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BUSINESS INSIDER INTELLIGENCE

THE RISE OF GENETIC TESTING IN HEALTHCARE

How leading genetic testing companies like Ancestry and 23andMe are carving into healthcare with the promise to fuel more personalized care

Insider Intelligence

KEY POINTS

- **Since the first human genome was sequenced in 2003, the genetic testing market has evolved rapidly alongside consumers' interest in how their genetic makeup affects their health.** The ability to sequence the human genome opened the floodgates to new understanding within the medical community about how genes impact health and disease development. This monumental feat laid the foundation for private genetic testing companies like 23andMe and Color to begin selling tests to consumers, allowing customers to mail in samples of their saliva in return for a snapshot into how their genetic variants could influence their health. And consumers have flocked to these products: More than 26 million consumers worldwide had been tested by genetic companies as of early 2019 — up from under 5 million three years prior.

- **Now, there's a massive opportunity for genetic testing firms to help healthcare organizations use DNA to steer more personalized treatments.** Genetic testing companies began taking advantage of consumer appetite for their products, launching new services that could calculate risk of developing certain conditions — and forging ties with healthcare companies looking to steer diagnoses and treatments based on patients' genetic variations. Genomic information has evolved from a consumer novelty to a transformative healthcare technology.

- **Four genetic testing companies — 23andMe, Ancestry, Color, and Invitae — have been racing to the forefront of healthcare using various business models to reach customers.** While overlap of product models exist among these four companies — all of which have been actively growing out their businesses in recent years — each takes a unique approach to the genetic testing space:
    - **23andMe** and **Ancestry** have a line of products that are sold directly to consumers, but the two have also built out healthcare-specific products. Ancestry offers physician-ordered tests that give consumers personalized insights about how their genetic variations could steer their health outcomes, and 23andMe works with pharma companies to craft more targeted drugs.
    - **Color** partners with players across the healthcare landscape to reach customers — allowing healthcare payers to offer its products to employees, for instance.
    - And **Invitae** has been focusing on offering its DTC physician-ordered tests, but has edged into the clinical research realm through a partnership with Apple — using the latter's Watches to collect heart health data and combine it with its genetic insights.
- **Healthcare incumbents across the ecosystem stand to benefit from the personalized insights genetic testing offers, including opportunities to craft more personalized treatments and management plans.**

- **Health systems.** A larger swath of hospitals has been placing their bets on precision medicine: 70% of US health systems have initiatives underway — and insights gleaned from genetic testing could be key to guiding these initiatives that tailor therapies to patients in lieu of taking a one-size-fits-all approach to treatment.

- **Pharma companies.** Genetic testing companies are forming alliances with pharma companies to offer up their troves of genetic data to guide drug development. Tapping into rich repositories of consumer data could help drug-makers accelerate drug development and create more accurate medications: The cost of bringing a prescription drug to market can amount to more than $3 billion over 10-plus years.

- **Payers.** Massive self-insured employers like Apple have started to offer genetic testing to employees in their health benefits packages. Doing so could make employees privy to their health risks and guide health management — which could proactively slim down payers' medical expenditures, which have been mounting over the years.

- **While the space has evolved rapidly in recent years, genetic testing companies are staring down barriers that could threaten their ability to retain business and attract new healthcare partners.** Despite rapid growth throughout the 2010s, the direct-to-consumer (DTC) genetic testing market has shown signs of slowing. This could cause genetic testing companies taking a DTC approach to pivot to form team-ups with health systems, for instance, to hook in new business. However, this may not be a surefire way to diversify revenue streams, considering healthcare professionals still largely express discomfort with interpreting and utilizing genetic data. Scrutiny surrounding the accuracy of health risk assessments and privacy concerns are also hindering companies from scoring business from wary potential customers or healthcare partners. And the coronavirus pandemic has placed an enormous financial burden on healthcare institutions — meaning, providers are likely to take a more conservative approach to investments, and we don't think tie-ups with genetic testing companies will be high on their priority lists.

Download the charts and associated data in Excel »

INTRODUCTION

Genomics has burst onto the healthcare scene in recent years, driven largely by rapid declines in the cost of DNA sequencing technology. The human genome was sequenced — or read in its entirety — for the first time in 2003, after more than 20 years of work and nearly $5 billion was put into the National Institutes of Health's (NIH's) Human Genome Project, which marked a huge step in helping scientists and medical researchers understand how genes and gene interactions impact disease development and progression. In the ensuing decades, genetic information catapulted into mainstream healthcare driven largely by the rapid decline in cost for DNA sequencing technology: While it can be difficult to precisely calculate the cost of sequencing DNA, National Human Genome Research Institute data reveals that costs for sequencing a genome have plummeted from $100 million in 2001 to sub-$1,000 in 2019.

DNA testing firms like Ancestry and 23andMe broke onto the scene with less comprehensive — and cheaper — analyses of genetic information via direct-to-consumer (DTC) tests, and consumers have flocked to them seeking to gain insights into their individual health risks. Ancestry and 23andMe both offer DNA testing at a price point between $100-$200 — prices that are likely more enticing to average consumers than higher-cost tests that explore the entire, or a larger portion of, the genome. Of the 26 million global consumers who took a DNA test in 2019, Ancestry and 23andMe tested 25 million — with Ancestry claiming to have sold 7 million new tests in 2019 alone, per MIT Technology Review. This marks a meteoric rise in consumer adoption over the course of the 2010s: In 2015, for example, fewer than 1.5 million global consumers had taken at-home genetic tests. This rapid increase led MIT Technology Review to project that genetic databases will hold the data of more than 100 million people by 2021.

The ability to provide genetic tests at a lower cost has opened up new opportunities in preventative medicine. For example, chronic illness accounts for 90% of the US' more than $3.7 trillion of annual healthcare spending — and healthcare stakeholders are actively looking for ways to assess population health risks and intervene earlier. Genetic testing is an enticing proposition for healthcare players that want to paint a picture of an individual patient's health risks — and use that information to help guide care plans that could mitigate the development or progression of a condition. For example, San Francisco-based genomics company Helix teamed up with the Renown's Institute for Health Innovation in 2018 to provide free genetic testing for 40,000 people through the Healthy Nevada project, with the goal of screening for three hereditary and preventable conditions. More than 10,000 people signed up for the program within the first four days, and of those who received actionable health results, Helix claims 90% would have been missed by current medical screening practices.

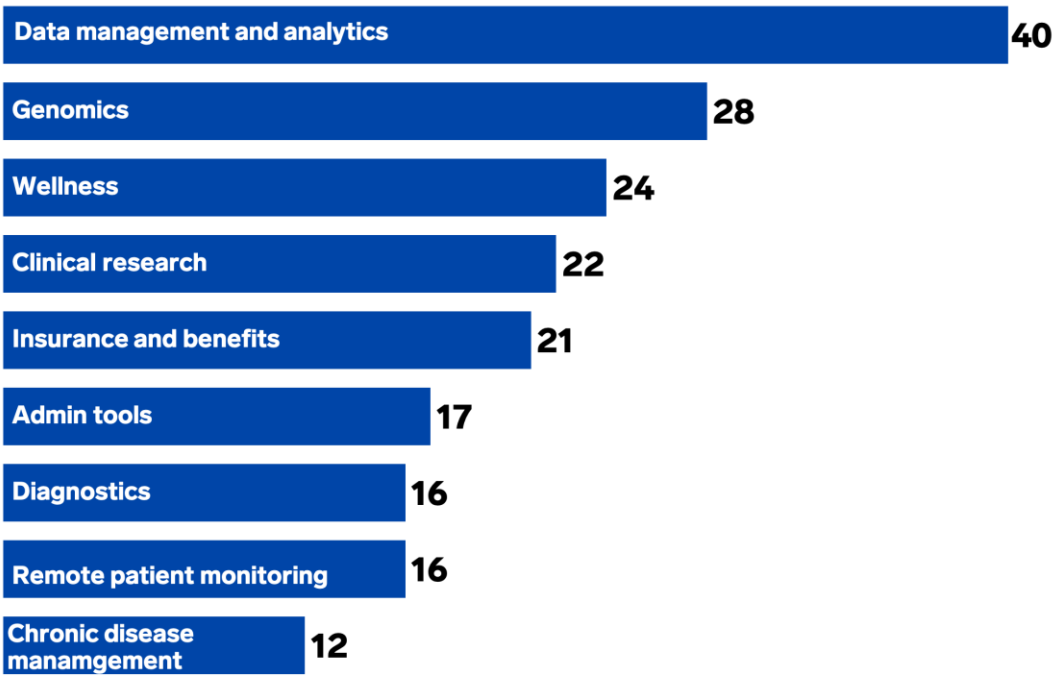
"It's about moving the point of care further upstream. We have this crazy notion in healthcare that someone who's sick is healthy all the way up until the point of diagnosis, and then they're sick. But obviously that's not true.
— **Othman Laraki, Color** CEO

Source: Business Insider Intelligence interview, 2019

But accessing, analyzing, and interpreting genomic data goes far beyond mailing out vials to patients and collecting their DNA — and big tech companies and startups are stepping up to provide clinicians with the infrastructure necessary to mine through and operationalize genomic info. Several high-profile, tech-savvy genetic testing companies like Color have emerged, offering end-to-end software solutions for healthcare organizations interested in utilizing genomic information, helping clinicians turn unstructured genomic information into actionable data they can use to inform care decisions. The heavy data lift associated with genomic analysis has also attracted the attention of big tech companies such as Google and Microsoft: Big tech companies have signed more than 250 digital health funding deals since 2010, and those funds went to genomics firms more often than startups in any other industry outside of data management.

