Methods and Applications

Demand for Direct-to-Consumer Genetic Testing Services in China and Its Implications for Precision Public Health — China, 2021

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ABSTRACT

Introduction: In China, the direct-to-consumer genetic testing (DTC-GT) industry has been undergoing exponential growth during the past few years. This study intends to assess characteristics of DTC-GT users in China, estimate the price elasticity of demand, quantify monetary values of DTC-GT features, and discuss its implications to the development of precision public health.

Methods: A total of 629 participants with an average age of 28.8 years were collected from an online survey conducted in November 2021. A discrete choice experiment and a mixed logit modelling approach were used to elucidate consumer preferences to DTC-GT services and evaluate monetary values of certain features.

Results: DTC-GT users were found to have a higher level of income on average. The price elasticity of DTC-GT services was estimated to be –0.72 (95% CI –0.73 to –0.70). The willingness-to-pay to genetic testing features of physical traits, personality, and dietary recommendation were estimated to be 90, 107, and 220 CNY, respectively.

Discussion: The nature of big genomic data makes DTC-GT have the potential to aid in the advancement of precision public health through more precise disease prevention and control strategies. The study also notes the need for addressing potential drawbacks of DTC-GT and protecting genetic privacy.

INTRODUCTION

Precision public health aims to more precisely describe and analyze individuals and their environment over their life course, tailor preventive interventions for at-risk groups, and eventually improve the overall health of the population by applying technologies from novel genomic big data (*1–2*). The genetic data collected by direct-to-consumer databases have the potential to aid in the advancement of precision public health (*3–5*). In China, the direct-to-consumer genetic testing (DTC-GT)[*] industry has also been undergoing exponential growth in the past five years. According to a recent report by Frost & Sullivan, in the mainland of China, the accumulated number of DTC-GT consumers has reached 12.1 million in 2020 and the market is projected to reach 72 million US dollars in 2021. Leading DTC-GT providers in China, such as WeGene and 23mofang, now offer different types of DTC-GT products to consumers in which the results can be easily accessed on a mobile phone without the need for an intermediary medical professional. Table 1 lists testing prices and features of selected DTC-GT products from major providers of China.[†] This expanding volume of East Asian users in China's DTC-GT market could become helpful for the research and development of precision public health in China (*6–7*).

Despite a considerable amount of research that has already utilized individual-level genetic data, little is known about what consumers know and how they respond to DTC-GT services in China. This article serves as the first study to assess characteristics of current DTC-GT users in China, estimate the price elasticity of demand, and quantify monetary values of major features provided by DTC-GT services.

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[*] Different from clinical genetic testing, DTC-GT is marketed publicly via Internet, social media, or television advertisements, and the products can be bought online or in stores directly by consumers. DTC-GT provides consumers access to their genetic information at a relatively lower price, without necessarily involving a healthcare provider or an intermediary medical professional in the process.

[†] There are two major testing methods with different levels of thoroughness used by DTC-GT products available in China's market. Most DTC-GT products use the SNP-chip genotyping method, which checks for the presence or absence of specific variants, such as particular single nucleotide polymorphisms (SNPs), across the genome at a relatively lower price. Another testing method used by a few high-end DTC-GT products is the whole genome sequencing (WGS) method, which sequences almost the entire genome and identify the variants present within it at a higher price.

METHODS

Sample Collection

The survey was conducted by the China Center for Genoeconomic Studies at China Agricultural University. After providing informed consent, 667 participants took our online survey in November 2021. The survey collected information on participants' demographic and socioeconomic characteristics as well as their experience of using genetic testing services. Excluding participants who did not complete the survey, our analytical sample totaled 629 observations. As reported in Table 2, the average respondent in our sample was 28.8 years old, completed 16.1 years of education, and earned about 105,000 CNY annually.

Design of the Discrete Choice Experiment

To evaluate consumer preferences in DTC-GT services and estimate monetary values of certain features, we integrated a discrete choice experiment (DCE) in the survey. The discrete choice experiment is an advanced research design that can reliably elicit consumers' true preferences and choice intentions by

TABLE 1. Selected DTC-GT products from major providers in China.

Testing method	Company	Product	Feature					Price per kit (CNY)
			Ancestry	Physical traits	Health	Personality	Lifestyle recommendation	
SNP-chip genotyping	WeGene	Basic kit	Yes	Yes	Yes	Yes	Yes	799
	23mofang	Health/ancestry kit	Yes	Yes	Yes	Yes	Yes	699
	23mofang	Ancestry kit	Yes	Yes	No	Yes	No	499
	Gese	Basic kit	Yes	Yes	Yes	Yes	Yes	699
	Genebox	Discovery kit	Yes	Yes	No	No	No	199
	Genebox	Expert kit	Yes	Yes	Yes	No	No	699
WGS	WeGene	WGS regular kit	Yes	Yes	Yes	Yes	Yes	3,999
	WeGene	WGS youth kit	Yes	Yes	Yes	Yes	Yes	2,499

Note: The data were collected (as of February 2022) from websites: WeGene, https://www.wegene.com/shop/ (last accessed February 11, 2022); 23mofang, https://www.23mofang.com/ (last accessed February 11, 2022); Gese, https://www.gesedna.com/ (last accessed February 11, 2022); Genebox, https://genebox.cn/ (last accessed February 11, 2022).
Abbreviation: DTC-GT=direct-to-consumer genetic testing; SNP=single nucleotide polymorphisms; WGS=whole genome sequencing.

