

Using Invisible Florescent Dye to Improve Technique for Doffing Personal Protective Equipment

By Saachi Jain

Abstract

Recent reports of health care workers getting infected with possibly lethal organisms like Ebola have highlighted the importance of correct technique for the use of personal protective equipment like gloves, gowns and masks. The purpose of this experiment was to evaluate the effectiveness of a CDC teaching video and slides in reducing the transmission of infection. A mock patient was covered with invisible florescent dye and ultraviolet(black) light was used to photograph volunteers after they examined the mock patient. The location and extent of florescent areas on skin surface were noted before and after educational video and poster. Video recordings of examination procedure and of the doffing (removal) procedure of personal protective equipment were used to identify the cause for transmission of dye from the mock patient to the volunteer's skin. This data showed that even after education, volunteers touched their face with infected gloves while examining the mock patient, touched the infected stethoscope after removing gloves, touched the outside of the gown when removing gown, and touched their wrist when removing the first glove. This analysis was used to insights regarding use of personal protective equipment. Invisible florescent dye should be used to objectively test health care workers technique regarding use of personal protective equipment to allow them to realize and correct their mistakes and thus give them the confidence to face dangerous infections.

Introduction

Recent reports of health care workers getting infected with dangerous organisms like Ebola have alarmed people in the health care community. Two nurses, Amber Vinson and Nina Pham contracted Ebola virus infection at Texas Health Presbyterian Hospital Dallas after caring for the first Ebola victim in USA. Nurse Amber Vinson stated that she had no idea how she got Ebola. She followed the CDC protocol every time she took care of Mr. Duncan. She said that ""We weren't the best prepared," she said. "We did not have extensive training. We did not have a level of feeling comfortable with putting on and taking off the protective equipment. We didn't have the time to practice it. There was not a lot of education done beforehand."

The health care worker should ensure that no skin is exposed and should exercise caution while with the isolated patient. The most challenging link in the chain is the exiting procedure. The health care worker must be fastidious in removing each contaminated item safely.

"Health care workers need to be meticulous," says Jeff Duchin, a professor of infectious diseases at the University of Washington School of Medicine and chief of communicable disease and epidemiology for Public Health—Seattle and King County, who spoke with Scientific American about infection control. "The potential to expose yourself is real." He also says that "The art of taking off the gear is difficult to master."

Centers for Disease Control (CDC) guidelines suggest basic principles that are: "Personal Protective Equipment (PPE) must be donned correctly in proper order before en-

try into the patient care area and not be later modified while in the patient care area.

The donning activities must be directly observed by a trained observer. During Patient Care PPE must remain in place and be worn correctly for the duration of exposure to potentially contaminated areas. PPE should not be adjusted during patient care. Health-care workers should perform frequent disinfection of gloved hands, particularly after handling body fluids. If during patient care a partial or total breach in PPE (e.g., gloves separate from sleeves leaving exposed skin, a tear develops in an outer glove, a needlestick) occurs, the healthcare worker must move immediately to the doffing area to assess the exposure and implement the facility exposure plan, if indicated by assessment. Doffing: The removal of used PPE is a high-risk process that requires a structured procedure, a trained observer, and a designated area for removal to ensure protection. PPE must be removed slowly and deliberately in the correct sequence to reduce the possibility of self-contamination or other exposure to Ebola virus. A stepwise process should be developed and used during training and daily practice”

The doffing (removal of personal protective equipment) procedure described by the CDC itself involves 24 steps to remove gloves, shoe covers, face shield, hood, gown and respirator mask. Even if a health worker completes training, they are not confident that they can do it perfectly again. In hospitals, people use gloves, gowns and stethoscopes but their technique is not always perfect. There is as yet no objective way to test if the health worker has made mistakes or not.

Invisible Black Light Body Paint is a theatrical paint that is invisible under normal lights but fluoresces back under UV Black Light. These are used during halloween, calligraphy, fabric dyeing and go bottles, They are also used to measure leaks in industrial systems. They have been used to teach pattern of primary and secondary transmission of infection among students as a kit made by a biotechnology education company Edvotek. Glo-Germ kit uses florescent dye and UV light to teach proper hand washing. There are no reports or research so far regarding their use in teaching correct personal protective equipment use by simulating the transmission of infection to health care workers.

If invisible florescent dye is placed on a mock patient, then, volunteers who examine that patient can be photographed under ultraviolet light to determine if their gloves, gowns, and masks were able to protect them; and by correlating the location of skin fluorescence with video recording of breach in protocol, improved teaching methods for protective personal equipment use can be developed.