Genomics Was The Second Largest Digital Health Investment Category For Global Tech Giants In The 2010s

Number of global startups backed by big tech cos



Note: Includes data from 2010 through October 2019. Excludes segments of startups for which there were fewer than 12 investments.

Source: CB Insights, "Where Tech Giants Are Betting On Digital Health," November 2019

Methodology: CB Insights reported data for the top 10 big tech companies: Google, Tencent, Microsoft, Intel, Samsung, Alibaba, Amazon, Comcast, Facebook, and Cisco. These investors were selected based on criteria including market cap, tech focus, and quantity and quality of healthcare investments.

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In this report, Insider Intelligence will examine the industry forces that have helped evolve genomic information from a consumer novelty to a transformative healthcare technology. We outline how some of the key players in the genetic testing space have altered their business models to appeal not only to consumers but also to healthcare players across the industry, including health systems and pharma companies. We provide a glimpse at what's next for the implementation of genomic information — namely, the barriers that are holding genetic testing companies back from reaching new customers, including how the coronavirus pandemic could impact growth in the space.

HOW GENETIC TESTING WORKS

TECHNIQUES USED TO ANALYZE THE HUMAN GENOME		
Genotyping	**Whole Exome Sequencing (WES)**	**Whole Genome Sequencing (WGS)**
• Looks for information at a specific place in the DNA to detect small genetic differences • Determines variations in genes by comparing a DNA sequence to other samples • Lower cost and faster than other methods • Notable players: 23andMe; Ancestry	• Sequences the exome, which makes up 1.5% of the genome but houses nearly all genes correlated with genetic disorders • Lower cost and faster than WGS • Notable players: Invitae; Gene by Gene	• Sequences complete DNA, or 3 billion base pairs • Unlike WES, can detect structural variants • Provides largest data set, but requires complex analysis and comes at a high price point • Notable players: Veritas; Nebula Genomics

Sources: Company websites; Frontiers in Immunology; Healio; Helix; Thermo Fisher

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Genetic testing companies employ different methods to conduct genetic health screenings that can be categorized based on the amount of genetic information that's processed and analyzed:

- **Genotyping by microarray.** For context, genotyping refers to the process of identifying differences in the genetic makeup, or genotype, of an individual through the examination of their DNA sequence compared with sequences of others. The microarray sequencing process offers a snapshot of an individual's full genetic profile via analysis of spit samples provided by consumers. And while this form of testing is convenient, it is limited in scope and clinical usefulness. For example, microarray sequencing can be useful for analyzing genetic health risks associated with a specific genetic variant like BRCA1 and BRCA2, which are genes affected in breast and ovarian cancer. But because it only examines a tiny fraction of a person's genetic profile, it's possible that person's genetic risks could be dramatically different a year or two after testing as researchers discover new linkages between genetic variation and disease that weren't initially tested for. This approach is typically associated with DTC genetic testing companies 23andMe and Ancestry Health.

- **Exome sequencing.** Exome sequencing is a more comprehensive method than microarray: This type of genetic testing examines approximately 30 million base pairs of DNA (roughly 1% of the human genome), which are linked to the vast majority of genetic diseases. Exome sequencing offers a similar level of diagnostic value to genotyping by microarray — and the process is also similar, requiring saliva samples from consumers. But because exome sequencing is more comprehensive, this method does not come with the potential downside of requiring additional testing down the line. Exome sequencing is commonly offered by population genomics firms like Color, Helix, and Invitae.

- **Whole genome sequencing.** This method produces the most complete picture possible of an individual's DNA — sequencing the full 3 billion base pairs that make up the human genome — but its value is up for debate, considering most of the genetic information examined through whole genome sequencing has no known purpose according to contemporary scientific literature. However, these tests — which generally require a blood sample to conduct — have historically come at a higher price point than other forms of genetic testing, making them more out of reach for consumers: The cost to complete a whole genome sequence in 2015 was $4,000, per the NIH, but has been falling dramatically over recent years with the possibility of dropping to $200 by 2021. There are few genetic testing companies that routinely offer whole genome sequencing; Veritas Genetics was one of the most notable before it suddenly halted US operations in December 2019 after failing to secure additional funding.

COMMON BUSINESS MODELS

Direct-To-Consumer (DTC)

Genetic testing companies that operate with a DTC approach have an edge in spurring consumer adoption, as their tests can be directly marketed to consumers and sold to them online and in stores. Unlike other forms of genetic testing that require physician sign-off, DTC genetic tests have the potential to reach more people interested in their genetic health risks because these tests are more widely accessible. For example, the key driver behind consumer adoption of genetic health tests is curiosity, so the wide presence of DTC genetic testing kits like those from Ancestry and 23andMe in retail stores and online marketplaces gives these companies a key advantage to bring in customers. In a 2019 survey of over 1,000 at-home genetic testing customers, general curiosity was the No. 1 reason cited for purchasing a genetic test — with 60% of respondents citing it as the main reason for taking a test, according to YourDNA.

However, advertising genetic testing products directly to consumers also comes with the drawback of greater regulatory scrutiny from the US Food and Drug Administration (FDA). When the FDA reviews genetic testing kits, it considers each individual genomic variant being analyzed for approval — meaning each time a genetic testing company wants to add a new variant to the list of those it analyzes, it must undergo a new review from the FDA. And an unfavorable decision from the FDA can be a major stumbling point for companies pursuing a DTC approach: In 2013, the FDA ordered 23andMe to halt sales of its health risk assessment screenings after concluding the company had failed to provide sufficient evidence as to the clinical validity of their tests — and the startup had to wait two years and whittle down the number of risk assessments it offered.

Physician-Ordered On-Demand (POD)

Some genetic testing companies have chosen to eschew the regulatory scrutiny that comes with DTC sales by offering consumers on-demand genetic tests that require physician review. Tests offered through a POD model tend to offer consumers the choice of sending their order to their personal physician for review and authorization, or to physicians that have been employed by the company or operate as part of a larger commercial network. Color, for example, offers physician-ordered tests made available by consumers' physicians or through Color-affiliated doctors. This is known as a hybrid model since it combines the ease of DTC testing with traditional elements used in the clinical space. Here's how it works: After placing an order, customers will fill out a brief form covering their family history, reasons for ordering, and so forth. If a physician believes insights from a genetic test would help a patient bolster their health management, the physician will place an order on the customer's behalf. By taking this additional step, the tests are now considered lab-ordered — which the FDA has largely decided is beyond its regulatory purview, per STAT. It's tough to quantify what proportion of genetic tests is fulfilled via hybrid models versus traditional and DTC models, but data suggests hybrid labs are eating up a big chunk of genetic testing: A large traditional laboratory reported last year that it's conducted 4 million genetic tests since launching in 1991, while a hybrid laboratory reported it's conducted 1.4 million tests since its founding in 2004.

