Purpose:

In the past decade, manufactures have introduced lead-equivalent (lead-free) radiation shielding garments which have become quite popular in interventional radiology (IR) due to their reduced weight when compared with traditional lead aprons. The material composition of lead-equivalent aprons varies significantly from manufacturer to manufacturer, and while some manufacturers use an undisclosed blend of materials, others publish their aprons composition. However, there does not yet exist any published scientific report describing the optimal lead-equivalent garment composition and under what conditions such a garment is most effective.

Methods:

To reflect modern practice, our analysis is based on the assumption that IR staff will never be in the primary beam, and their radiation protection garment should therefore be optimized to attenuate scattered x-ray spectra. Using a Monte Carlo radiation transport code, the scattered spectrum at different points in an interventional suite was determined for a modern angiographic system as a function of patient size, C-arm configuration and the position of the physician within the room. A sequential quadratic programming optimization routine was used to determine the optimal combination of metals to produce the lightest apron which attenuates the scattered x-ray spectrum as effectively as a traditional 0.5 mm thick lead apron.

Results:

Our analysis indicates that for the scattered x-ray spectra most apparent to IR personnel, lead is not the most efficient shielding material by weight. Using numerical optimization and a specific analysis of typical IR suite scatter spectrum, we are able to recommend a shielding garment construction which is equally effective to a standard lead garment but with a 44% reduction in weight.

Conclusions:

A clear algorithm is presented for determining the best composition to satisfy a variety of endpoints which can be used both in apron manufacturing and in verification that the claims of a lead-free garment manufacturer are valid.