TABLE 2. Summarized characteristics by consumers' experience with the usage of DTC-GT services from an internet-based survey (N=629).

Variable	Pooled		DTC-GT user		Non-DTC-GT user	
	Mean	SD	Mean	SD	Mean	SD
Demographic and socioeconomic characteristics						
Male	40.1%	–	44.5%	–	39.1%	–
Age (years)	28.8	7.8	29.0	6.3	28.7	8.0
Ethnic minority	4.6%	–	3.6%	–	4.8%	–
Full-time students	22.6%	–	15.5%	–	24.1%	–
Party member	22.4%	–	34.5%	–	19.8%	–
Years of schooling	16.1	2.1	16.2	2.3	16.1	2.0
Annual income in 10,000 CNY	10.5	13.2	13.9	18.6	9.8	11.7
Knowledge, experience, and perception to DTC-GT						
Knowing DTC-GT very well	23.5%	–	69.1%	–	13.9%	–
Knowing DTC-GT a little	64.9%	–	30.9%	–	72.1%	–
Having used DTC-GT before	17.5%	–	–	–	–	–
Friends or relatives have used DTC-GT before	24.6%	–	71.8%	–	14.6%	–
No. of respondents	629		110		519	

Note: "–" means not applicable.
Abbreviation: SD=standard deviation; DTC-GT=direct-to-consumer genetic testing.

replicating real-life situations (*8*). Then, we identified possible attributes associated with consumers' preferences/purchase decisions of DTC-GT products. To ensure feasibility and respondents' understanding of the choice tasks, we restrained the choice experiment to including four key attributes with various levels: (a) price (levels: 300/600/900/2,500 CNY per testing kit), (b) features of genetic testing results provided (levels: health and ancestry/physical traits/personality/dietary recommendation), (c) research collaboration status (levels: no external collaboration/collaborating with research institutes/having published research articles), and (d) types of interpretation for testing results provided [levels: by words/by artificial intelligence (AI)/by staff]. We applied the D-optimal procedure to generate a total of 8 choice tasks by using JMP (Version 13, SAS Institute Inc., Cary, NC, USA). Each choice task included three DTC-GT alternatives and an opt-out option. In the survey, respondents were asked to choose their most preferred option in each choice task, and an example choice task is presented in Table 3.

Statistical Analyses

This research used the mixed logit model that allowed for random parameters and heterogeneous preferences to estimate attribute coefficients, price elasticity of demand, as well as willingness-to-pay (WTP) for different features in DTC-GT services. Price elasticity was used to evaluate the responsiveness of demands to changes in the price of DTC-GT services. WTP measured the maximum price a consumer is willing to pay for a specific feature of DTC-GT services. All statistical analyses were performed using Stata/MP (Version 14, StataCorp, College Station, TX, USA).

RESULTS

Chinese Consumers' Knowledge, Experience, and Perception of DTC-GT Services

As reported in Table 2, 88.4% of respondents were aware of DTC-GT services, 24.6% respondents reported that their friends or relatives had used DTC-GT services before, and 17.5% respondents (N=110) had actually used or purchased DTC-GT services by themselves. Compared to respondents who have not taken DTC-GT services before (column 3), there was a higher proportion of Han Chinese males and party members among prior users of DTC-GT services (column 2). DTC-GT users on average earn 42,000 CNY more than non-DTC-GT users annually. Overall, 69.1% of DTC-GT users reported knowing DTC-GT services very well, compared to only 13.9% of non-DTC-GT users; 71.8% of DTC-GT users have at least one friend or relative who also has taken DTC-GT services, and the proportion is much lower among non-DTC-GT users (14.6%), which is consistent with the classic theory of diffusion of innovation (*9*).

TABLE 3. An example of a choice task offered to respondents.

Option (A)	Option (B)
Price: 600 CNY	Price: 300 CNY
Ancestry analysis (e.g. the proportion of Northern Han Chinese in the ancestry component)	Ancestry analysis (e.g. the proportion of Northern Han Chinese in the ancestry component)
Health analysis (e.g. the risk of Type 2 diabetes)	Health analysis (e.g. the risk of Type 2 diabetes)
Physical traits (e.g. the genetic height)	
Research collaboration: collaborating with several research universities/institutes	Research collaboration: collaborating with several research universities/institutes
Interpretation for testing results: by detailed text explanation	Interpretation for testing results: by detailed text explanation
Option (C)	**Option (D)**
Price: 900 CNY	
Ancestry analysis (e.g. the proportion of Northern Han Chinese in the ancestry component)	
Health analysis (e.g. the risk of Type 2 diabetes)	(None of the above)
Dietary recommendation (e.g. alcohol drinking advice)	
Research collaboration: having published several research articles	
Interpretation for testing results: by Artificial Intelligence	

