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Transformation

Next Gen Tech: Healthcare

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Key takeaways

- The US has one of the most expensive health systems in the world, with spending totaling $4.3 trillion in 2021 alone. But could wider adoption of AI technologies lead to a savings? Potentially, as pharmaceutical companies have long been in the vanguard of artificial intelligence, and researchers have been applying complex AI models to unlock the mechanisms of disease.
- Increasing life expectancy, population growth, antibiotics resistance and the "explosion" of healthcare data are all increasing the demand for new healthcare technologies, practices and approaches. Here, we explore five breakthroughs that have the potential to disrupt the industry and revolutionize healthcare as we know it.
- Bank of America Institute's 'Next Gen Tech' series explores 30 breakthrough technologies across artificial intelligence (AI), computing, robots, communication, healthcare, energy and mobility, that are about to alter our lives. Join us as we discuss what's next on the tech horizon.

This publication is part of Bank of America Institute's 'Next Gen Tech' series – focused on sharing 30 breakthrough technologies that will transform the world. Each week, we'll highlight one of seven categories (artificial intelligence, computing, robots, communication, healthcare, energy and transport), and share advancements within each, so stay tuned for more.

Healthcare: From GPT to GLP-1, transformation is here

The US has one of the most expensive health systems in the world, with spending totalling $4.3 trillion in 2021 alone, thanks in part to waste. Approximately 25% of healthcare spending in the country is considered wasteful, and about one quarter of that could be recovered through interventions. According to the Journal of the American Medical Association, the annual cost of wasteful spending in healthcare has ranged from $760-$935 billion in recent years, and the largest source of such waste is administrative costs (roughly $266 billion).

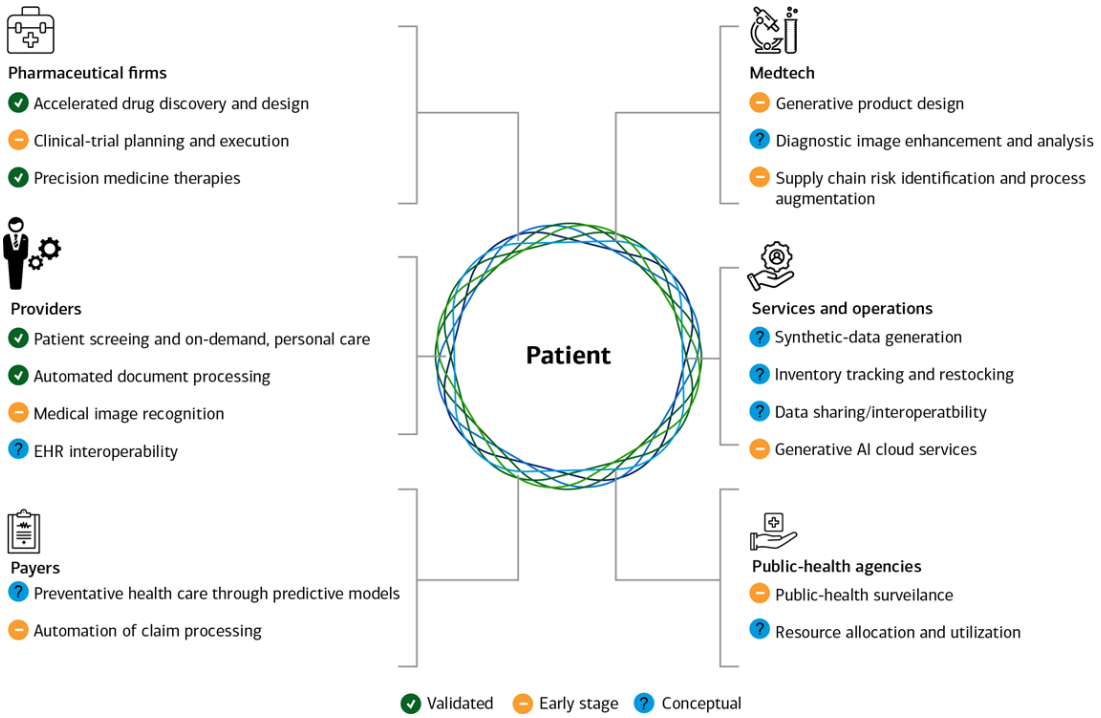
However, the National Bureau of Economic Research (NBER) estimates that wider adoption of AI technologies could lead to a savings of five to 10 percent in US healthcare spending, roughly $200-$360 billion annually in 2019 dollars. These estimates are based on specific AI-enabled use cases that employ today's technologies, are attainable within the next five years, and would not sacrifice quality or access. And these opportunities could also lead to nonfinancial benefits such as improved healthcare quality, increased access, better patient experience, and greater clinician satisfaction (see: Tough hiring tests healthcare's patients for more).

