

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

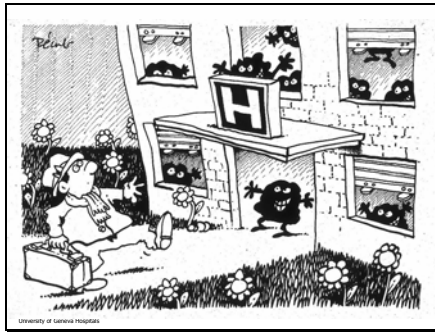
Slide 1

Alcohol Sanitizers
and Their Effect on Viruses

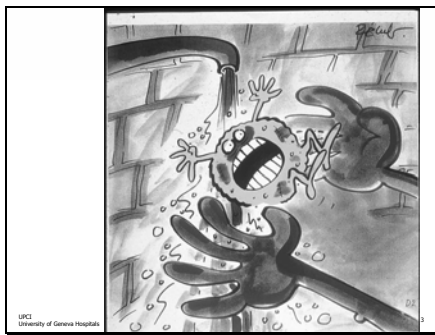
Didier Pittet, MD, MS,
Professor of Medicine
Chair, Infection Control Program
University of Geneva Hospitals, Switzerland

Sponsored by: **Deb Medical Hand Hygiene** www.deb.co.uk
A Webber Training Teleclass www.webbertraining.com

Slide 2



Slide 3



Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 4

- Adherence with the recommendations for hand hygiene practices remains extremely low in most healthcare settings
- Some of the key parameters for noncompliance have been clearly identified and corrective actions proposed
- New guidelines for hand hygiene have been published

Boyce and Pittet, *MMWR* 2002; 51:1-44

UPCI
University of Geneva Hospitals

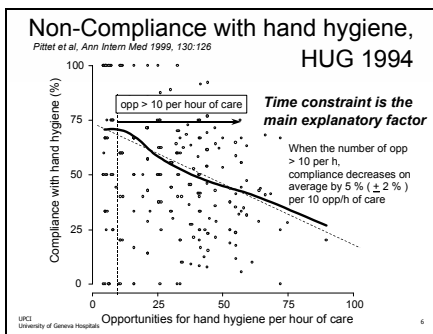
Slide 5

Today's objectives

- To review some of the implications of the new hand hygiene guidelines
- To discuss the importance of viruses as human and nosocomial pathogens
- To review whether hands play a role in the spread of viral infections
- To discuss whether alcohol sanitizers have an effect on viruses
- Virucidal activity of antiseptics
- Selecting a hygiene agent

UPCI
University of Geneva Hospitals

Slide 6



Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 7

Observed reasons for not washing hands
Time and system constraints

- High demand for hand hygiene is associated with low compliance
- Full compliance with conventional guidelines may be unrealistic

Voss and Widmer - Inf Control Hosp Epidemiol 1997; 18:205
Pittet et al, Annals Intern Med 1999; 130:126

UPCI
University of Geneva Hospitals

Slide 8

Advantages of alcohol-based hand antiseptics vs. handwashing


- Faster and of greater efficacy than soap & water handwashing
- Improved accessibility
 - No sinks (plumbing) required
 - In rooms, corridors, nursing stations
 - As a pocket container
- Effective against a wide array of organisms, including multi-drug resistant pathogens

Pittet et al, Ann Intern Med 1999 - Pittet, ICHE 2000 - Boyce and Pittet, MMWR 2002

UPCI
University of Geneva Hospitals

Slide 9

*Handwashing ...
an action of the past
(except when hands are soiled)*



Alcohol-based handrubbing is standard of care

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 10

Time constraint is currently a (the?) major obstacle for hand hygiene

Solution:
Handrubbing is standard of care

Implication:
A system change is required

Slide 11

Implications of hand hygiene guidelines
A system change is required

- Provide easy access to hand hygiene materials
 - Handrub solution
 - at the patient's bedside
 - eventually at the patient's room entrance
 - in convenient locations
 - in individual pocket-sized containers
 - Dispenser
 - conveniently located
 - working appropriately

