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Airport Full Body Screening: What is the Risk?

Pratik Mehta¹ and Rebecca Smith-Bindman, MD²

¹Bachelor of Arts Candidate in Public Health, University of California, Berkeley

²Departments of Radiology and Biomedical Imaging, Epidemiology and Biostatistics, Obstetrics, Gynecology, and Reproductive Sciences, University of California, San Francisco

In response to a passenger smuggling plastic explosives hidden in his underwear onto a Detroit-bound airliner on Christmas Day in 2009, the Transportation Security Administration (TSA), a department of the US Department of Homeland Security, began pushing forward with its plan to place full body scanners in all American airports. Thus far, the TSA has deployed 486 scanners in 78 airports in the United States, with an estimated 1,000 scanners to be deployed by the end of 2011.

There are two types of full body scanners in use. Each generates a detailed outline of the human body for the purpose of identifying contraband hidden under clothing. The millimeter wave scanners emit extremely low energy waves- each scan delivers a small fraction of the energy of a cell phone- and the scanners capture the reflected energy. The backscatter x-ray scanner, the more common scanner type in the U.S., utilizes very low dose x-rays, similar to those used in medical imaging. In contrast to x-rays used for medical imaging where variation in the transmission of x-rays *through the body* are used to generate an image, backscatter scanners detect radiation that *reflects off* of the person imaged. When radiation passes through air, it deposits energy into the tissue that absorbs it, and with the backscatter technology, all of the energy of the scan is absorbed by the most superficial tissues of the body such as the skin.

Both machines types have the capacity to create extremely detailed and revealing images of those screened- the machines generate outlines that reveal genitalia, breasts, buttocks, fat creases and all types of prosthetics, catheters and piercings. The TSA has taken several steps to ensure the privacy of passengers given these machine capacities. They have implemented technology that blurs the images of the face; installed software to make the images less provocative; installed software that displays a chalk outline of subjects; and have separated the security personnel who view the images from the passengers, so that the screeners never see the passengers directly. Further, while the scanners have the capacity to store, and export the scanned images –functions that are intended only to be used when the machines are used for testing, evaluation and training - the TSA has made it impossible for scanners deployed in airports to save or export images. Even with these assurances, reports of tens of thousands of scanner images that were improperly saved and disseminated have raised concerns as to whether these assertions are true¹, and further concerns have been raised whether employees can alter the settings of the machines on site to remove these safe guards that the TSA has put in place.

Even with the measures taken by the TSA to ensure privacy, religious groups ², the American Civil Liberties Union– who liken the scans to virtual strip searches ³, and the

Correspondence: Rebecca Smith-Bindman, MD, Department of Radiology and Biomedical Imaging, University of California, San Francisco, 350 Parnassus Ave, Ste 307, San Francisco, CA 94115 (Rebecca.smith-bindman@radiology.ucsf.edu).

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Electronic Privacy and Information Center (EPIC, a public interest research center) have protested the use of the scans.⁴ EPIC has filed a suit in federal court against the Department of Homeland Security that alleges the scans violate the Fourth Amendment, the Privacy Act, The Religious Freedom Restoration Act and the Video Voyeurism Prevention Act.⁵

The second concern is limited to the safety of the backscatter x-ray scanners, which, unlike the millimeter wave scanners, use ionizing radiation. The potential for ionizing radiation to cause damage depends on the dose; at low doses, radiation causes biological damage, but cells repair this damage rapidly. At moderate doses, cells can be changed permanently, becoming cancerous or leading to other abnormalities such as birth defects. At even higher doses (such as those delivered through radiation treatment for cancer), cells cannot be replaced quickly enough and serious health problems can arise.

The doses of ionizing radiation emitted by these backscatter x-ray scans is exceedingly low - so low that it is really not known whether there is any potential for causing harm. The TSA considers the risk for causing harm trivial. Even though the doses are low, the cancer risk merits consideration given there are 750 million passenger enplanements a year and even a small risk per person could potentially translate into a significant number of cancers.

When focusing on the potential harm of these backscatter scans, it is helpful to separate the quantification of the *dose* associated with these scans from the quantification of the *risks* of these exposures, and to focus on risks among subgroups of individuals who may be particularly vulnerable to the carcinogenic effects of the radiation.

Exposure to ionizing radiation: full body airport scans versus ubiquitous background exposures

Individuals are routinely exposed to ionizing radiation from many different natural sources, and ionizing radiation is widely used in industry and medicine. According to a recent report from the National Council on Radiation Protection and Measurements (NCRP)⁶, individuals in the United States are exposed to an average of 6.2 millisieverts (mSv) of ionizing radiation annually – or approximately 0.01 microsievert (μ Sv) per minute. The two most common sources of exposure are medical procedures and ubiquitous background radiation, sometimes described as natural sources of radiation – including radiation from the sun and cosmic rays; and radiation from radon that is released from the earth. The backscatter x-ray scanners expose individuals to 0.03–0.1 μ Sv per scan^{7–10} or the equivalent to 3–9 minutes of radiation received from naturally occurring sources as part of daily living. Thus, the exposure from the scans is relatively small.

Naturally occurring radiation is higher at the altitudes of commercial air flights because of the greater proximity to the sun. The radiation associated with a flight will vary with altitude and latitude, but overall, air travel is associated with an exposure of approximately 0.04 μ Sv per minute of flight time.^{6, 7, 11} The backscatter x-ray scans deliver radiation equivalent to around 1–3 minutes of flight time. Put into context of the entire flight, if a woman embarks on a 6-hour flight, she will be exposed to approximately 14.3 μ Sv of radiation from the flight, and 0.03–0.1 μ Sv from passing through the scanner at the airport. Thus, the scan will increase her exposure by less than 1%. The suggestions that individuals who may be particularly vulnerable to radiation effects may want to avoid the scans are unwarranted concerns; the flights themselves may expose them to a small increased exposure to ionizing radiation, but the scans will further increase that exposure by a only a very small amount.