Consumer Preferences, Price Elasticity of Demand, and Willingness-to-Pay for DTC-GT Services in China

Parameter estimates (available upon request) demonstrate that respondents prefer to have a DTC-GT service with a lower price and external research collaborations. They prefer additional genetic testing features of dietary recommendation over personality and physical traits. In terms of result interpretation, respondents have a slightly higher preference for having the information by words rather than by staff or AI. The price elasticity of DTC-GT services was estimated to be –0.72 [95% confidence interval (CI): –0.73 to –0.70], indicating that a 10% increase in prices of DTC-GT services would result in a 7.2% decrease in consumer demand. This finding is in line with existing literature that has reported inelastic or nonresponsive demand to a price change of healthcare services in China and across the world (10–11). Besides basic health and ancestry reports by a DTC-GT product, the mean willingness-to-pay for additional genetic testing features like dietary recommendation, personality, and physical traits was estimated to be 220, 107, and 90 CNY, respectively, illustrating a potential demand for personalized nutrition among Chinese consumers.

DISCUSSION

The nature of big genomic data makes DTC-GT a promising way to improve the health of sub-groups within the population who are more predisposed to certain health conditions and ailments (7,12–13). As illustrated in Figure 1, aligned with the aims of Healthy China 2030, health equity could be advanced through targeted interventions on the basis of both longitudinal behavioral records and genetic data obtained from DTC-GT of subpopulations in the future.

This study was subject to some limitations. First, the current study was based on a sample of 629 participants collected from an online survey, which might lead to a lack of statistical power due to the relatively small sample size. Second, the sample was not nationally representative and more studies are needed to generalize our findings.

Nonetheless, a couple of potential drawbacks of DTC-GT should be noted and avoided. From the perspective of consumers, there could be adverse psychological effects when knowing the potentiality of severe diseases from testing results, and consumers may make irrational decisions that could damage their health based on non-deterministic DTC-GT results (14). DTC-GT companies are thus responsible for ensuring the transparency of information and informing consumers to avoid any misinterpretation. In addition, genetic privacy and data protection are a primary legal concern associated with DTC-GT in China (15). On April 15, 2021, the Biosecurity Law of the People's Republic of China enacted stricter controls on the use of individual genetic data,
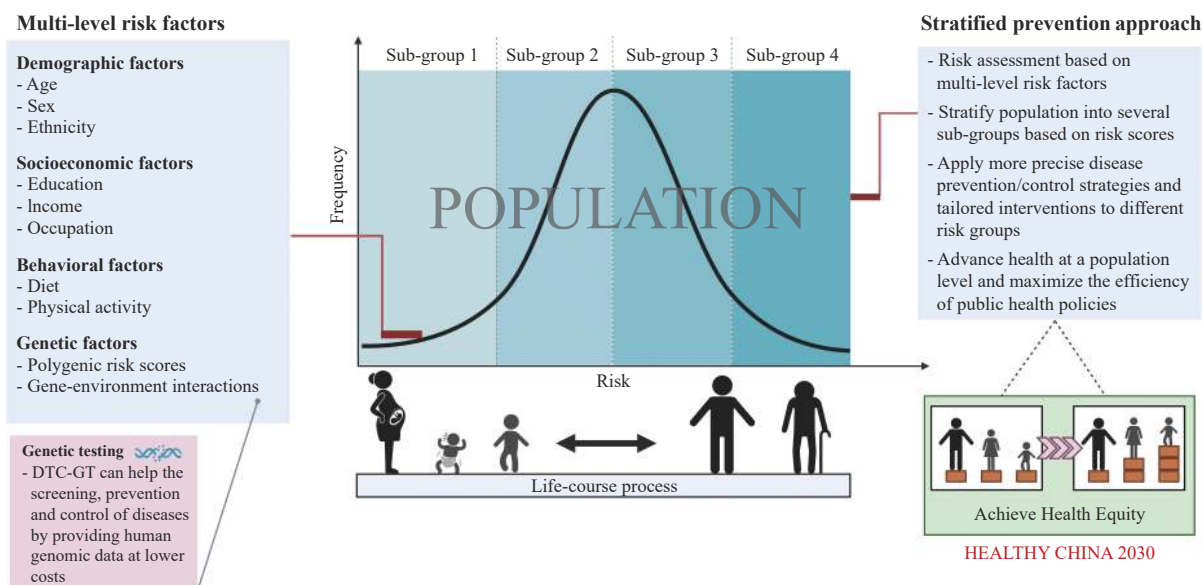

FIGURE 1. A precision public health framework to stratify the population and provide tailored interventions.
Abbreviation: DTC-GT=direct-to-consumer genetic testing.

warranting Chinese consumers with enhanced genetic data and privacy protections. Still, developing a comprehensive legal framework to regulate genetic data and the rapidly evolving DTC-GT market will be a challenge to the government in China.

Conflicts of interest: No conflicts of interest.

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