UPCI University of Geneva Hospitals Boyce & Pittet, MMWR 2002; 51:1-44 11

Slide 12

Efficacy of hand hygiene products



UPCI University of Geneva Hospitals 12

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

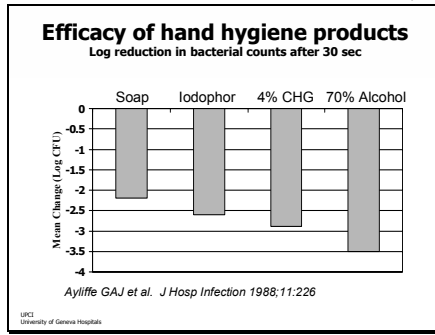
www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

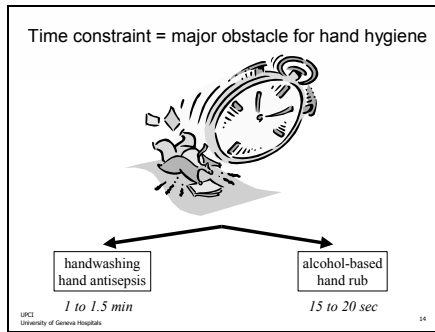
A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

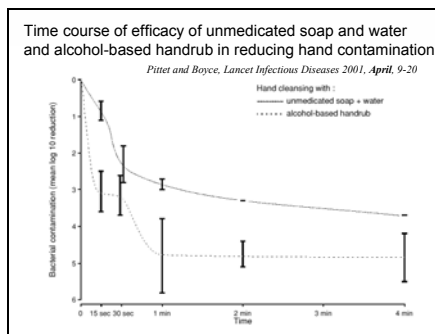
Slide 13



Slide 14



Slide 15



Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

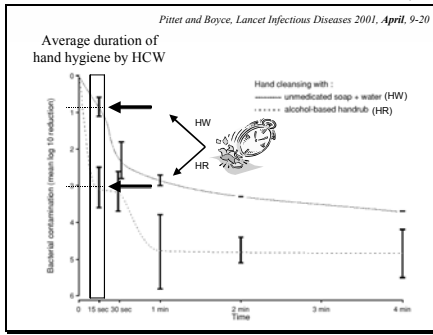
www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 16



Slide 17

Implications of hand hygiene guidelines

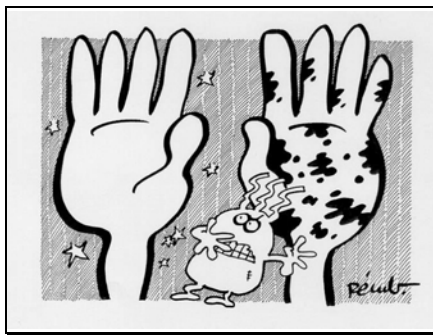
Handrubbing efficacious

- Handrubbing is more efficacious than handwashing with soap and water
- Some agents are more efficacious than others
- Time spent handrubbing is critical
 - agent must be applied on dry hands and allow to dry
 - education is critical
- The clinical effectiveness (i.e. impact on nosocomial transmission) of the use of different agents remains to be tested prospectively

UPC
University of Geneva Hospitals

Pittet D et al, *Lancet* 2000; 356: 1307-1312
Boyce & Pittet, *MMWR* 2002; 51:1-44

Slide 18



Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

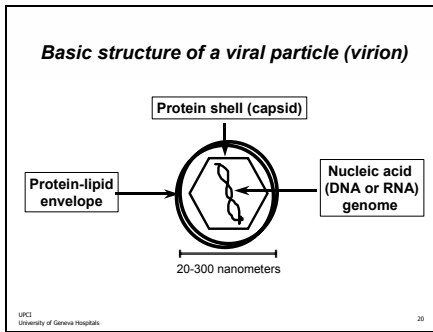
Slide 19

Should we consider viruses ?

- Viruses are important nosocomial pathogens, but mostly underrecognized and underreported
- Some viruses are foodborne pathogens
- Hand transmission is significant in the spread of viruses
- Appropriate hand hygiene action can stop viral cross-transmission

UPCI University of Geneva Hospitals 19

Slide 20



Slide 21

Important human viruses

UPCI University of Geneva Hospitals 21

Non-enveloped

- Adenoviruses (conjunctivitis, diarrhea, respiratory tract infections)
- Astroviruses (diarrhea)
- Caliciviruses (diarrhea, outbreaks in geriatrics)
- Enteroviruses (fever, rash, diarrhea, encephalitis)
- Hepatitis A
- Papillomaviruses (warts, cancers)
- Parvovirus (B19)
- Rhinoviruses (cold)
- Rotaviruses (diarrhea, outbreaks in pediatrics)

