

Engineering Controls for Tuberculosis: Upper-Room Ultraviolet Germicidal Irradiation Guidelines

Response to Peer Reviewers' Comments

Specific Questions

1. Is the guideline provided for average UVGI intensity (30-50 μ W/cm²) in the upper-room air appropriate? Would it be better to use a minimum average intensity (e.g., 30 μ W/cm²)? Would some other guideline be more useful?

The range of UVGI intensity (30-50 μ W/cm²) was included in the document at this time. Additional information was also provided (see # 2 below) to help design upper-room UVGI systems so this UVGI intensity range can be achieved.

2. Is the guideline for installing louvered fixtures that provide 0.17 UV-C watts per each ft² in a room appropriate? Is the guideline of 0.085 UV-C watts per ft² for fixtures without louvers in rooms with 9 ft or higher ceilings appropriate?

This suggestion was included in the document to provide practical guidance to upper-room UVGI system designers. One reviewer suggested that the volume of air in the upper room (rather than floor space) would be a better way to estimate the fixtures needed for UVGI systems. Based on her research, this guideline was also added to the document.

3. Other than the information provided in the draft document, what other methods are available for obtaining "spot measurements" of the upper-air UVGI intensity when the UVGI system is composed of multiple fixtures?

One method suggested by a reviewer was added to the document.

4. Is it appropriate to provide a guideline that states UV lamps should be replaced when the lamps start to emit approximately 70% of their original output? What is the best way to measure the output of the UV lamps in a fixture?

There was agreement among the reviewers that "relamping" should be done as recommended by manufacturers or at least on a yearly basis. This was added to the document.

5. Under "air mixing guidelines" it is stated in the draft that fans should be used to continually mix the air if there is any question about vertical air mixing between the upper and lower portion of a room. Will the use of mixing fans have any affect on other infection control issues?

It was suggested by a reviewer that mixing fans may affect the designed airflow within an infection isolation room. It is noted in the document that mixing fans may not be appropriate for use in isolation rooms.

General Comments

Many general comments were addressed in the revised document. Several comments that were not believed to add to the document or were not necessarily accurate were not addressed.

The NIOSH/CDC recommended exposure limit (REL) was first published in 1973. Based on the REL, the maximum recommended exposure to UVGI is 6 mJ/cm^2 at 254 nm for a daily 8-hr work shift. This corresponds to a maximum recommended exposure for eight hours to UVGI at a wavelength of 254 nm of $0.2 \mu\text{W/cm}^2$. Based on this, upper-room UVGI system designers have used $0.2 \mu\text{W/cm}^2$ as the maximum lower (occupied) room irradiance at any time in order to limit the irradiance level in the lower room to the 8-hr REL. Some reviewers jointly noted this limits the radiation level in the upper-room thereby decreasing the potential effectiveness of the system. Therefore, they thought it appropriate that the only figure that should be quoted in the document is 6 mJ/cm^2 for an 8-hour exposure. A comment was added to the document to clarify that workers move around when performing their duties and may not be exposed to a single irradiance level (e.g., $0.2 \mu\text{W/cm}^2$) during their work shifts.

Not all of the questions posed in the cover letter to reviewers could be answered at this time. Additional research needs to be done in several areas including fixture installation and room irradiance measurements. However, the studies noted in the document have shown that a properly designed and maintained upper-room UVGI system may be effective in killing or inactivating virulent tuberculosis bacteria. Therefore, sufficient information is now available to develop guidelines for designing safe and effective systems.