Materials and Methods

Materials:



Gloves, paper gowns, masks, one impermeable plastic gown, stethoscope

75 watt CFL Blacklight bulb and bulb holder

GloMania UV bodypaint . Invisible UV bodypaint that is florescent under UV light. It washes out and is safe and non toxic.

Cooking oil to make suspension of dye in oil

Sunglasses

Camera for video and still photographs.

Computer to show powerpoint slides and video from Centers for Disease Control to educate volunteers in proper technique in use of gloves, gowns, and masks. Also to analyze videos and photographs in iMovie and iPhoto

13 volunteers/subjects (students or adults) 2 were used as subjects and 11 as volunteers.

Slides from CDC:

Guidance for the Selection and Use of Personal Protective Equipment in Healthcare Settings (<http://www.cdc.gov/hai/prevent/ppe.html>) has developed this slide set for use by staff development, infection control, and occupational health personnel for training healthcare personnel on how to select and use personal protective equipment PPE to protect themselves from exposure to microbiological hazards in the healthcare setting.

Available Formats for download: Powerpoint, PDF, video, poster (<http://www.cdc.gov/hai/pdfs/ppe/PPE-Sequence.pdf>)

Method:

- 1 Place one volunteer (mock patient) in impermeable bodysuit and gloves to lie on a couch. Mark a wound with a red marker on the bodysuit in chest area. Apply oil based

liquid to which invisible florescent dye has been mixed on to the front of the bodysuit and to his gloves.

2 Show the volunteers where the gloves, gowns and stethoscopes are placed and ask them to examine the patient and place a dressing dipped in liquid (invisible dye) on the chest wound after donning the gloves, gown and mask. They should help the mock patient sit up in the bed and then lay him down again. (Mock patient will unexpectedly hug them in the process). Take videos of each volunteer performing the requested action.

4. Take photos of each volunteer under ultraviolet light wearing the personal protective equipment. Make sure they wear sunglasses when bathed in UV light.

5. Take videos of each volunteer removing the personal protective equipment and discarding the gloves, gown and mask in a bin.

6. Take photos of each volunteer under ultraviolet light again without the a personal protective equipment.

7. Hold a teaching session using CDC guidelines and videos for the volunteers and demonstrate correct use of the gloves, gown, and the correct order in which to remove them. Stethoscope to be removed first followed by gloves, gown and lastly the mask.

8. Ask the volunteers to repeat the clinical exam including application of dressing and take the videos of the process.

9. Take the photos of each volunteer with the personal protective equipment under ultraviolet light.

10. Take video of the glove, gown and mask doffing (removal) procedure

11. Take the photos of each volunteer without the personal protective equipment under ultraviolet light.
12. Examine photos and note transmission of dye to the various body parts of the volunteers before and after the training .
13. Examine videos to identify how skin soilage occurred in each volunteer and identify common mistakes. If a volunteer has transmission of dye even after training, analyze the videos to see the cause of the transmission and how that transmission could have been avoided.
14. Incorporate the problems noted and improve the teaching technique. Generate insights from lessons learned from mistakes made by the volunteers.

Discussion

11 volunteers had video and ultraviolet light photography before and after watching the Centers for Disease Control powerpoint and video regarding correct techniques of donning and doffing the protective equipment.

Ages were 14, 13, 57, 68, 41, 35, 35, 49, 39, 47 and 44 yrs. Average age was 40 yrs and median age was 46 yrs. Six females and 5 males were represented. Occupations were: 2 students, 3 doctors, 1 psychologist, 1 dietician, 1 gemologist, 1 businessman, 1 money manager and 1 housewife.