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com


www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 22

Important human viruses (2) 

- Enveloped
- HIV
- Herpes
- Hepatitis B
- Hepatitis C
- RSV
- Influenza
- Vaccinia

UPCI University of Geneva Hospitals 22

Slide 23

Viral shedding and transmission

- Human pathogenic viruses are not part of the normal microflora
- Viruses are shed by infected host for varying periods
- A large proportion of infected individuals/animals remains asymptomatic and discharges viruses into surroundings
- Hospitals, nursing homes, daycare centers
- The longer a virus can survive outside the body host, the higher its spreading potential

UPCI University of Geneva Hospitals 23

Slide 24

Viral shedding and transmission
(continued)

- Hands can become contaminated by viruses either:
 - DIRECTLY, by contact with any virus-containing body fluid from self or others
 - INDIRECTLY, by touching or handling virus-contaminated surfaces or objects
- Fingers (in particular pads and tips) are the most likely to come in contact with infected individuals/animals, their body substances or other contaminated materials

UPCI University of Geneva Hospitals 24

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 25

Do viruses survive on hands ?
If yes, how long can they survive ?

UPCI
University of Geneva Hospitals

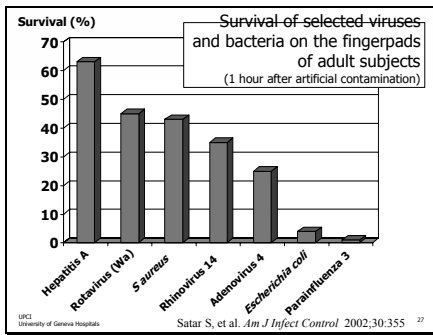
Slide 26

Virus acquisition, and survival on hands

- Many viruses survive long enough on both hands and inanimate surfaces to permit transfer and cross-transmission
- Viruses are particularly sensitive to drying, thus can survive better on skin than onto dry surfaces, dependent on ambient humidity
 - ex: all non-enveloped viruses survive as well as, if not better than *S aureus*
 - ex: enveloped viruses survive less longer, but somewhat similar to *E coli*

UPCI
University of Geneva Hospitals

Slide 27



Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet


June 24, 2003

Slide 28

**Do hands play a role in
the spread of viral
infections ?**

UPCI
University of Geneva Hospitals

Slide 29

Rhinoviruses 


- Responsible for most upper respiratory tract infections
- Can survive on hands for hours
- Hands clearly implicated in human cross-transmission

Reed SE. *J Hyg* 1975;75:249
Hendley JO, et al. *Epidemiol Rev* 1998;10:242- Ability of hand hygiene to stop cross-transmission is shown

Gwaltney JM Jr. *Virus infections in humans*.
3rd ed. Yale University Press. 1997:815

UPCI
University of Geneva Hospitals

Slide 30

Adenoviruses 

- Responsible for conjunctivitis, cystitis, pneumonia and gastroenteritis
- Outbreaks in hospitals and daycare centers
- Outbreaks of ketaroconjunctivitis in ophthalmology
- Can survive on hands for many hours

Montessori V et al. *Am J Infect Control* 1998;26:399
Graham ML. [Thesis] University of Ottawa. 1997- Hands clearly implicated in human cross-transmission and persistent carriage after handwashing with soap and water

Jernigan JA et al. *J Infect Dis* 1993;167:1307


UPCI
University of Geneva Hospitals

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003


Slide 31

Caliciviruses
(SMRS, small round structured viruses) 

- Norwalk outbreaks of gastroenteritis and diarrheal diseases in community and hospitals
Kapikian AZ et al. *Fields virology*. Raven Press. 1990:1353
Denmen VC et al. *J Infect Dis* 2000;181 Suppl 2:281
- Most common cause of foodborne disease in US
Denmen VC et al. *J Infect Dis* 2000;181 Suppl 2:281
Guzewich J et al. US Food and Drug Administration's Center for Food Safety and Applied Nutrition. 1999.
Parashar UD et al. *Epidemiol Infect* 1998;121:615
- Can probably survive on hands for hours