It is informative to contextualize the exposure from the backscatter scans with the other sources of radiation frequently experienced. An individual would have to undergo more than

50 airport scans to equal the exposure of a single dental x-ray; 1,000 airport scans to equal the exposure of a chest x-ray; 4,000 airport scans to equal the exposure of a mammogram; and 200,000 airport scans to equal the exposure of a single abdominal and pelvic CT scan. Thus, the doses for the airport scans are exceedingly low compared with doses routinely received in the health care context.

Cancer risks associated with the backscatter x-rays

Estimating the *risk* associated with these extremely low dose exposures is more difficult than quantifying the *exposure*. Published studies that have demonstrated an association between radiation exposure and cancer risk have been done at doses that are much higher than the levels emitted by the scans.¹¹ To estimate the risk of these scans we must rely on extrapolation from these higher dose studies, yet extrapolation of cancer risks from high dose to the exceedingly small doses of these scans is questionable, and may be inappropriate. Specifically, it is usually assumed that a “linear no-threshold” model applies—that is, the risk is directly proportional to dose, and that there is no threshold—meaning every exposure carries some risk, even the exceedingly small doses of the airport scans. However this may not be accurate. Even so, no alternative model exists.

Second, the exposure from these scans is concentrated in the superficial tissues – primarily the skin— and there is no accepted mathematical model for understanding the relationship between skin exposure and risk of skin cancer¹¹. Thus the available models that can be used to estimate future cancers are inaccurate, since the distribution of the exposure from these scanners to the skin is different than the distribution of exposures to the whole body assumed by these models. The backscatter x-rays *will* be concentrated in breast tissue, so the breast exposure from these scans can be used to accurately predict breast cancer risk.¹¹

Given these two limitations on cancer projections, we estimated the risk of exposure to the backscatter x-rays scanners in three groups: all flyers, frequent flyers, and frequent flyers who are 5 year-old girls. This last group was chosen as children are more sensitive to the effects of radiation than adults, and we can use existing models to accurately estimate the risk of breast cancer from these scans.¹¹ For these estimates, we extrapolated from the linear dose-risk relationship model, assumed all passengers undergo a full body scan for each trip, assumed 100 million unique passengers will take the 750 million flights in a year, and assumed the exposure of the scans is 0.1 μ Sv.⁹ Several groups have developed models to allow estimation of the risk of cancer following exposure to ionizing radiation, and we used their estimate of an increase of approximately 0.08 cancers per sievert of exposure to estimate cancers that could potentially result from the scans.^{11–13}

All Flyers

Among the 750 million enplanements per year taken by 100 million passengers, six cancers over the lifetime of these individuals could result from the backscatter scans. These six cancers need to be considered in the context of the 40 million cancers that would develop in these individuals over the course of their lifetimes due to the high underlying cancer incidence.

Frequent Flyers

Among 1 million frequent fliers who take ten trips per week for a year, where each trip lasts 6 hours in duration (i.e. 60 hours of flying per week), four additional cancers could occur from the backscatter scans. These four excess cancers need to be considered in the context of the 600 cancers that could occur from the radiation received from the flying at high

elevations, and in context of the 400,000 cancers that would occur in these 1 million individuals over the course of their lifetimes.

Five Year-Old Frequent Flyers

The breast dose for the backscatter scans is 0.049 μSv per scan⁸ and the risk of breast cancer increases by 9140 cases per 100,000 5 year-old girls exposed to a sievert of radiation.¹⁴ We estimate that for every 2 million girls who travel one round trip per week, one additional breast cancer could occur from these scans over their lifetime. This increase of one cancer per 2 million young girls needs to be put in the context of the 250,000 breast cancers that will occur in these girls over the course of their lifetimes due to the 12% lifetime incidence of breast cancer.

While several groups have called for research on the association between airport scan exposures and risks, these examples show the difficulty in using epidemiological methods to better estimate the risks of such extremely low exposures.

In medicine, we try to balance risks and benefits of everything we do, and thus while the risks are indeed exceedingly small, the scanners should not be deployed unless they provide benefit - improve national security and safety – and consideration of these issues is outside the scope of our expertise. Issues have been raised regarding the efficacy of the scanners and if the scanners are not deemed efficacious they should not be used.¹⁵

Based on what is known about the scanners, passengers should not fear going through the scans for health reasons, as the risks are truly trivial. If individuals feel vulnerable and are worried about the radiation emitted by the scans, they might reconsider flying altogether since most of the small, but real, radiation risk they will receive will come from the flight, and not from the exceedingly small exposures from the scans. Discomfort with the backscatter scanners exist in part because of health and privacy concerns, and in part because the TSA does not permit independent assessment of the machines, raising concerns that if the machines do not function as provided, or if the settings are changed by employees after the machines are installed, or if they undergo software or mechanical errors or malfunctions, unknown effects could result.¹⁶ The TSA asserts that the machines have been adequately tested by various organizations^{7, 9, 17} but as pointed out by Professor Sedat, one of four Professors at the University of California San Francisco who wrote Dr. John P. Holdren, assistant to the President for Science and Technology, more independent testing is necessary noting that *it is premature to put a whole population through this with out more due diligence and independent testing*.¹⁶ It would seem prudent of the TSA to permit additional testing to verify the safety of the devices.

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