Based on these AI-driven use cases, private payers could save roughly seven to nine percent of their total costs, amounting to $80-$110 billion in annual savings, within the next five years. Physician groups could save three to eight percent of costs, amounting to between $20-$60 billion in savings. Meanwhile, hospitals could see savings of between four and 11 percent, or $60-$120 billion each year, the report estimates.

Pharmaceutical companies have long been in the vanguard of artificial intelligence. Even before the rapid explosion of ChatGPT interest, researchers were applying complex AI models to unlock the mechanisms of disease. In fact, McKinsey estimates that generative AI could create $60-$110 billion a year in economic value for the pharma and medical product industries going forward, largely because it can boost productivity by accelerating the process of identifying compounds for possible new drugs, speeding their development and approval, and improving the way they are marketed.

Increasing life expectancy, population growth, antibiotics resistance and the "explosion" of healthcare data are all increasing the demand for new healthcare technologies, practices and approaches. Here, we explore five breakthroughs – AI drug discovery, AI diagnostics, Liquid biopsy, genomics, and GLP-1s – that have the potential to disrupt the industry and revolutionize healthcare as we know it.

Exhibit 1: Emerging generative AI use cases now exist in all health care segments, from providers and pharmaceutical firms to payers, medtech, service providers, and public health agencies
Generative AI has potential use cases across all health-care segments



Source: BCG analysis, How Generative AI is Transforming Healthcare

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1) AI drug discovery

The healthcare industry is on the cusp of being revolutionized through AI drug discovery, helping to reduce spend, time to market and personalization of drugs and treatments. In fact, research into AI drug discovery is rapidly accelerating; in 2005 there were only 203 research papers on Pubmed.com in this medical field, and by 2018 this number had risen to 7,668.[1]

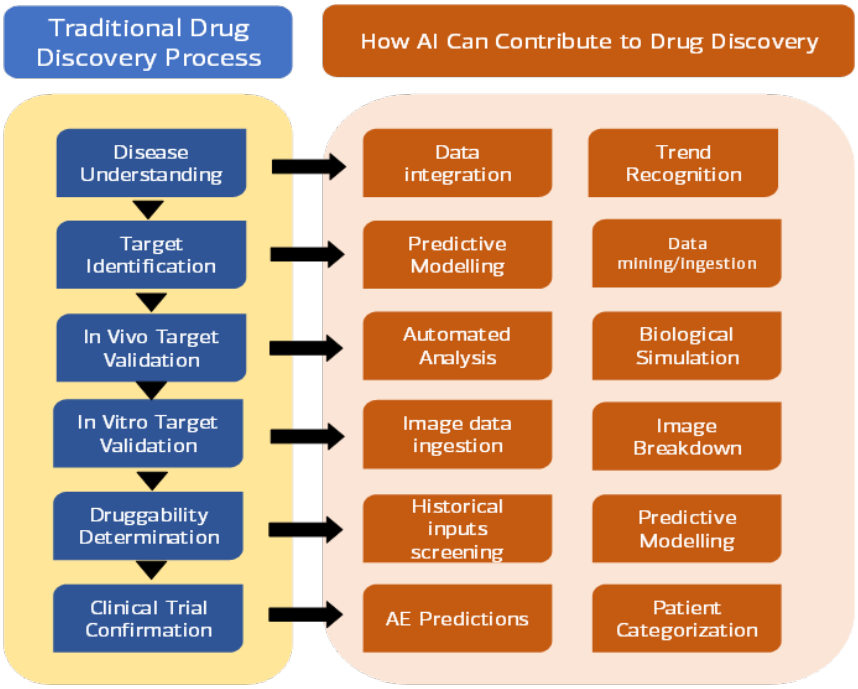
The drug development process has inefficiencies that could be addressed with AI. Such applications include: (1) AI-assisted therapeutic target selection; (2) personalized genomic screening for diagnosis and personalized therapy; (3) clinical trial optimization for streamlining enrollment, fragmenting patient populations, and precision targeting based on mutations to increase chance of response; and (4) optimizing healthcare systems resulting in efficiencies in time and cost. However, given the complexity of biological systems, the data used to train AI models in healthcare will likely be much more densely packaged and more difficult to ingest compared to more generalist use cases of OpenAI's ChatGPT.