UPCI University of Geneva Hospitals 31

Slide 32

Hepatitis A virus 

- Infection is common worldwide
- Foodborne disease and outbreaks
- Endemic in developing countries (children)
- Frequently asymptomatic among young children, but transmission to older age groups is frequent
- Uncooked food and hand cross-transmission
- Can survive on hands for several hours
Mbithi JN et al. *Appl Environ Microbiol* 1993;59:3463
- Hands clearly implicated in human cross-transmission: 10 sec contact is enough
Sattar SA et al. *Foodborne disease handbook: vol 2*. Marcel Dekker. 2001:205
Badawid S et al. *Appl Environ Microbiol* 2000;66:2759
- Associated with high morbidity and societal costs 32

Slide 33

Rotaviruses 

- Leading cause of gastroenteritis in infants worldwide
- Outbreaks in hospitals, daycare centers, schools
Rogers M et al. *Am J Infect Control* 2000;28:378 Brown DWG et al. *Lancet* 1989;2:737
Demshy PH. *Pediatr Infect Dis* 2000;19:5103 Kocovick BH et al. *Appl Environ Microbiol* 1983;46:813
- Asymptomatic infection is common, but clinical cases excrete large amounts of viruses in feces
Saulsbury FT. *J Pediatr* 1980;97:61
- Can survive on hands for many hours (~*S aureus*)
- Hands clearly implicated in human cross-transmission; hands of care givers play an important role in virus spread
Sattar SA et al. *Infection, sterilization, and antisepsis: principals and practice in healthcare facilities*. APCT. 2001:173

UPCI University of Geneva Hospitals 33

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com


www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 34

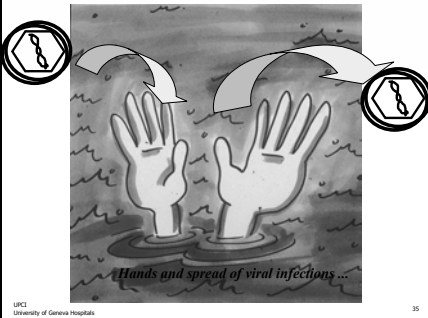
Respiratory syncytial virus (RSV) 

- Most frequent cause of serious upper respiratory tract infection in children
- Outbreaks in hospitals and daycare centers
- Can survive on hands
- Hands clearly play a role in cross-transmission
 - More frequent handwashing by HCWs reduces transmission
 - Cohorting of RSV patients reduces spread

Hall CB. *Clin Infect Dis* 2000;31:590
Ruuskanen O. *J Hosp Infect* 1995;30 Suppl:494


UPCI
University of Geneva Hospitals

Slide 35



UPCI
University of Geneva Hospitals

Slide 36

Hands and spread of viral infections 

- Hands could act as vehicles for many viruses
- Proper hand hygiene action could reduce the spread of viruses
- The lack of direct evidence for the relation between improved hand hygiene and reduced viral spread is due to the difficulty in working with viruses, our inability to discriminate between simultaneous spread by hands and other vehicles in a given condition, and diagnosis difficulties for viral infections
- Hands clearly play a role in cross-transmission

Satar S et al. *Am J Infect Control* 2002;30:355

UPCI
University of Geneva Hospitals

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com


www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 37

Hands and spread of viral infections 

THUS:

Proper hand hygiene action and optimal hand hygiene formulations should include agents active against viruses at least in conditions where viruses of significance for humans are expected

UPCI
University of Geneva Hospitals 37

Slide 38

Important questions

- 1- Does hand hygiene agents' activity against bacteria equal activity against viruses ?
- 2- Are there relevant methods to test hand antisepsis agents against viruses ?
- 3- Is there a framework to allow label claims against viruses ?

UPCI
University of Geneva Hospitals 38

Slide 39

Important questions

- 1- Does hand hygiene agents' activity against bacteria equal activity against viruses ?
- Are there relevant methods to test hand antisepsis agents against viruses ?
- Is there a framework to allow label claims against viruses ?

UPCI
University of Geneva Hospitals 39

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 40


Differences between viruses and bacteria toward hand hygiene action

- viruses are much smaller than bacteria
- viruses are compact in nature
- viruses (like bacteria) have ability to survive on hands
- viruses can « hide » within skin surface crevices
- viruses are more difficult to dislodge by simple handwashing than bacteria

UPCI University of Geneva Hospitals 40

Slide 41


Virucidal activity of antiseptic agents against viruses

- Enveloped viruses are easy to kill 
 - HIV
 - HBV
 - RSV
 - Influenza
 - Vaccinia
 - Log reductions obtained in the range of 2.5 to 6 using ethanol/isopropanol (30 sec to 2 min testing)
 - Some activity of CHLX – Benzalkonium / detergent