Results

Volunteer 1 - TY

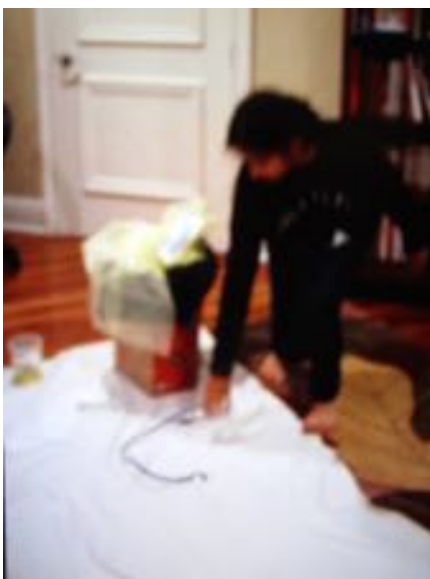
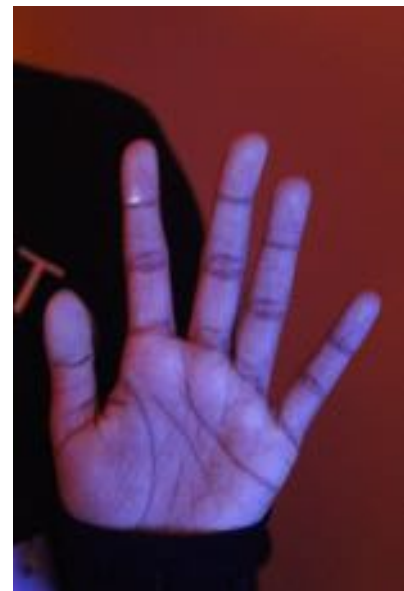


Before PPE education TY had florescence on right hand - suspect she touched infected gloves and gown as she pushed the gown down into the garbage to keep things neat.

After education, she was perfect.

Lessons: Safety first always. Resist reflex urge to clean up.

Volunteer 2 - SY



SY - Right hand infected - probably because she picked up infected stethoscope to put in place and left index finger by unknown reason not caught on video. After education, the instructions regarding removing one glove and making into a ball with other hand were difficult to follow and the heavily soiled glove was touched by bare left hand.

Lessons:

- 1) Do not touch stray stethoscopes with bare hands.
- 2) Be extra careful when removing gloves and avoid the temptation to keep the free hand close to the one pulling the glove up into a ball.

Volunteer 3 - TJ



TJ had florescence on nose and right hand second and third fingers. The nose was probably touched while adjusting stethoscope. He took out right hand glove and used the ungloved right hand to touch the outside of left glove and infected his right hand. He did not do the education and repeat study.

Lessons:

- 1) Do not adjust stethoscope or be very careful regarding stethoscope after touching the patient.
- 2) Take care removing the second glove to avoid infecting the ungloved hand.

Volunteer 4 - RG





RG had florescence on chin, neck and on the right and left hands.

He adjusted his stethoscope and touched the stethoscope with right hand as he removed the gown. He touched the front of his gown as removed it. he did not do education and repeat study.

Lessons:

- 1) Avoid touching neck with gloved hand as stethoscope is adjusted. Adjust stethoscope at the Y joint rather than near the earpieces. Stethoscope should be removed carefully before removing gloves.
- 2) Avoid touching gown from outside as it is removed.

3) Volunteer 5 - KJ

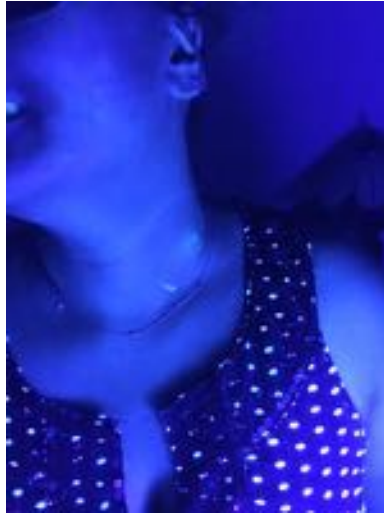


KJ had fluorescence at right 3rd finger probably from poor technique when removing gloves.

Lesson: Correct glove removal technique is most important.

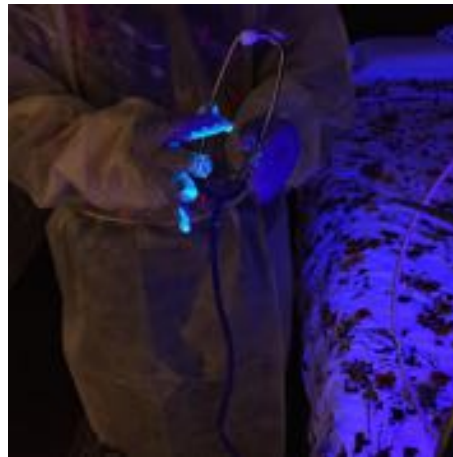
Volunteer 6 —JS





JS had florescence on left 5th finger due to difficulty removing glove which snagged on the ring on finger. After education she has new area of infection at right and left exposed neck areas possibly from hug given by patient to her doctor

