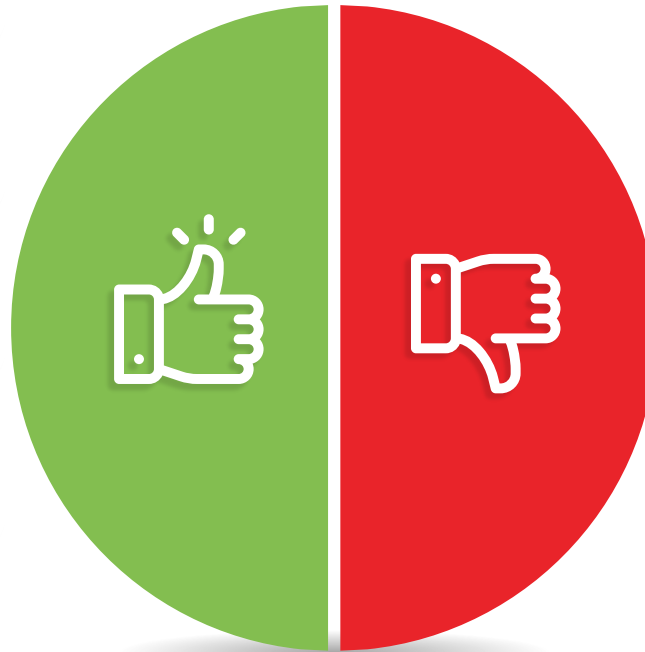
Regular QC of scope washers / equipment



Identify & respond to high-risk patients



Timely & thorough reprocessing



Ignore the problem – “it’s never happened in our unit”



Hang wet scopes



Ignore QC for scope washers / equipment



**RUSH SCOPE WASHERS**



Allow scopes to cake

# Thank you

“Soap and water and common sense are the best disinfectants”

— Sir William Osler