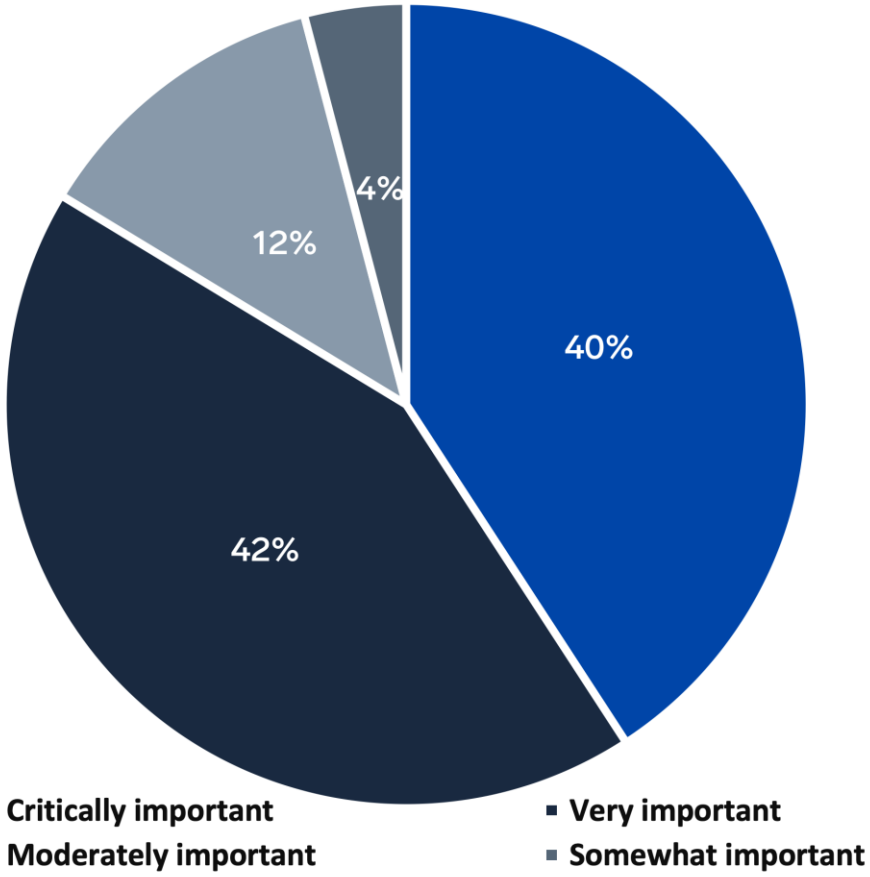
However, some bioethicists and genomic health experts have raised the question of whether the POD model has been deemed a distinction from DTC despite a lack of any real differences. For instance, medical geneticist and consultant to Helix Dr. Robert Green has called the regulatory line between these two approaches "controversial," highlighting that some people within the medical community feel more interaction between patients and the ordering physician should take place to ensure the tests are being properly ordered. Yet proponents of the POD approach tend to frame the conversation in terms of access. Further, in some cases, a physician will only sign off for the test if patients can prove risk, potentially barring certain people from being able to access tests and genetic insights: Chief Medical Officer at Invitae Dr. Robert Nussbaum told Insider Intelligence that it may prove difficult for some individuals to prove the existence of a hereditary genetic risk — including people who were adopted and do not have a relationship with their birth parents, as well as members of certain ethnic minority groups where medical history is not openly discussed or available.

Population Genomics

We're seeing more health systems and other large healthcare organizations pursue a population-centered approach to genomic information. Population health, while not uniformly defined, refers to the use of customized combinations of traditional and nontraditional care that cater to the health management of specific groups with identifiable needs. Genomic health firms that utilize this model still incorporate a physician review of potential participants, but they tend to pursue new users through large research and preventative health programs rather than market their products to individual consumers. This approach allows genetic testing companies to lean on their preexisting relationships with health organizations to recruit huge numbers of participants, while providing their partners with the benefit of more targeted and potentially actionable health information. For example, NorthShore University Hospital contracts with Color on a project to offer free genetic screenings to a portion of its patients to unlock information about their genetic predispositions to cancer, heart disease, and adverse medication reactions in order to personalize treatment plans. This could help hone treatments, save resources, and cut costs, considering that costs associated with treating common conditions like breast cancer increase as the disease progresses. Health systems are also displaying interest in initiatives that support population health, meaning we could see a larger swath looking to strike deals with genetic testing companies a la Color and NorthShore: 82% of health system executives consider population health "very" or "critically important" to future success, per a 2019 Numerof & Associates survey.

US Hospital And Health System Execs Consider Population Health Vital To Future Success

Q: How vital is population health to future success?



Note: Values don't total 100% due to rounding; no respondent selected "low importance," "slightly important," or "not at all important."
Source: Numerof & Associates, "The State of Population Health Survey," March 2019
Methodology: Online survey of 528 executives from US health systems, hospitals, and medical centers conducted by Numerof & Associates and Jefferson College of Population Health from August to October 2018.

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KEY PLAYERS

PROMINENT US GENETIC TESTING COMPANIES				
	23andMe	ancestry	color	INVITAE
Models	• DTC kits: Ancestry, health risk assessment • Therapeutics arm	• DTC ancestry kits • Physician-ordered health risk assessment	• Physician-ordered testing and risk assessment services through partnerships with health systems, pharma companies, and healthcare payers	• Physician-ordered testing
Strengths	• Has amassed data from at least 10 million consumers • Consumer mindshare • Growing healthcare presence	• Has amassed data from at least 7 million consumers • Consumer mindshare • Growing healthcare presence	• Casts a wide net across the healthcare industry • Offers insight from genetic counselors	• Recent acquisitions could foretell plans to expand alliances with health systems and pharma firms
Threats	• Slowing DTC market • Privacy concerns	• Slowing DTC market • Privacy concerns	• Health systems may slow precision medicine efforts due to COVID-19 and its financial impact	• Health systems may slow precision medicine efforts due to COVID-19 and its financial impact

Source: Company websites; MIT Technology Review

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23andMe

23andMe historically took a DTC approach to the genetic testing market — but it's been expanding beyond its core product to focus more heavily on its value as a health tool in an effort to boost business. 23andMe was founded in 2006 and has since raised over $780 million in funding, catapulting it beyond a $2 billion valuation, per CNBC. In the years since it's been up and running, 23andMe has aggressively lengthened the list of conditions and risk factors it tests for, likely hoping to appeal to as wide an audience as possible. For example, in March 2019 it added diabetes to the docket of conditions it tests for, which could help users glean a better understanding of the likelihood they develop the condition which affects many people that are unaware: While about 27 million people in the US are living with diagnosed diabetes, an estimated additional 7 million are afflicted but are undiagnosed, according to American Diabetes Association's most recent figures.

Precision Medicine

23andMe's Genetic Health Risks reports give consumers insights into whether they possess variants associated with risk of developing certain conditions. 23andMe's tests scan for variants that may signal higher risk for a slew of conditions, like whether a patient is at a higher risk for developing Parkinson's Disease, age-related macular degeneration, and breast cancer. Gleaning genetic insights into patients' risk factors can help doctors fuel initiatives for precision medicine, which makes use of variations in consumers' genes, environment, and lifestyle to guide the prevention, diagnosis, and treatment of diseases, rather than using a one-size-fits-all approach to treatment, which providers have historically prescribed.

Health systems are pressing start on precision medicine initiatives — opening up the opportunity for genetic testing companies like 23andMe to help supply the genetic information needed to fuel these endeavors.

Health systems are beginning to instate precision medicine programs: 69% of health systems have precision medicine initiatives underway, but the plurality (38%) are operating "low maturity" programs — defined as those that have been running for one year with just two use cases — per a 2020 survey conducted by the Centers for Connected Medicine (CCM). That's compared with 12% running "high maturity" programs — those that have been around for four years with eight different use cases. The fact that 23andMe is offering genetic insight into certain cancers — the tests for which earned FDA approval in March 2018 — bodes well for the company when it comes to attracting potential health system partners, considering that the majority of health systems deploying precision medicine are narrowing in on oncology: 94% of health systems with precision medicine programs up and running are applying it to oncology, and 29% are applying it to neurology, according to CCM.

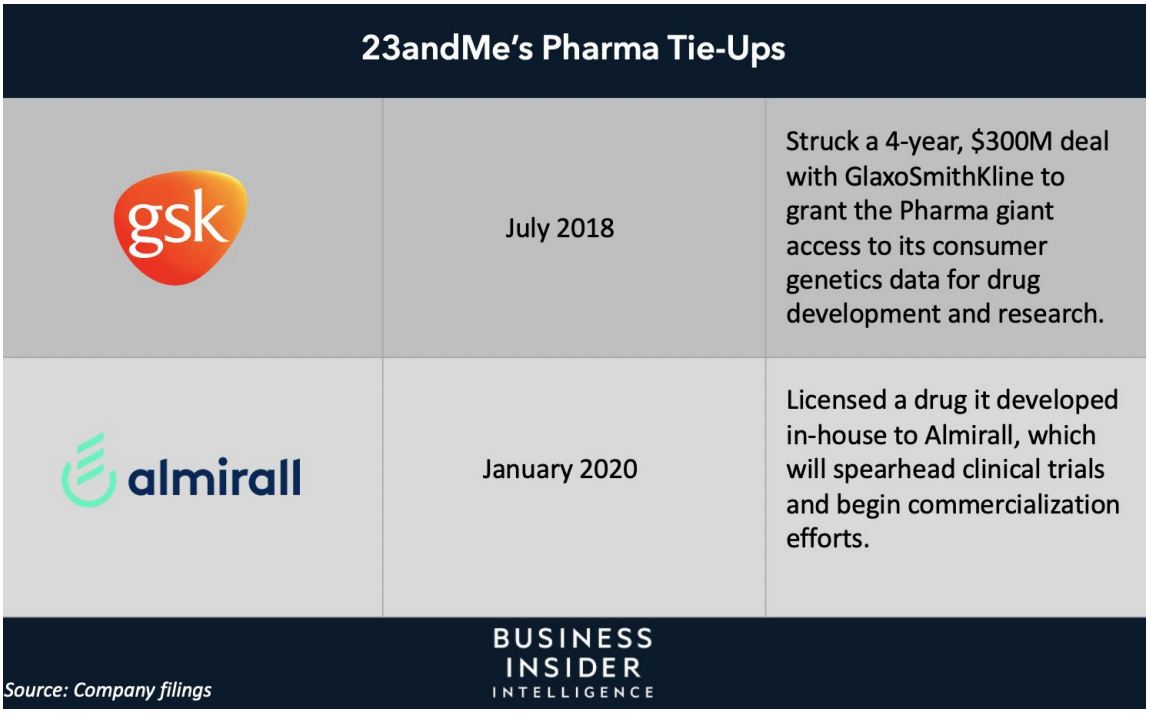
But healthcare stakeholders have voiced concerns that 23andMe is leading consumers astray with the insights it's churning out — which could be a deterrent for providers. Research conducted by rival Invitae revealed that 23andMe's breast and ovarian cancer test misses almost 90% of gene mutation carriers, as it scans for just three of more than 1,000 variants of two breast cancer genes. And medical experts have warned against 23andMe's tests, citing concerns that patients could think the likes of 23andMe's tests could supplant genetic workups ordered by doctors — which could mean patients aren't getting the medical tests and care they might need. Further, while 23andMe isn't trying to pass its tests off as totally inclusive and advertises the limitations of its kits, concerns abound that consumers could mistake a result that says they do not possess some mutations as putting them 100% in the clear as not having any risk of cancer. Such ambiguous clinical utility could raise concerns about using DTC tests to inform treatment strategies, which could hamper potential tie-ups between the genetic testing giant and health systems looking to deploy precision medicine initiatives.

