

3D Printing in Health Care

Educational Briefing for Non-IT Executives

Executive Summary

Early 3D printers were large, expensive industrial machines, prohibiting widespread adoption. Since their inception in the 1980s, 3D printer costs have decreased even as capabilities have improved, and a flood of new technologies and vendors has made the market more competitive. 3D printing already has some footholds in the health care industry (e.g., hearing aids, dentistry), but expectations for this technology have grown over the past few years due to the potential value of “printing anything”—from biological organs to a house. The enthusiasm surrounding 3D printing is justified, as the technology has the potential to streamline manufacturing, allowing health care organizations (and eventually patients) to design and produce products on demand, cheaply and efficiently.

What is 3D Printing?

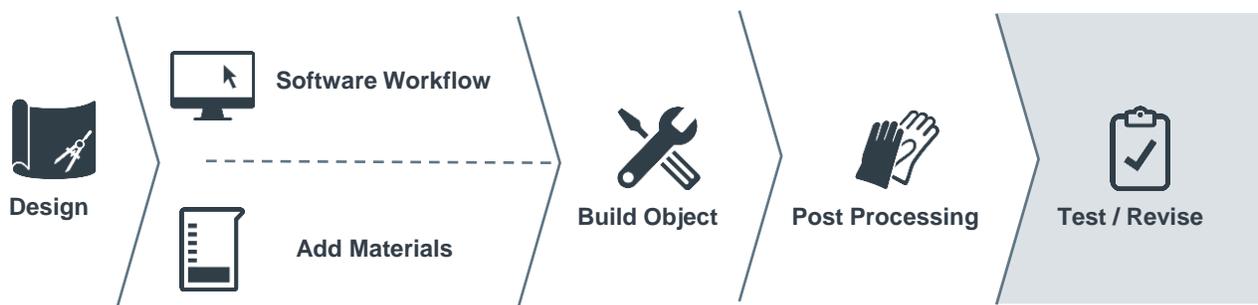
3D printing, also known as “additive manufacturing,” is a process that lays down successive layers of material to build three-dimensional objects. Additive manufacturing differs from conventional “subtractive manufacturing,” which cuts away excess materials from an original source to make the desired part. 3D printing has expanded across a number of industries, including aerospace, industrial manufacturing, automotive, consumer goods, energy, retail, entertainment, military defense, health care, and more.

3D printing can produce objects using a wide variety of materials, including polymers (e.g., plastics, rubber, resins, liquid photopolymers), powdered metals and alloys (e.g., aluminum, steel, titanium), ceramics, wax, sand, organic materials (e.g., stem cells, wood), and other composites. Health care applications typically utilize polymers, metals, donor cells, and other biomaterials.

The first step in the 3D-printing process is to create a digital model, which is done with computer-aided design (CAD) software, but may also involve a 3D object scanner or medical imaging. Within the software workflow, users can adjust the printing process to match their needs regarding segmentation (e.g., outlining and coloring the structure of a heart model), functionality (e.g., the need for an object to include a movable hinge), or structural complexity (e.g., shape, texture, layer thickness). The design is then imported into a slicer program that determines how the printer will build each layer before it is converted into a file format that can be read by the printer.

Once the print process begins, the machine works autonomously, following the rules of the digital file with little or no need for human involvement. After the printing is complete, there is often a post-processing phase which can include coloring, sanding, sterilization, polishing, or removing structures that were needed to support printed overhangs on the 3D object.

The 3D Printing Process



How is 3D printing used or applied in health care?

Medical 3D printing applications have expanded considerably, though some advanced uses will likely take another five to ten years before they are put to clinical use:

- **Surgical planning**—Health care providers can 3D print patient-specific models of organs, nerves, tumors, and other tissues from CT¹ or MRI² scans. These models can be used for general education purposes (for both clinicians and patients) to help diagnose an illness, or for surgeons and other support staff to plan for an upcoming surgery.
- **Prosthetic limbs**—3D-printed limb prosthetics are much faster and cheaper to produce than traditional prostheses. The quick turnaround times and ability to customize each device have made limb prosthetics particularly popular for growing children, athletes, or anyone with an amputation. 3D printing is also used to develop exoskeletons, which can help patients learn to walk again after injury.
- **Implants**—Today, the vast majority of in-ear hearing aids are made using 3D printing to custom fit the devices for each patient's ear canal. Beyond hearing aids, a number of other 3D-printed implants are already being used in patient care, including hip and knee joints, spinal disks, bone replacements (e.g., a printed titanium sternum), and plates for craniofacial reconstruction.
- **Bioprinting**—Researchers are testing out new ways to use 3D printers and stem cells to print blood vessels, muscles, bones, cartilage, and functional organs. This type of printing is still heavily focused in academic / laboratory settings, but has great potential to transform patient care. 3D-printed tissues and organs may be used for testing pharmaceuticals or cosmetics, modeling the effects of different diseases, and reducing problems with organ rejection.

Why is it important?

3D printing can yield long-term strategic value by enhancing design-to-manufacturing capabilities, speeding time to market, and offering differentiated service in specific areas of patient care. While these tools were initially limited to professional design engineers for producing models and prototypes, 3D printing technology is beginning to play a broader role serving medical researchers, physicians, academics, manufacturers, and consumers.

How does 3D printing affect health care providers and IT leaders?

Better patient care

- 3D printers enable health care organizations to produce custom-made medical products and equipment. By building patient-specific devices such as implants, anatomical models, and surgical tools, hospitals and health systems can improve outcomes, personalize care and increase patient satisfaction.

Increased collaboration and creativity

- 3D printing democratizes product design and manufacturing. Within a health system, 3D printing creates new multidisciplinary communication channels and opportunities for clinical innovation.

Questions That Hospital Executives Should Ask Themselves

- 1 How would we use 3D printing, and what type of printing technology is best for our use case(s)?
- 2 Do we have the internal talent and infrastructure for 3D printing, or should we outsource services?
- 3 If we run in-house printers, which department will lead the deployment? How will this scale over time?

Additional Advisory Board research and support available



Report: [3D Printing in Patient Care](#)



Webconference: [The Hospital of the Future](#)