One of the first areas AI is likely to replace is the labor-intensive data mining work of drug discovery. Currently, the drug discovery process consists of several steps, including: data mining – a process in which the collection and compound profiling of data from various sources such as gene expression data, proteomics data, and/or transgenic phenotyping can yield decisions for target identification/prioritization – and genetic associations – a process that looks for connections between phenotypic evidence and genotypic markers (for example cross-linking the presence of certain mutative genes to the onset of certain cancers).

That said, BofA Global Research believes that the major technological hurdle lies in the homogenization of multimodal data. Unlike LLMs (large language models), which take simple inputs (i.e., texts, images), AI models in healthcare deal with complex biological systems and the training difficulty is magnitudes higher than a LLM, according to key opinion leaders in the space. BofA Global Research analysts see major technical difficulty with homogenizing multi-modal data in a way suitable for ingestion (packaging genomics and clinical data is dimensionally more difficult than packaging text or images).

[1] MedicalFuturist

Exhibit 2: The future of drug discovery could leverage the use of AI in many areas
Comparison of traditional drug discovery process and AI process



Source: BofA Global Research

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Simulation can already be used in pharma

Using life sciences as an example, AI and simulation technologies can take a molecular structure and simulate it billions of times, making small changes each time to see which structure is optimal. According to Jack Hidary, CEO of SandboxAQ, we can now do in a matter of weeks and months tasks that would take 10 years in the physical world, particularly in pharma. Drug discovery involves high costs and has a high failure rate (90%), which makes the business model unpredictable. The average investment is one to four billion dollars and it takes 10-15 years to develop the drugs, forcing revenues from the 10% of drugs that are successful to pay for the 90% that failed.

Eroom's law to be reversed

This helps explain Eroom's law (the observation that drug discovery becomes slower and more expensive over time), which entails a decrease in R&D (research and development) efficiency, or cost-per-output. This is where companies spend more per new drug on R&D than they make in revenue. Per Hidary, new AI simulation work can change sectors such as life sciences from a business of mostly failure to one with predictable revenues. It allows companies to take all the data and molecular information and run billions of simulations de-risking the molecules, dramatically cutting down drug development time.

AI technology is helping biopharma and research institutions achieve breakthroughs in treatments for cancer, Alzheimer's, Parkinson's and other conditions. In fact, where a biotech company may take eight weeks to achieve results, the same results could have taken eight months and billions in expenses without AI's assistance.

2) AI diagnostics

Typically, correctly diagnosing diseases takes years of medical training. Even then, diagnostics is often an arduous, time-consuming process. However, AI has recently made huge advances in automatically diagnosing diseases, making diagnostics cheaper and more accessible. AI is particularly helpful in areas where the diagnostic information a doctor examines is already digitized such as: detecting lung cancer or strokes based on CT scans, assessing the risk of sudden cardiac death or other heart diseases based on electrocardiograms and cardiac MRI images, classifying skin lesions in skin images, and/or finding indicators of diabetic retinopathy in eye images.