Volunteer 7 — PY

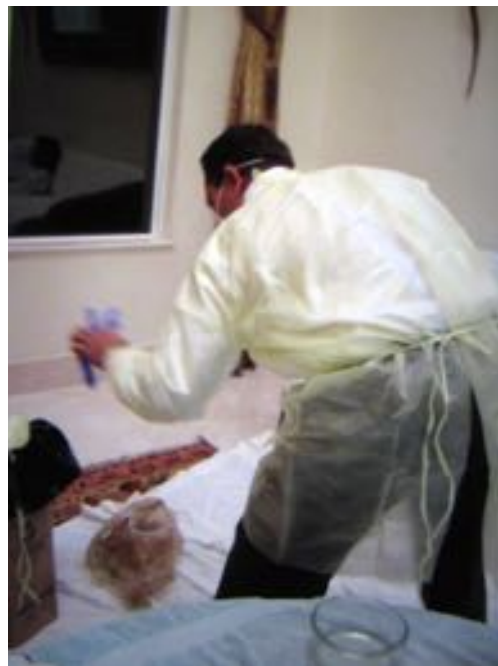


PY had florescence on right palm on first attempt from stethoscope but had even more infection on second attempt. She removed gloves improperly, touched the sleeve of her gown and touched clean hand with infected glove when trying to follow CDC directions.

Lessons:

- 1) Practice is necessary to flow CDC directions regarding glove removal. She pulled at sleeve of gown with clean hand to expose edge of second glove.

Volunteer 8 — SJ



SJ did everything well both times, but picked up his glove from ground when it fell and infected right thumb area.

Lesson: Avoid reflex actions and move slowly and deliberately. Do not pick up any objects if they fall on ground.

Volunteer 9 — NJ



NJ had no infection on both occasions. He, an anesthesiologist, used his usual technique and removed both the gown and gloves quickly in one movement. After CDC education, he removed the gloves followed by gown with perfect technique. He found the CDC method slower but agreed that it was more secure.

Lesson: Extensive daily experience made it easy for him.

Volunteer 10 — RJ



RJ had no florescence before or after education. He had some facial scars that had faint florescence but were not felt to be the transmission of dye and pressed even after washing off with soap.

Volunteer 11 — LJ



LJ did well . She was slow and careful both times and used correct technique. No fluorescence was found.

All photos were taken by Saachi Jain

Volunteer	Before Education	After CDC Education	Cause
TY	Rt hand	none	pushed gown
SY	Both hands	Left hand	glove doffing technique
TJ	Nose, Rt hand	-	adj steth, glove doffing
RG	Chin, neck, right and left hands	-	Adjusted stethoscope and removed it last
KJ	Right hand	-	glove doffing technique
JS	Left hand	neck	ring snag, patient hug
PY	Left palm	Rt hand	Stethoscope, touched sleeve of gown, glove
SJ	Left thumb	none	picked glove from floor
NJ	none	none	past experience
RJ	none	none	weak natural florescence
LJ	none	none	slow, methodical

3 of 11 volunteers did not do the CDC education and repeat study.

Of the 8 volunteers who completed both parts, 3 had no infection before or after the education.

Of the 5 volunteers who failed before education, watching CDC powerpoint and video regarding sequence and technique of donning and doffing personal protective equipment, 3 of 5 (60%) failed again. The location of infection on the second attempt was different and 2 of the three failures were associated with inability to perfectly perform the complicated glove doffing procedure.

Discussion

Analysis of videos and photographs under UV light has shown that this technique of using invisible florescent dye to is a sensitive way to pick up even the slightest contact with a soiled glove or gown.

Glove doffing was the most common reason for infection. Even after looking at the CDC technique on powerpoint and video, there were errors made by 2 people. The gloves were not long enough to come over the gown and exposed skin at wrist increased the chance of infection at wrist area as the gloves were removed. Double gloving is one way to decrease risk and is recommended in some situations. One idea may be to remove the glove and then wear a new glove before removing the gown. Different methods could be tested with this technique and the the best method developed in a scientific manner.

Stethoscopes were found to a major cause for infection. The shared stethoscope in a patients room is commonly used inside isolation rooms. Touching/ adjusting the stethoscope and then pulling it out of ear at neck led to infection at neck. Even a new stethoscope will get infected at the neck area unless care is taken to avoid touching the higher neck portion with infected gloves. Stethoscope should be removed first, then gloves, gown and lastly the mask. Bluetooth stethoscopes are an option and could be placed in patients rooms.

Gowns were also tricky to remove. The advice is to remove them without touching the outside portion. However this became difficult since the inside and outside are of the same color. Even on frame by frame video, it was difficult to note if someone touched the outside or inside portion as they rolled it up to throw away. A gown with a different color on the inside may be helpful.