"Direct-to-consumer genetic testing enables patients to become more informed of their risk and engaged in their care. Early testing and treatment will lead to better outcomes."
— **Richard Loomis, Elsevier** Chief Informatics Officer, Clinical Solutions

Source: Business Insider Intelligence Digital Health Pro Survey, July 2019

Health Record Play

23andMe indicated a shift into the health records space when it began trialing a service that aggregates users' genetic data with other medical stats. Announced in July 2019, the service seeks to patch some holes in health records by prompting a segment of its users to share lab results, prescription information, and medical history as well as the information collected from their genetic test in one spot — which could offer a fuller picture of the patient's health. This could be valuable for patients' care delivery teams since genetic info is often missing from health records — like Apple's Health Records offering, for example. And a glimpse into genetic insights — when combined with other health info — could be yet another avenue to doling out more personalized care.

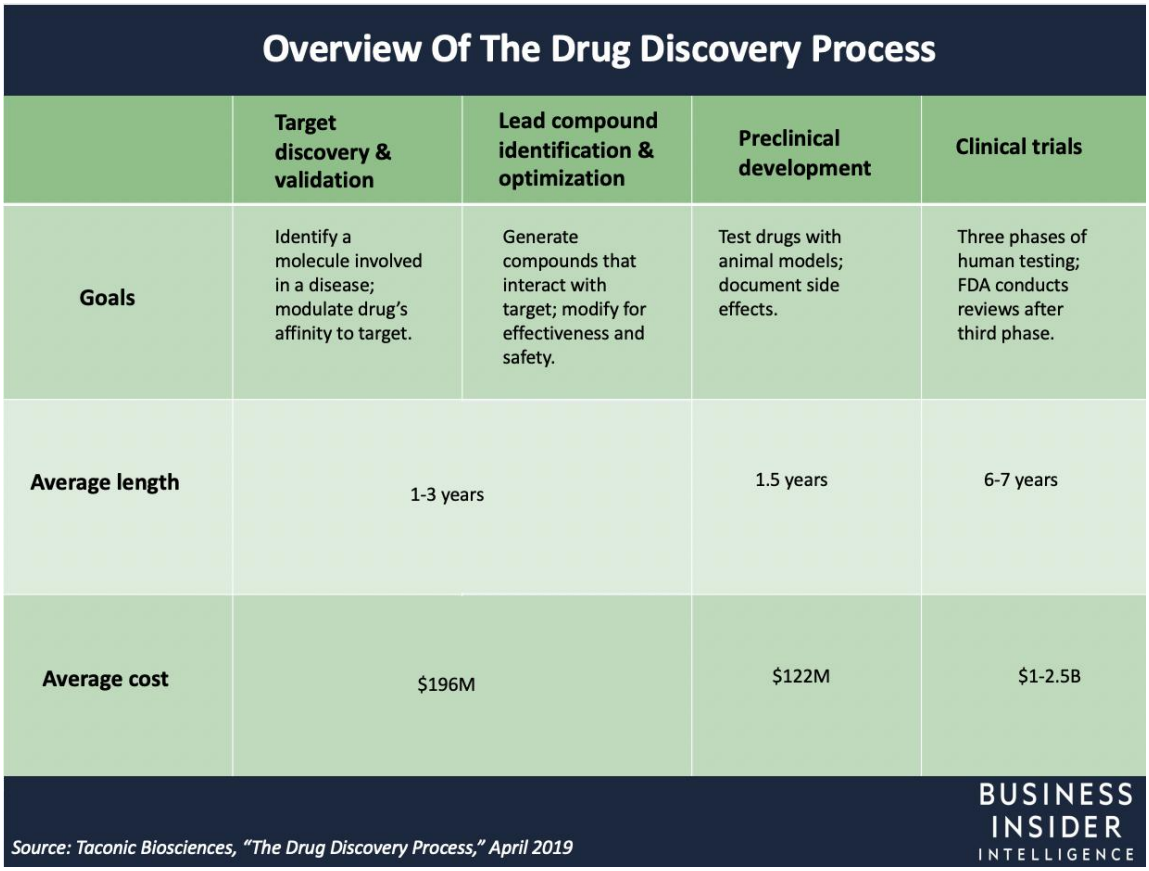


23andMe has been landing pharma tie-ups to hook in cash as it branches out from the DTC model. 23andMe has a dedicated genetic research arm, 23andMe Therapeutics, through which it's building out a massive dataset of genetic information. The company introduced its therapeutics unit in 2015 in an attempt to translate its large repository of genetic information to inform drug therapy development. Since its debut, 23andMe Therapeutics has inked some major deals with pharma companies eager to dig into the data to design more tailored, effective drugs.

23andMe's largest pharma deal to data is with British pharmaceutical company GlaxoSmithKline (GSK). In July 2018, GSK announced a four-year, $300 million deal for access to 23andMe's troves of consumer genetics data for drug development and research. Through the deal, GSK gains access to genetic data for the 80% of 23andMe's 5 million customers who consented to share their data for research purposes. The pair will split the proceeds from any new treatments or medicines that arise from the collaboration.

For GSK, the data from 23andMe will provide more data points for drug developments and help to reduce overhead costs for trials:

- **GSK could lower drug development costs by more effectively recruiting patients for clinical studies.** The cost of bringing a prescription drug to market could top $3 billion over the 10-plus years it takes to develop, in large part due to the complexity of clinical trials, according to Taconic Biosciences' estimates. So, anything that helps hook in patients and their health metrics more quickly could help pharma companies shave down the time it takes to complete the process.
- **A greater breadth of genetic data could help GSK develop more targeted drugs that have a greater probability of making it to market.** Only about 10% of drugs that start in early stage testing make it to patients, GSK President of Research and Development Hal Barron told Fortune. GSK could leverage 23andMe's massive genetic database to better target new treatments and cut failure rates — and bypass shoveling out cash on drugs that never actually hit the market.



Overview Of The Drug Discovery Process

	Target discovery & validation	Lead compound identification & optimization	Preclinical development	Clinical trials
Goals	Identify a molecule involved in a disease; modulate drug's affinity to target.	Generate compounds that interact with target; modify for effectiveness and safety.	Test drugs with animal models; document side effects.	Three phases of human testing; FDA conducts reviews after third phase.
Average length	1-3 years		1.5 years	6-7 years
Average cost	$196M		$122M	$1-2.5B

Source: Taconic Biosciences, "The Drug Discovery Process," April 2019

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23andMe sent a shockwave through the pharma space when it licensed a drug it developed in-house to Spanish pharma company Almirall — and it plans to spearhead trials on its own in the future. 23andMe is handing off the rights to the drug it created, which could be used to treat the common skin condition psoriasis, to Almirall, which will take the lead on clinical trials and commercialization. But 23andMe doesn't seem to be content with sticking strictly to preclinical development: When it announced the Almirall deal, it also hinted at plans to develop and trial drugs on its own in the future — which is something CEO Anne Wojcicki has flagged as a long-term goal for years, per Forbes.