The application AI in diagnostics is just beginning – more ambitious systems involve the combination of multiple data sources (CT, MRI, genomics and proteomics, patient data, and even handwritten files) in assessing a disease or its progression. AI can use image analysis of biological and medical images (microscopy, genomic heatmap, CT scans, MRI scans, etc.) to compute the effects of target modification in animal models, for example. Furthermore, AI, when compared to human scientists, can process these images 10-100x faster.

3) Liquid biopsy

Liquid biopsy (LB) is a disruptive technology in diagnostics – a "simple blood test" that can provide critical health information, especially for cancer. LB is emerging as a non-invasive alternative to tissue-based biopsies, aiding therapy selection in late-stage cancers and monitoring for cancer recurrence, and potentially playing a role in early-stage cancer screening. However, many technical and regulatory challenges remain, but nonetheless, the LB field is growing.

For starters, the increasing accessibility and decreasing cost of next-generation DNA sequencing (NGS) throughout the 2010s catalyzed the exploration of liquid biopsy in cancer, as most of the LB technology is sequencing-based. With the promise of early disease detection and non-invasive disease monitoring moving from the lab to the clinic, the first clinical validation of ctDNA (circulating tumor DNA) analysis occurred in 2014.

Liquid biopsies start from collecting a patient sample, typically a blood draw where chemicals in the sample collection tube help stabilize any cfDNA (circulating free DNA). Several 'sample preparation' and analysis processes typically follow, such as plasma isolation and analyte extraction, target enrichment to select a subset of genes for analysis, NGS library preparation and DNA sequencing at depth (i.e., 500-1000x coverage), followed by data analysis, interpretation and reporting.

4) Genomics

Genomics is defined as the study of the complete set of genes (the genome) of organisms, or the way genes work, and interact with each other and with the environment. Genomics incorporates elements of genetics but is concerned with the characterization of all genes of an organism, rather than individual genes.[2]

Although DNA was first isolated as early as 1869, it took more than a century for the first genomes to be sequenced. The history of genomics dates back to the 1970s when scientists determined the DNA sequence of simple organisms. However, the greatest breakthrough occurred in the mid-1990s when scientists sequenced the entire genome of a free-living organism (influenza).

Recent advances in low-cost genome sequencing could take us to the next frontier in healthcare and medicine by enabling precision medicine. The combination of genetic information and proteomics, the study of proteins, means we can create treatments personalized for the individual. While the first sequencing of the human genome in 2003 cost around $2.7 billion, this dropped to below $1,000 by 2014, with the possibility of reducing this to just $100 per genome and less than one hour in the coming years. Hence, the ability to quickly and cheaply sequence has implications spanning drug discovery, medicine, and wellness, to food agricultural applications and synthetic biology.

Gene therapy: Large opportunity with huge unmet need

Gene therapy and gene editing are, broadly speaking, two approaches designed to correct the function of an abnormal gene. The key difference is that gene therapy aims to restore function by adding a new therapeutic genetic sequence, while gene editing focuses on directly altering specific genetic sequences in the genome. These approaches are best suited to monogenic diseases, which are caused by specific mutations in a single gene. There are an estimated 4,000 genetic-related disorders, meaning the gene therapy and gene editing markets represent a large opportunity with great unmet need. Although there are only two FDA-approved gene therapies in the US today, thousands of clinical trials for gene therapy and gene editing are currently being run worldwide.