Reflex sudden actions got some volunteers in trouble. Tendency to push the gown into the garbage pail and to pick up a fallen glove was noted. Sudden actions should be avoided.

This experiment only used gloves, mask and gown since face shield or hood are cumbersome. This technique could be used with the advanced protective equipment used for ebola to create confidence and to perfect the techniques.

Some drawbacks of this experiment were that only 11 subjects were used and 3 of them could not complete the second portion of the study. The video at times was from an angle where the suspected exposure could not be confirmed. The lighting and darkness of the room when taking the photographs was not standardized and some areas of fluorescence could be missed. There seemed to be a learning effect such that the last three volunteers became aware of the sensitivity of the test and observed the other volunteers and had perfect records. Just observing how others get infected has a role in teaching correct use of personal protective equipment.

Works Cited

"166 - Detection of a Simulated Infectious Agent." 166 - Detection of a Simulated Infectious Agent. N.p., n.d. Web. 30 Nov. 2014. <<http://www.edvotek.com/166>>.

And, Aled. "Sequence for Putting on PPE." CDC Sequence for PPE (n.d.): n. pag. Web.

"Cdc Video for Ebola." N.p., n.d. Web. <<http://www.cdc.gov/media/video/fullvideo/EbolaTrainCDCAL.wmv>>.

"Changes to Ebola Protection Worn by U.S. Hospital Workers." The New York Times. The New York Times, 14 Oct. 2014. Web. 22 Nov. 2014.

"Darklight FX - Visual Effects, Photography, Posters, and Tech Products. Blacklight & Glow in the Dark Effects!" Darklight FX - Visual Effects, Photography, Posters, and Tech Products. Blacklight & Glow in the Dark Effects! N.p., n.d. Web. 23 Nov. 2014.

"Glo Germ: Handwashing, Aseptic & Isolation Techniques, Infection Control, Contagion, Meryl Streep." Glo Germ: Handwashing, Aseptic & Isolation Techniques, Infection Control, Contagion, Meryl Streep. N.p., n.d. Web. 30 Nov. 2014. <<http://www.glogerm.com/>>.

"Guidance on Personal Protective Equipment To Be Used by Healthcare Workers During Management of Patients with Ebola Virus Disease in U.S. Hospitals, Including Procedures for Putting On (Donning) and Removing (Doffing)." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 10 Nov. 2014. Web. 21 Nov. 2014.

"How Did a Dallas Nurse Catch Ebola?" Scientific American Global RSS. N.p., n.d. Web. 30 Nov. 2014.

"NASA Science." Ultraviolet Waves. N.p., n.d. Web. 23 Nov. 2014. <http://missionscience.nasa.gov/ems/10_ultravioletwaves.html>.

"Protecting Healthcare Personnel." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 16 Oct. 2014. Web. 13 Dec. 2014.

"Protecting Healthcare Personnel." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 16 Oct. 2014. Web. 22 Nov. 2014.

Rubock, Paul. "Working Safely with Ultraviolet Radiation." COLUMBIA UNIVERSITY (n.d.): n. pag. Environmental Health and Safety. Columbia University, May 2005. Web. 22 Nov. 2014. <<http://ehs.columbia.edu/UV.pdf>>.

Shoichet, Catherine E., Greg Botelho, and Jason Hanna. "How Did Nurse Amber Vinson Get Ebola? 'It Is a Mystery to Me,' She Tells CNN." CNN. Cable News Network, 06 Nov. 2014. Web. 30 Nov. 2014.

Sun, Albert, and Hannah Fairfield. "How the Speed of Response Defined the Ebola Crisis." The New York Times. The New York Times, 03 Nov. 2014. Web. 23 Nov. 2014.

Swerdlow, A. J. "Fluorescent Lights, Ultraviolet Lamps, And Risk Of Cutaneous Melanoma." BMJ: British Medical Journal 297.6649 (1988): 647-50. Web.

Swerdlow, A. J. "Fluorescent Lights, Ultraviolet Lamps, And Risk Of Cutaneous Melanoma." BMJ: British Medical Journal 297.6649 (1988): 647-50. Web.

"WHITE INVISIBLE UV Body Paint, Black Light Liquid Paint 1oz." N.p., n.d. Web. <http://www.amazon.com/WHITE-INVISIBLE-Paint-Black-Liquid/dp/B00JV6ILQY/ref=sr_1_4?s=beauty&ie=UTF8&qid=1417393569&sr=1-4&keywords=glomania+uv+paint>.