Clinical Research

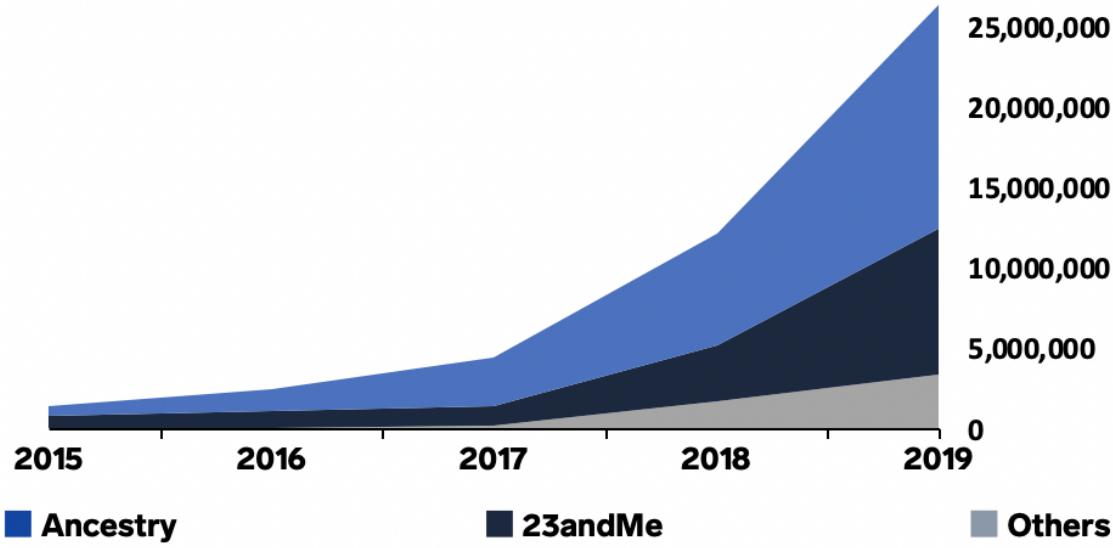
23andMe is leveraging its massive consumer base to make inroads into the clinical research space. It works with New York-based TrialSpark, a company that helps provider organizations become clinical trial sites, in a partnership that leverages 23andMe's network of users who have opted in to participate in research — about 8 million out of its 10 million total to date — to identify those who'd be a good fit for Trial Spark-contracted studies. As many as 86% of clinical trials fail to hit recruitment targets within their given time frames, according to 2018 research published in Contemporary Clinical Trials. But TrialSpark's partnership with 23andMe could be a game changer, as 23andMe's users can be funneled into studies that fit with their medical history and are close enough to their geographic location — so, organizations running studies will likely be wooed by the ability to tap 23andMe's large pool of customers for trial recruitment.

Ancestry

Ancestry has been dominating the DTC genetic testing space — historically outpacing 23andMe — but it's also following in 23andMe's footsteps and gunning for a broader healthcare play. Ancestry.com's DTC genetic sequencing division AncestryDNA has seen meteoric growth in the last several years: It counted about 14 million users at the end of 2018 — up from about 3 million in 2017 — compared with 23andMe's 10 million at the end of 2018, according to MIT Technology Review. And when the company unveiled its dedicated health-focused division AncestryHealth to test for hereditary condition risk — versus just breakdown of their origin — in October 2019, it revealed it was following 23andMe's suit with a broader health play.

Global Consumer Appetite For Genetic Testing Ballooned In The Late 2010s

Total number of consumers tested by genetic testing companies globally



Note: 2019's figures represents data collected as of January 1, 2019.
Source: MIT Technology Review, February 2019
Methodology: MIT Technology Review's estimates are based on its own reporting, data aggregated by the International Society of Genetic Genealogy, and public statements by the four largest genetic testing companies. MIT Technology Review used the companies' disclosures closest to January of each year.

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Ancestry Human Diversity Project

Before its AncestryHealth launch, Ancestry was collaborating with genealogy research institutions across the US and the globe to provide the rich datasets needed to fuel research. AncestryDNA users can opt into the research, which uses data including biological samples and genetic info. Tying up with research groups grants Ancestry another revenue channel: The company says that, in some cases, it gathers compensation from collaborators. And getting their hands on Ancestry's mountain of genetic data could help augment researchers' understanding of genetics' role in the development of certain diseases and traits, per its website.

AncestryHealth

Ancestry pulled the curtain back on a dedicated health segment in October 2019 with two services for determining risk of hereditary conditions: AncestryHealth Core and AncestryHealth Plus. Notably, the company decided to forego the DTC approach favored by 23andMe, opting instead to provide physician-ordered tests through a partnership with PWNHealth.

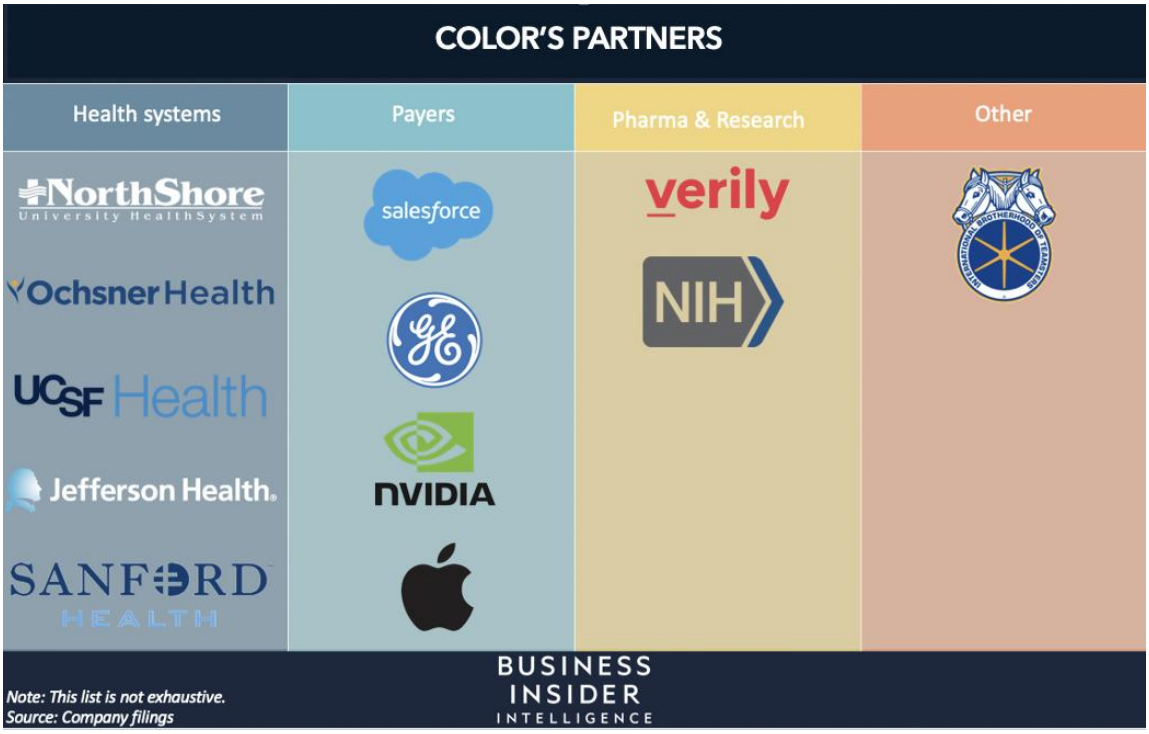
- **AncestryHealth Core informs customers of their genetic risk factors and carrier status for hereditary diseases, like breast cancer and heart disease.** Using the same genotyping technique as AncestryDNA and competitor 23andMe, AncestryHealth Core takes a snapshot of 700,000 pieces of genetic info for its health tests. However, this genetic snapshot isn't likely to highlight all possible risks, considering 700,000 gene pairs represent less than 1% of an individual's total genome.

- **AncestryHealth Plus offers a more comprehensive picture of genetic health and regular health updates.** AncestryHealth Plus is more expensive than the Core — $199 versus the Core's $149 price tag — but the potential insights the test offers for consumers are likely to outweigh the higher cost. Unlike the Core test, AncestryHealth Plus fully sequences a user's exome, allowing for more robust reporting, as well as the potential to glean new health insights over time as science progresses. And AncestryHealth Plus should give Ancestry access to long-term cash flow: It charges a $49 fee billed every six months and offers customers quarterly health recommendations and any updates to their genetic risk factors. This allows the company to turn one-time consumers into returning customers.

Drug Development

Ancestry dipped its toes into the biotech space with its now-ended alliance with Alphabet's largely-secretive Calico unit to examine how genetic factors influence life span — but both firms remained tight-lipped on the specifics of their partnership. Though it remains unclear what the partnership unearthed, Calico was interested in combing through Ancestry's arsenal of genetic data to pinpoint genetic links among people who live longer, according to Business Insider Prime. Theoretically, insights gleaned from this research could help design therapies that beat back aging or fight against diseases that shorten patients' lifespans. While the tie-up has been severed, it reveals just how valuable Ancestry's repository of genetic data could be when it comes to cutting-edge research into the ways in which individuals' genetic makeup affect disease development and progression. Thus far, Ancestry hasn't taken the pharma alliance or drug discovery route, but to stay afloat and on par with its top rival 23andMe, it's possible we'll see team-ups like this materialize.