The two main approaches for gene delivery are viral and non-viral vectors. Viral vectors are currently a delivery vehicle used in FDA-approved gene therapies. Non-viral techniques are currently being studied as a safe and effective way to deliver genetic material to cells for therapeutic effect. Each approach has advantages and disadvantages in terms of efficacy, safety, manufacturing and packaging capacity. Viral vectors are the most used method for gene therapy and gene editing in the clinic. Nevertheless, several non-viral vector technologies are currently being developed to overcome the current limitations. Significant advantages from using non-viral vectors and safety concerns surrounding viral vectors could pave the way for the former to become more widely used in gene therapy and gene editing.

Gene editing: Directly modifying the genome

In contrast to gene therapy, gene editing (or genome editing) directly modifies a patient's existing genome to achieve a therapeutic effect. It has multiple applications to modify a patient's genome including gene insertion, deletion (knockout), correction, modification, activation, or a combination of editing targets (multiplex editing). Gene editing can be accomplished through a variety of methods. Similar to gene therapy, it can be performed 'in vivo' by infusing the necessary biological machinery directly into a patient, or 'ex vivo,' where cells are removed, modified, and transplanted back into the patient.

Proteomics: Next big thing after genomics

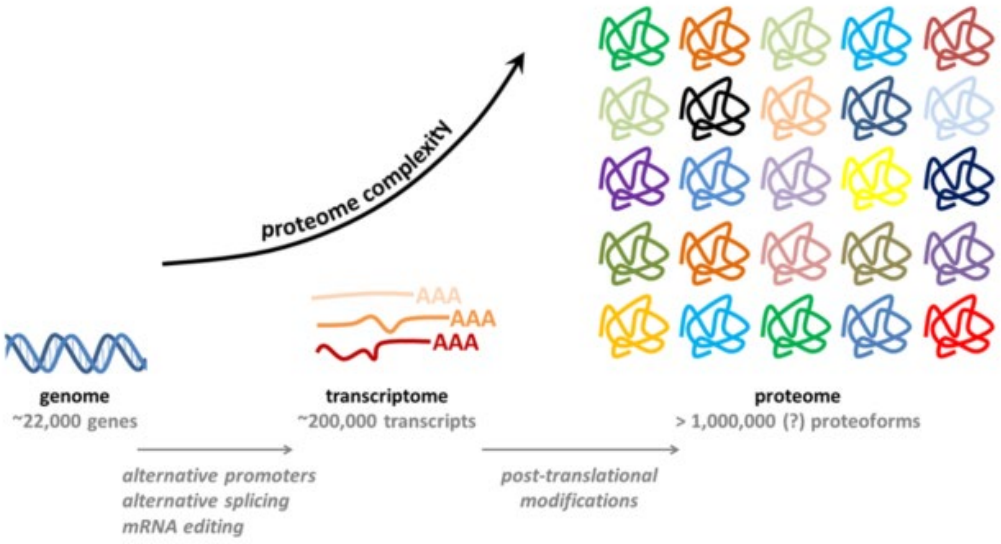
Proteomics is roughly defined as large scale study of proteins. The proteome is defined as the entire set of proteins produced or modified by an organism or system. The term proteomics was coined to make an analogy with genomics, the study of the genes. Proteomics, however, is much more complicated than genomics, mostly because while an organism's genome is rather

[2] World Health Organization (WHO)

static/constant, the proteome differs from cell-to-cell and constantly changes dynamically through its biochemical interactions with the genome and the environment.

Proteomics is an important new field because it can help identify and monitor biomarkers and can also facilitate drug development by providing a comprehensive map of protein interactions associated with disease pathways. For instance, proteomics has previously been used to expose undesirable, off-target effects in the drug discovery process.

Exhibit 3: Proteomics is the next step in the study of biological systems and is loosely defined as the global analysis of proteins in a protein complex, organelle, cell, tissue or complete organism
Basics of proteomics



Source: Erasmus University Medical Center, Proteomics Center

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CRISPR 1.0

"CRISPR" is an acronym for "clustered regularly interspaced short palindromic repeats," which are unique DNA sequences found in some bacteria and other microorganisms. CRISPR 1.0, the first generation of the technology, essentially makes cuts in the DNA. Cells repair these cuts, and this process usually stops a harmful genetic mutation from having an effect.