UPCI University of Geneva Hospitals Boyce & Pittet, MMWR 2002; 51:1-44 41

Slide 42

Virucidal activity of antiseptic agents against viruses

- Non-enveloped viruses are more difficult to kill 
 - Alcohols, ethanol and isopropanol are more effective than medicated or nonmedicated soaps
 - rota - adeno - rhinoviruses : 60% ethanol (> 3 log R)
 - coxsackie / ECHO
 - HAV and enteroviruses may require 70-80% alcohol
 - polio : 70% ethanol
 - ethanol > isopropanol
 - Log reductions obtained in the range of 0.4 to 3 using ethanol/isopropanol (30 sec to 2 min testing)
 - Efficacy is influenced by temperature, virus/antiseptic ratio, and protein load
 - Poor/no activity of other antiseptics

UPCI University of Geneva Hospitals Boyce & Pittet, MMWR 2002; 51:1-44 42

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 43

Activity of antiseptics used for hand hygiene against non-enveloped viruses

- Active
 - Alcohol, 60 to 95 %
(ethanol > isopropanol)
- Poorly active
 - Benzalkonium chloride
 - Chlorhexidine gluconate
 - Triclocarban
 - Triclosan
 - PCMX

UPCI University of Geneva Hospitals 43

Slide 44

Important questions

THUS,
hand hygiene agents' activity against bacteria does not mean activity against viruses

1) most antiseptics are inactive against non-enveloped viruses

2) alcohols (60 to 90%) :
- reduce bacteria \log_{10} counts by 4 to 6
- reduce viruses \log_{10} counts by 0.4 to 3

UPCI University of Geneva Hospitals 44

Slide 45

Important questions

- Does hand hygiene agents' activity against bacteria equal activity against viruses ?
- 2- Are there relevant methods to test hand antiseptics agents against viruses ?
- Is there a framework to allow label claims against viruses ?

UPCI University of Geneva Hospitals 45

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 46

**Are there methods
available to test hand
antiseptics against
viruses ?**

UPCI
University of Geneva Hospitals

Slide 47

Types of tests against viruses

IN VITRO
SUSPENSION TESTS
CARRIER TESTS

IN VIVO
HUMAN SUBJECTS (WHOLE HANDS, FINGERTIPS,
FINGERPADS)
ANIMAL MODELS

EX VIVO
HUMAN TISSUE (SKIN, UMBILICAL CORD, CORNEA)
ANIMAL TISSUE (RAT, GUINEA PIG)

S.A. SATTAR, ANTISEPTICS & VIRUSES, TELE-LECTURE, MAY 2002
UPCI University of Geneva Hospitals See also: Satar S et al, Am J Infect Control 2002;30:355

Slide 48

***In vivo* tests against viruses**

THE FINGERPAD METHOD FOR VIRUCIDAL
ACTIVITY IS AN ASTM STANDARD (E-1838)
A SIMILAR METHOD HAS BEEN PROPOSED TO ASTM
FOR WORKING WITH BACTERIA FUNGI
A WHOLE-HAND METHOD ALSO IS NOW AN ASTM
STANDARD (E-2011)
EUROPEAN METHODS

S.A. SATTAR, ANTISEPTICS & VIRUSES, TELE-LECTURE, MAY 2002
UPCI University of Geneva Hospitals See also: Satar S et al, Am J Infect Control 2002;30:355

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 49

Activity of an alcohol-based handrub against 3 non-enveloped viruses

Virus tested	Baseline control (PFU)	Reduction with handrub	Reduction with water	<i>p</i>
Adenovirus type 4	0.23 X 10 ⁵	>99.99%	85.0	0.0003
Rhinovirus type 14	0.95 X 10 ⁵	≥99.90%	94.0	0.0004
Rotavirus strain WA	0.33 X 10 ⁵	99.99%	89.0	0.0003

Fingerpad method with 12 volunteers for each virus. 10 µL of virus with soil load on each digit + dried. Exposed to 1 mL of handrub with 60% ethanol vs. water

UPCI University of Geneva Hospitals Sattar et al., *Infect Control Hosp Epidemiol* 2000; 21: 516 49

Slide 50

- Important questions**
- Does hand hygiene agents' activity against bacteria equal activity against viruses ?
 - Are there relevant methods to test hand antisepsis agents against viruses ?
 - 3- Is there a framework to allow label claims against viruses ?
- UPCI University of Geneva Hospitals 50