Color



Color — previously Color Genomics — takes a business-to-business approach to the genetic testing market, fueling health systems' and research organizations' precision medicine and population health initiatives. Color counts a slew of healthcare partners that rely on its physician-ordered tests to allow medical professionals access to deeper insights into what's driving individuals' health. And not only does the startup rely on the expertise of physicians to connect users with tests, it also employs genetic counselors who are licensed practitioners to help patients better understand the potential impact of their test results — which could help quell some concerns regarding a lack of interaction between patients and doctors who can interpret test results that have bubbled up regarding physician-ordered tests.

Health System Partnerships

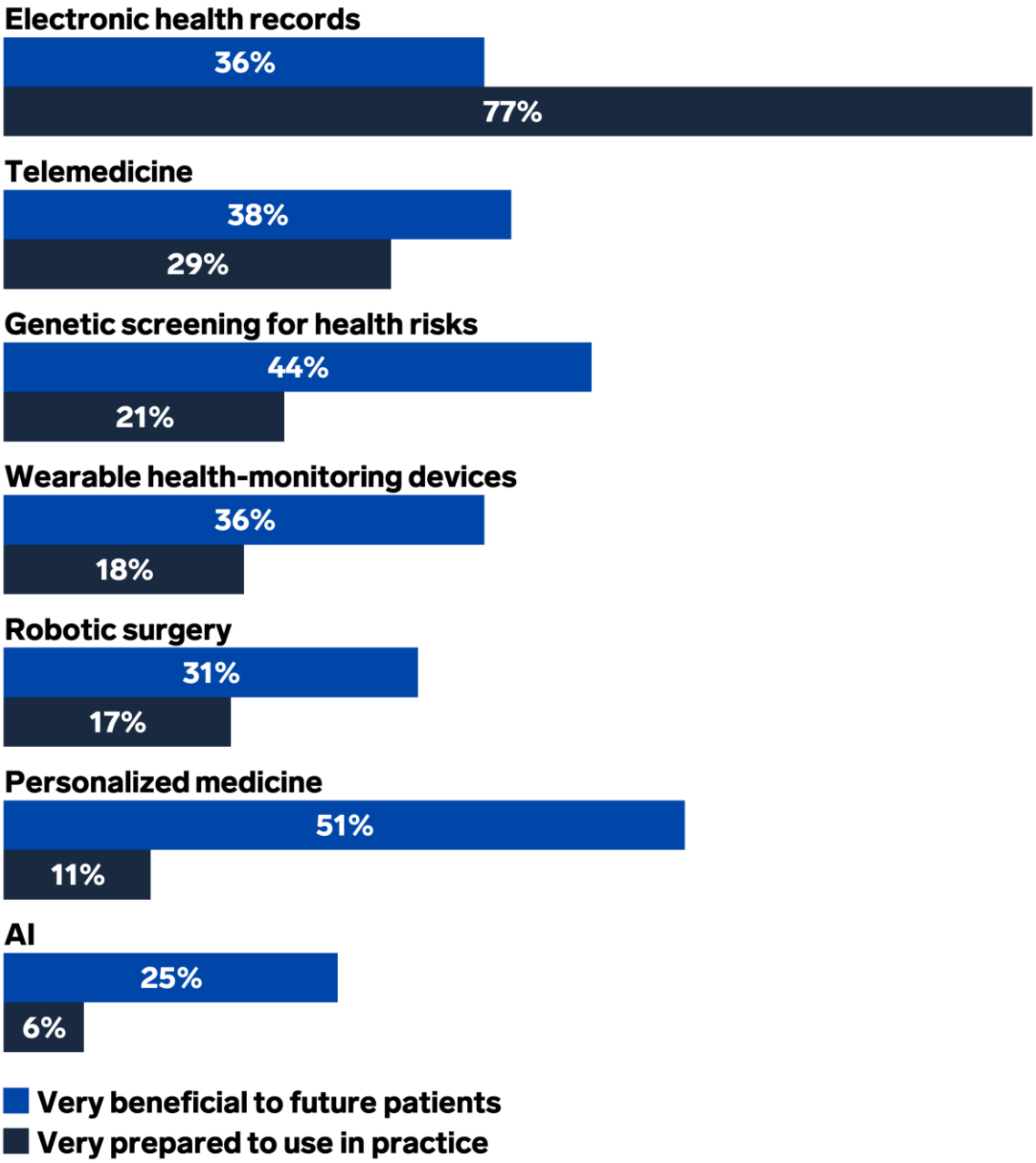
Color offers its health system partners the backbone for genomic sequencing and expertise needed to spur personalized medicine efforts. Its roster of partners includes Illinois-based NorthShore University Health System and Louisiana-based Ochsner Health. NorthShore is offering segments of its patient base with free genetic testing as a part of their primary care exams, for instance, which doctors will leverage to assess genetic predispositions to cancer, heart disease, and adverse medication reactions to personalize treatment plans, a practice called precision medicine. This info could help catch disease earlier — and generate cost savings, considering conditions like breast cancer can become more expensive to treat as they progress.

"[Genetic testing companies] will provide the genetic signals to guide more precise care and pharma intervention for lifestyle illnesses that have very low remission rates because of one-size-fits-all approach."
— **Ranjan Sinha, Digbi Health** Founder and CEO

Source: Business Insider Intelligence Digital Health Pro Survey, February 2020

Color also provides training for physicians employed by its partner provider firms to help them learn more about genetic testing and its benefits. This could help clinicians overcome concerns about their abilities to make use of genetic screenings: While 44% of US physicians think that genetic screening for health risks is "very beneficial" for their patients, only about half as many (21%) feel "very prepared" to use it in their practice, according to a 2020 Stanford Medicine survey. So, offering onboarding and support services to the clinicians who are providing the care likely makes Color an attractive partner for hospitals considering implementing a genetic screening initiative.

How Beneficial US Physicians Think Genetic Screening Is Vs. How Prepared They Are To Use It



Source: Stanford Medicine, "2020 Health Trends Report," January 2020
Methodology: Survey of 523 American Medical Association-verified US physicians conducted by Stanford Medicine and Brunswick Insight from September to October 2019.

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Medical Researcher Partnerships

Color is providing the genetic testing infrastructure to large-scale population health initiatives looking to gain genetic insights — helping the startup extend its reach to potentially millions of consumers. In 2019, Color scored separate deals with the NIH and Alphabet's life sciences arm Verily to provide actionable genetic info for their respective population-level projects.

- **NIH's All of Us initiative.** In a multiyear partnership with the US government branch, Color will be tasked with delivering all genetic testing results to participants, providing genetic counseling for those whose genetic profile reveals actionable health information, building custom software and data tools, and more. The NIH officially launched its decade-long research project, All of Us, in May 2018 with the aim of incorporating the biological, genetic, and lifestyle information of 1 million people — to become the first research program of its kind with the largest, most diverse participant base — and it's already locked in over 200,000 enrollees.

"The purpose of genetic counseling is to take the information that is returned from [a patient's] sample and make it meaningful for their health."
— **Lauren Ryan, Color** Head of Clinical Services

Source: Interview with Business Insider Intelligence, October 2019

- **Verily's Project Baseline.** Verily tapped Color to supply participants of Verily's Project Baseline research platform with genetic information in October 2019. Project Baseline began in 2017 with goals of making clinical research more accessible to participants and arriving at a quantifiable "baseline" for good health. The research project has since launched several clinical research projects in partnership with some of the largest names in healthcare, including: Pfizer, Mayo Clinic, Novartis, the American Heart Association, and Stanford Medicine. We think Color will benefit from the exposure that comes when partnering with a Google-affiliated business — and it could give it access to its growing list of esteemed healthcare organizations.

Employer Partnerships

Color boasts partnerships with major self-insured employers — which are likely betting on the genetic insights its tests offer to steer high-value care delivery and whittle down medical spending. Color's employer partners include big names like Apple and Salesforce. Color's test pinpoints gene mutations linked to common and costly conditions, like certain types of cancer and heart disease. So, theoretically, if a patient's genetic test comes back with a result that's cause for concern, doctors could formulate a personalized treatment plan that helps patients take preventative moves to sidestep disease development or progression. And, in the case of cardiovascular disease, employers could save big, considering heart disease costs could top $1 trillion in the US over the next two decades, per an RTI International study. We know that employers are staring down amplified medical spending, so helping employees stay ahead of the curve on any adverse health developments could help employers sidestep some of these costs: Medical costs for US employers are expected to grow 6% in 2020, marking a four-year high. And we think Color has more deals with employers on the horizon, considering Color CEO Othman Laraki recently told us that Color's large employer partners regularly see 30-50% of employees sign up for Color's genetic testing services within a year of adding their services to company health plans — making these tie-ups a huge opportunity for Color to see uptake in its services.

Invitae

Invitae reaches consumers through myriad channels, including physician-ordered tests, and has recently been expanding via partnerships and acquisitions. The public company has been up and running since 2010 and offers physician-ordered tests to consumers. It also connects with biopharma companies to offer tests for patients who meet criteria and help firms boost recruitment for trial, and contracts with employers looking to provide genetic testing for employees.