The most studied CRISPR system is associated with the "Cas9" protein and is known as CRISPR-Cas9. In 2012 and 2013, researchers modified CRISPR-Cas9 to serve as an effective and efficient technology for editing the genomes of plants, animals, and microorganisms. Since then, CRISPR-Cas9 has been used to modify the genomes of a variety of species, ranging from mice and fruit flies to corn and yeast.

Hence "CRISPR-Cas9" is a gene editing technology that offers the potential for substantial improvement over other similar technologies in ease of use, speed, efficacy, and cost. It is also important to differentiate between the use cases of CRISPR: Somatic gene editing (occurs in single cell, offspring cannot inherit mutation) and Germline (occurs in gametes, offspring can inherit mutation).

Many in the scientific, engineering, and business communities believe that CRISPR-Cas9 could offer revolutionary advances in the investigation, prevention, and treatment of diseases; understanding of gene function; improvement of crop yields and development of new varieties; production of chemicals used in biofuels, adhesives, and fragrances; and control of invasive species.

CRISPR 2.0: Base editing

CRISPR 2.0 is the base editing technique that targets the core building blocks of DNA, which are called bases. The human genome contains roughly three billion base pairs (letters) or six billion DNA in a cell. Overall, there are four DNA bases known as A, C, G and T. These letters pair off — A with T and C with G — to form DNA's double helix. Instead of cutting the DNA, CRISPR 2.0 can convert one base letter into another. Base editing can swap a C for a T, or an A for a G. In theory, base editing should be safer than the original form of CRISPR gene editing. Because the DNA is not being cut, there's less chance that you'll accidentally excise an important gene, or that the DNA will come back together in the wrong way.

CRISPR 3.0: Prime editing

This technique allows scientists to replace bits of DNA or insert new chunks of genetic code. It has only been around for a few years and is still being explored, but its potential is huge because prime editing vastly expands the options. CRISPR 1.0 and base editing (2.0) are somewhat limited – you can only use them in situations where cutting DNA or changing a single letter would be useful. Prime editing could allow scientists to insert entirely new genes into a person's genome.

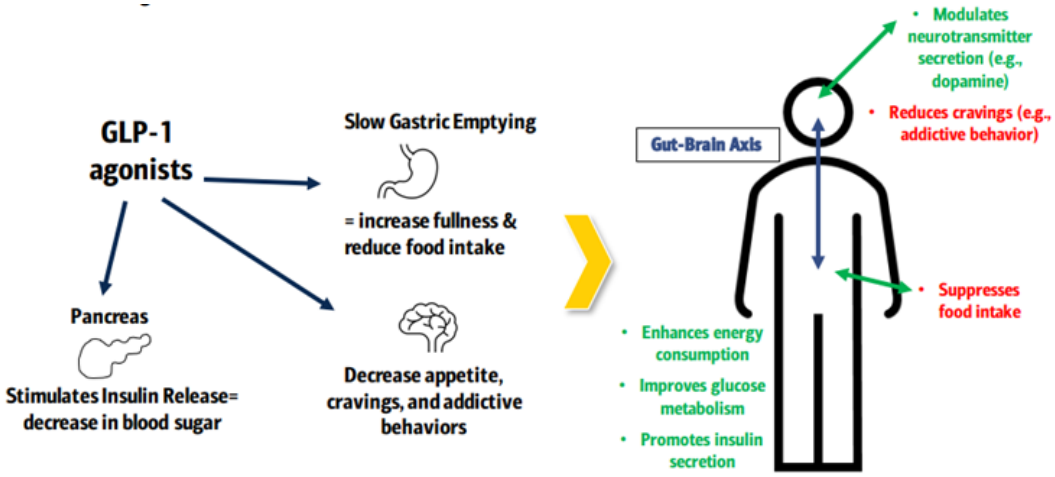
Prime editing is a 'search-and-replace' genome editing technology in molecular biology by which the genome of living organisms may be modified. The technology directly writes new genetic information into a targeted DNA site and utilizes methodologies similar to precursor genome editing technologies, including CRISPR/Cas9 and base editors.

