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Potential health impacts of particle and volatile organic compound emissions from consumer level 3D printers

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Consumer level fused filament fabrication (FFF) 3D printers are widely used in small-scale indoor environments and public spaces, where vulnerable populations like children may be exposed to the potentially hazardous emissions. Studies have found a mixture of particles and volatile organic compounds (VOCs) being emitted from operating those 3D printers, however the health impacts of the emissions are not well known. This study systematically characterized particle and VOC emissions from multiple 3D printers using various filament materials based on a standard test method and estimated the potential health impacts of emissions according to modelling and experimental assessment. The emission levels and characteristics of particles (ultrafine, fine and coarse) and numerous VOCs were investigated, as well as the operation parameters that affect the emission characteristics, such like print temperature, printer brand, filament material, brand and colour. Chemical composition of 3D printer emitted particles were analysed by different instrumentations and compared to the properties of the bulk filament material. Particle health impacts were assessed by *in vivo* exposure and *in vitro* cellular and chemical experimental methods, and exposure levels of VOCs were assessed by an indoor exposure model. The health-related results were discussed by relating to ambient particulate matter health related study and indoor air quality regulations and criteria. Overall, this study finds FFF 3D printing will emit high levels of particles and numerous VOCs, which are potentially hazardous to human health, indicating that exposure to 3D printing emissions should be controlled.