Invitae revealed the value of genetic data in the tech-focused clinical trial space through a recent partnership with Apple — which has been leveraging its Watch to entrench itself in the medical research realm. In November 2019, Invitae launched a new app, dubbed Invitae Discover, aimed at gathering heart health data from the Apple Watch and Health app, which the company will combine with users' genetic information to study potential genetic causes of atrial fibrillation (Afib).

With expanded access to consumer-generated health data via the Apple Watch, Invitae can explore the linkages between genetics and observable biometrics. The duo's study could home in on genetic variants that scientists at Invitae think may be related to Afib and other heart diseases, but so far have been unable to prove. Cross-referencing heart health data over a long period of time from potentially thousands of users could help Invitae narrow down which of these perplexing genetic variants are involved with the development of Afib — making it an attractive partner for pharma and other researchers that will want to target these genes and develop effective therapies to address the problem.

Invitae had a busy start to 2020 — acquiring three companies that indicate shifts in strategy. In March 2020, Invitae announced it would acquire three companies — YouScript, Genelex, and Diploid — for a combined value just shy of $200 million, per a CB Insights newsletter.

Here's how each tie-up would boost Invitae's value in the eyes of healthcare partners:

- **YouScript provides a platform that helps physicians make use of patients' genetic testing results, per GenomeWeb — which could help Invitae land team-ups with health systems.** The platform allows doctors to modify and manage patients' medication based on genetic test results — and the solution can be embedded into EHRs. This would likely allow doctors to make use more seamlessly of genetic info gleaned from tests without stepping outside of workflows. And the platform has revealed that it's able to generate a 42% cut to readmission rates — which is an attractive proposition to hospitals staring down penalty fines for higher readmission rates.

- **Genelex is a pharmacogenetic testing firm that can power precision medicine efforts and help circumvent adverse drug events.** Pharmacogenetic testing is the testing of certain genes to determine how patients could react to specific drugs — and the insight from these tests could help providers decrease the number of "trial-and-error" doses, and steer speedier, more tailored treatments: Adverse drug events cost the US an estimated $30 billion annually.

- **Diploid could provide Invitae a tech boost and help it process more data faster.** Diploid deploys AI software that diagnoses genetic disorders from patients' gene sequencing and other clinical data, per GenomeWeb. And this isn't Invitae's first acquisition that helps it automate diagnostics: It snapped up Jungla in July 2019, which also uses AI to interpret genetic tests.

"Increased [consumer] awareness [of genetic testing] has created a clinical care opportunity and will soon drive payer demand for pharmacists and prescribers to utilize proven precision medicine tools and medication decision-support technologies to identify the most appropriate medication and dose based upon a patients' genetics."
— **Jacques Turgeon, Tabula Rasa** Chief Scientific Officer

Source: Business Insider Intelligence Digital Health Pro Survey, July 2019

THREATS TO THE LONG-TERM VIABILITY OF DTC GENETIC TESTING

Shrinking DTC Genetic Testing Market

While some projections pinned the DTC genetic testing market to keep skyrocketing to 100 million tests deployed by 2021, a sudden dip in the market makes us think the space won't remain fruitful. Illumina — which develops the tech backbone for many genetic testing companies — pointed out that there's "unanticipated market softness" in the DTC genetic testing sector in a 2019 recent earnings call. And recent actions taken by genetic testing firms that primarily implement a DTC approach provide evidence to Illumina's claim: Both 23andMe and Ancestry slashed their workforces at the beginning of 2020, which we posited was due to shrinking demand for the products.

The downturn in the DTC genetic testing market could be driven in part by waning consumer interest in the space. While early adoption of genetic testing kits was promising, genetic testing firms have struggled to convert that promise into sustained consumer interest and adoption, which makes sense considering the limited utility of their one-time-use products. Further, consumers may be unwilling to cough up the funds necessary for costlier tests, especially those that are sequencing larger portions of the genome — even when companies do what they can to whittle down prices: Massachusetts-based whole genome sequencing company Veritas shuttered its US operations in December 2019, mere months after chopping down the price of its test by nearly half, likely a bid to rope in consumers. Thus, we think firms relying mainly on DTC sales will make more concerted pivots into business-to-business models, striking tie-ups with hospitals, medical researchers, pharma, and employers to keep hooking in business.

Genetic testing firms have been criticized for insufficient data security measures, which is likely raising consumers' brows and constricting the market. These firms have proven to be prime targets for hackers: In November 2019, genetic testing firm Veritas announced it suffered a cyberattack through which customer information was potentially compromised, per Bloomberg. Further, legislation surrounding the ways in which companies can handle consumers' genetic data remain murky: In 2017, Senator Chuck Schumer (D-New York) wrote a letter to the US Federal Trade Commission urging the group to ensure that genetic testing firms' privacy policies are transparent to consumers. And while genetic testing companies like 23andMe share users' anonymized data with researchers and drug companies, researchers have determined that it's possible to correctly identify 40-60% of all genetic testing participants by comparing genetic data against public data sets such as census data or voter lists. And news about the potential mishandling of genetic data may dissuade consumers from making the purchase: In a recent YourDNA survey, 40% of consumers who had never taken a DNA test cited privacy concerns as the driving reason they shied away.

Additionally, a considerable number of consumers aren't willing to pass along their genetic info without compensation. In a March 2020 study cited in Science Daily, researchers asked respondents whether they'd give their genetic data to a tech company involved in biomedical research — and while 38% said they'd be unwilling to pass over their data, 51% said they'd provide it if they were financially compensated, up from the 12% that said they'd give it up free of charge. Thus, it could be more difficult for the likes of 23andMe to wrangle in customers completing DTC tests to opt into research if they're not being rewarded in any way. But we're seeing some smaller firms start to address this: For instance, LunaPBC is offering company shares in exchange for genetic information — and they'll start receiving payouts once the startup becomes profitable. And we think we'll see more genetic testing firms take creative approaches to incentivize consumers to offer them their data for research.

"I believe we'll see a rise in individuals exercising their rights to get a copy of and share their data — electronic health records, DNA files, wearable feeds — for initiatives they deem important… Individuals' rights to control and delete their data trail, the ethics of data use, and protection of privacy will go from themes to business imperatives in 2020."
— **Dawn Barry, LunaPBC** cofounder and president

Source: Business Insider Intelligence Digital Health Pro Survey, December 2019

A Lack Of Preparedness In Healthcare

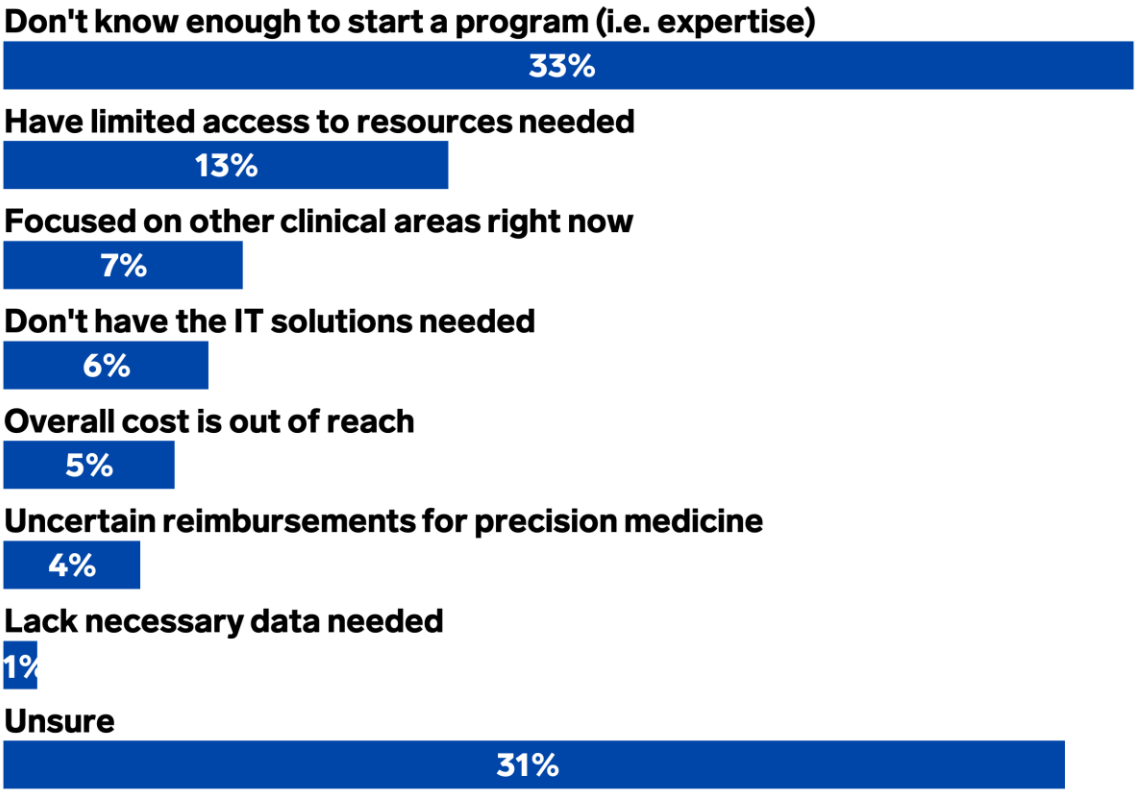
"DTC genetic testing companies have had little impact on health care to date. While they help people learn about potentially heritable diseases for which they may be at risk, the information is not actionable, in most cases, because [it] is not integrated with clinical care… In contrast to DTC services, genetic testing that's integrated with care is beginning to improve diagnostic accuracy and treatment effectiveness for a growing number of diseases."
— **Marcus Thygeson, Bind** Clinical Lead