5) GLP-1s

Obesity remains one of the most pressing public health challenges of our time – and an individual with obesity is at higher risk for a broad range of other diseases (e.g., comorbidities) and all-cause mortality. However, more than half of the world's population is projected to be overweight or obese by 2035, with an estimated economic impact of $4.3 trillion (around 3% of global GDP). According to the CDC (Centers for Disease Control and Prevention), obesity costs the US healthcare system nearly $173 billion per year. So, while treating obesity initially could weigh on healthcare spending, not treating it could bankrupt the system.

Enter: GLP-1s. Glucagon-like peptide 1 (GLP-1) and glucose-dependent insulinotropic polypeptide (GIP) are hormones responsible for the "incretin effect," or the augmentation of insulin secretion, however, there are many downstream effects of GLP-1 drugs, which can lead to dramatic weight loss.

Exhibit 4: GLP-1 stimulates insulin release, helping to decrease appetite, cravings, and addictive behaviors while slowing gastric emptying, which increases feelings of "fullness," therefore reducing food intake
Schematics of GLP-1



Source: BofA Global Research

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GLP-1 reducing obesity could save US healthcare $1.5 trillion over 30 years

A Leonard D. Schaeffer Center for Health Policy and Economics at the University of Southern California (USC Schaeffer) white paper found that coverage for new obesity treatments could generate $245 billion in cost offsets to Medicare in the first 10 years alone. By 30 years, these offsets could increase to $1.5 trillion assuming that 100% of obese people takes GLP-1. As of mid-2023, about 4 million people used one of the drugs, which represents only 1% of the US population.

Pharma Impact: Dialysis, sleep apnea

Among healthcare providers, many view cardio, dialysis, and sleep apnea as the areas that would see the most pressure on utilization of the healthcare / hospital / patient bed system. In the mid-term, if there were broad and consistent use of GLP-1 drugs, BofA Global Research sees GLP-1s impacting cardio, sleep apnea, and dialysis ahead of ortho volumes/spending. Hospitals would likely see pressure on utilization, but this would take time to build. As noted above, improvements in longevity could mitigate volume pressure and some subsectors could even benefit if people live longer (e.g., personal care, senior living), while other subsectors, that take risk, such as capitated physicians, would benefit.

Non-Pharma Impact: Consumer food staples, apparel, gambling, longevity

GLP-1s also have downstream effects such as lower appetite and a reduction in cravings/addictive behaviors. The impact of these effects is unclear, but could change consumer behavior over the longer term, with some industries benefitting while others are at higher risk. To this end, BofA Global Research evaluated the potential impact of broad adoption of GLP-1 drugs on consumer-focused sectors: (1) consumer staples: less snacking, less unhealthy food, and less alcohol consumption; (2) apparel retail: weight loss potentially translates into a wardrobe replacement spending cycle; (3) gambling: reduction in addiction to casinos. In 2013, the American Psychiatric Association recognized pathological gambling as an addiction instead of an impulse control disorder, which makes gambling problems relevant to GLP-1 and related addiction research; (4) senior living / home care thanks to a longevity boost spurred by healthier lifestyles. And while the improved health of society could reduce the number of surgeries and cardio events, there would still be demand for senior care.

Oral GLP-1 pill will be a gamechanger

Currently, injectable formulations are dominating the GLP-1 market, but the development of oral drugs could expand the type-2 diabetes (T2D) and underpenetrated obesity market. At the American Diabetes Association (ADA) meeting in June 2023, data was presented from multiple investigational oral daily non-peptide GLP-1 agonists. They are small molecules that do not degrade in the gastrointestinal (GI) tract and there are no stringent restrictions on administration. Oral GLP-1s could potentially broaden overall access to the market and not necessarily replace injectables.

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