Slide 51

- Is there a framework to allow label claims against viruses ?**
- Satar S et al. Hygienic hand antiseptics: should they not have activity and label claims against virus. *Am J Infect Control* 2002;30:355
- The lack of recognized surrogates/standards for testing agents against viruses:
 - makes the development of products expensive and time consuming
 - results in the listing of easy-to-kill (enveloped) viruses on product labels conferring them an unjustified advantage
 - encourages label claims against viruses
 - makes product comparisons difficult
- UPCI University of Geneva Hospitals 51

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 52

Is there a framework to allow label claims against viruses ? (2)

Satar S et al. Hygienic hand antiseptics: should they not have activity and label claims against virus. *Am J Infect Control* 2002;30:355

- Testing should be conducted with proper surrogates using rigorous test conditions
 - *in vitro*, alcohol-based products reach a 2 to 3 log reduction in virus infectivity (in contrast to soap and water that hardly reach a 1 log reduction)
- possible surrogate for testing activity against viruses include: adeno-, rhino-, rota-, and enteroviruses, and Hepatitis A virus
- fingertip or fingerpad methods are more appropriate
- ultimate testing is the demonstration of viral cross-transmission and infection

UPCI University of Geneva Hospitals

Slide 53

Alcohol-based handrubbing is standard of care

UPCI University of Geneva Hospitals

Slide 54

Alcohol-based handrubbing is standard of care

... viruses will suffer

UPCI University of Geneva Hospitals

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 55

Alcohol-based hand rub solutions

- Increasing acceptance - even in the USA
- Formulations with $\geq 60\%$ alcohol have broad spectrum activity, including activity against enveloped as well as most non-enveloped viruses
- Hepatitis A virus, caliciviruses, and parvoviruses might be more resistant
- There is a need for a regulatory framework for virus testing
- Hand hygiene major concern remains compliance

Boyce & Pittet, *MMWR* 2002; 51:1-44
Satar S et al, *Am J Infect Control* 2002;30:355

UPCI
University of Geneva Hospitals

Slide 56

Conclusions (1)

- Viruses are important nosocomial pathogens
- Hands play a key role in viral spread
- Virucidal activity is needed in formulations
- Alcohol-based products are the best choice
- There is a need for viral surrogates for testing agents
- Label claims against HIV, HBV, HCV, and influenza are useless
- Regulatory framework for label claims is needed
- Clinical effectiveness of hand hygiene products with virucidal activity should be demonstrated

UPCI
University of Geneva Hospitals

Slide 57

Selecting a hand hygiene agent

- Handrubs contain 60-95% of alcohol
- Ethanol is the commonly used alcohol but propanol and mixtures are also available
- Handrubs are available as rinses (low viscosity), gels, and foams
- The higher the content in alcohol (max 90%), the higher the wider the spectrum of efficacy against viruses
- Agent selection is a difficult task

UPCI
University of Geneva Hospitals

Sponsored by Deb Medical Hand Hygiene www.deb.co.uk

Hosted by Paul Webber paul@webbertraining.com

www.webbertraining.com

Alcohol Hand Sanitizers and Their Effect on Viruses

A Webber Training Teleclass with Dr. Didier Pittet

June 24, 2003

Slide 58

Implications of hand hygiene guidelines

Selecting a hand hygiene agent

1. Form a multidisciplinary team to establish criteria for product selection; consider:
 - fragrance
 - skin tolerance
 - antimicrobial properties
 - user acceptance
 - costs
 - accompanying dispenser(s)
2. Evaluate several products in clinical settings
3. Project resources and costs
4. Perform a pilot test with the selected product(s)

- Major determinants of product selection are: user acceptance and antimicrobial profile

UPCL University of Geneva Hospitals 58

Slide 59

Implications of hand hygiene guidelines

CONCLUSIONS (2)

- A system change must be addressed in most HCF
- Introduce/promote handrubs hospital-wide
- Promote/facilitate skin care
- Monitor and feedback performance regularly
- Secure active participation at both individual and institutional level
- Implement a product selection process
- HCW education and motivation is fundamental
- Multivariate promotion strategies
- Successful campaign will reduce infection rates and antimicrobial resistance spread, and enhance patient safety

UPCL University of Geneva Hospitals Boyce & Pittet, MMWR 2002; 51:1-44 59

Slide 60