Source: Business Insider Intelligence Digital Health Pro Survey February 2020

Precision medicine is gaining steam among early-moving health systems, but genetic testing firms looking to tie up with provider organizations may have a hard time hooking in customers because doctors are ill-equipped to decode genetic data. A lack of necessary expertise tops healthcare leaders' list of barriers to crafting a precision medicine strategy — which could dissuade them from forging ties with genetic testing firms, as educating their clinicians may be too big a task. In fact, 33% of acute care leaders cited lack of knowledge as the primary barrier holding their organization back from moving into precision medicine in a December 2019 Definitive Healthcare survey. This makes sense, considering that there are gaps between doctors' positive stance on the innovative tools that could drive precision medicine and how prepared they feel to make use of them: For example, while 44% of physicians think genetic screening would be beneficial to patients, only 21% feel "very prepared" to use it, per a recent Stanford Medicine survey of 523 practicing US physicians. This signals that, broadly, doctors may be unable to handle and operationalize the data generated by genetic tests.

A Lack Of Expertise Is Holding US Hospitals Back From Deploying Precision Medicine

Q: Which of the following best describes the primary barrier to your move into precision medicine?



Note: Respondents include organizations without precision medicine programs that don't plan to establish one in the near future (n=84).
Source: Definitive Healthcare, "2019 Precision Medicine Study," December 2019
Methodology: Survey of leaders from 122 US-based acute care organizations conducted by Definitive Healthcare.

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Inadequacies In Health Risk Assessments

Invitae has presented research claiming DTC genetic analysis fails to flag health risks nearly 100% of the time for certain minority racial groups. False negatives are when a consumer receives genetic testing results that fail to mark genetic variants linked to increased health risks. Perhaps more dangerous than false positives, false negatives can easily lure patients into believing they've received a clean bill of health, which some may use as justification to avoid medically recommended cancer screenings and other preventative measures. This could deter consumers from using DTC tests — as the potential for receiving false negatives wouldn't make it worth the cost.

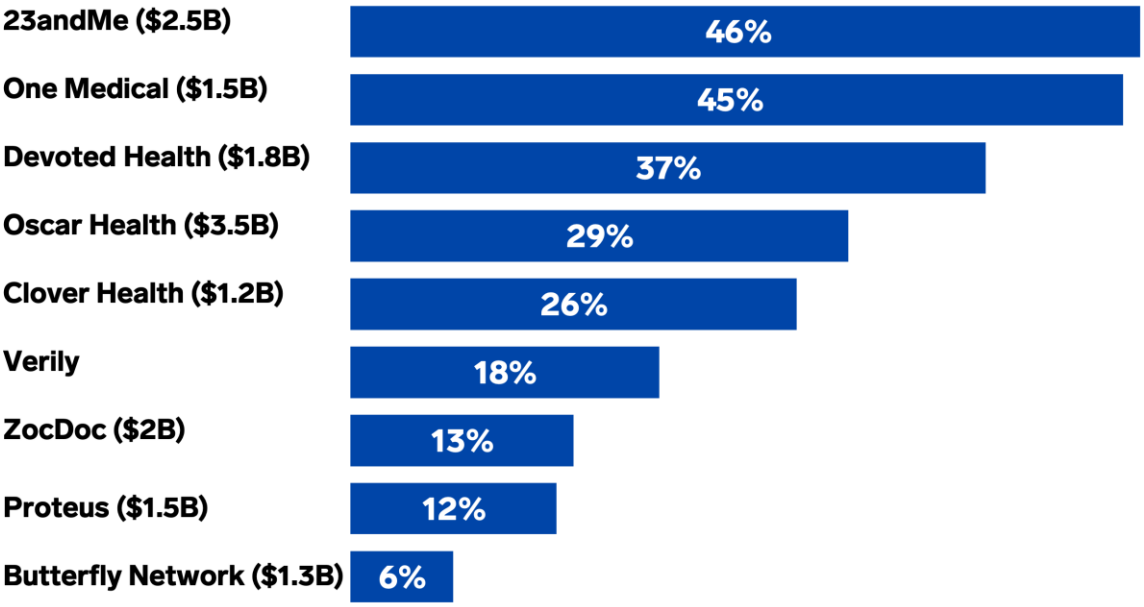
Biased genetic data bases are leading doctors astray — which might make them wary of partnering with genetic testing companies without diverse samples. Genetic databases composed predominantly of people with European ancestry are leading doctors to inaccurately diagnose and prescribe treatments to non-European patients, per PBS. While only 12% of the global population is of European descent, nearly 80% of people included in genomic research are of European descent. A lack of diversity in genetic research exacerbates inequitable health outcomes: Algorithms that doctors use to prescribe the appropriate amount of a blood thinner Warfarin work well for people with European genes, for example, but have been shown to consistently overprescribe for African American patients, putting them at risk of excessive bleeding.

Overvalued Startups

Startups are burning through cash and remaining off the public market — which could lend credence to the notion that genetic testing companies are overvalued. Whether or not digital health startups are overvalued has been debated: In April 2019, fewer than half (46%) of healthcare pros said they thought 23andMe's $2.5 billion valuation was in line with its market potential — and that was before DTC companies started making major switches to operations in response to market slowdowns. Further, some of the biggest players — including 23andMe, Ancestry, and Color — have yet to go public, which calls into question the long-term viability of digital health startups. Successful IPOs typically require companies to generate significant revenues, so the dearth of genetic testing IPOs could hint at overvalued startups: There were rumors circulating in 2019 that Ancestry was going to make a public debut, but we don't anticipate those coming to fruition as the market remains on the decline.

Most US Healthcare Experts Though Digital Health Unicorns Like 23andMe Were Overvalued In 2019

Respondents that answered "yes" to "I believe the following 'unicorn' valuations are in like with their market potential."



Note: Verily's valuation was not available.
Source: Venrock, "2019 Healthcare Prognosis," April 2019
Methodology: Survey of 250 respondents from health IT startups, large employers, insurance companies, healthcare providers, academic institutions, the government, and investment companies conducted by Venrock in March 2019.

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HOW THE CORONAVIRUS PANDEMIC WILL AFFECT GENETIC TESTING COMPANIES

We think the coronavirus pandemic — and the economic downturn that has accompanied it — will act as another hit to the DTC genetic testing space. As a recession and economic hard times have consumers shoring up expenses, we think consumers will place spending on nonessential health products like genetic testing on the backburner: During the last recession, consumer spending dropped to a record low, per the US Bureau of Labor Statistics. And in late March, a survey conducted by Business Insider Intelligence revealed that 50% of consumers were spending less on nonnecessities. Not only do we think that the economic slowdown should further rein in consumer funds channeled into the genetic space, but it could also pump the brakes on deals with hospitals. Hospitals have taken a serious financial blow amid the pandemic — bleeding an estimated $50 billion monthly — so, they'll likely be channeling resources into companies that can help them recoup lost revenue and placing population health and precision medicine programs on hold.

However, genetic testing firms have the lab equipment, infrastructure, and expertise to conduct coronavirus testing on a wide scale — and we've seen some companies shift into coronavirus-specific endeavors to remain relevant. For example, Israeli company MyHeritage rapidly pivoted to ramp up coronavirus testing in Israel in late March. Also in late March, Color launched a testing laboratory integrated with public health tools in Burlingame, California, to process clinical samples and support public health efforts in containing the spread of the virus — with the bold goal of performing 10,000 coronavirus tests per day with a lab turnaround time of 24 hours. It also introduced a contact tracing element to its coronavirus play through which it facilitates outreach to people who may have been exposed. Further, in May, Color unveiled its COVID-19 Essential Workforce Testing program. Shifting operations to focus on the coronavirus should help these firms hang onto their relevance and up their value proposition in the eyes of partners: For example, Color's employer partners could potentially leverage the program that helps facilitate bringing employees back to work safely and efficiently. While it remains unclear how the pandemic will affect the genetic testing space in the long term, we think those that are working to appeal to partners with coronavirus-specific solutions are in a better position to cement relationships now.

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