

Review

Ethical, Legal, and Social Implications of Genomics in China: A Scoping Review and Implications for Precision Public Health

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ABSTRACT

We conducted a scoping review of Chinese language studies on the ethical, legal, and social implications of genomics and identified four broad themes: ethical considerations, regulatory framework, perceptions of genomics and precision medicine, and future directions of genomics. Ethical, legal, and social implications of genomics are growing in importance and are highly relevant to public health in China.

China is one of the six countries involved in the Human Genome Project and is a critically important player in human genome research globally. China's regulatory requirements for genomics research and practices are evolving, and after the birth of the world's first genetically edited babies (1), there has been a renewed interest in assessing the ethical, legal, and social implications (ELSI) of genomics in China.

Applications of genomics lead to Precision Medicine, which tailors treatments to individuals (2), with potentially revolutionary changes in three areas: disease classification, clinical research paradigms, and clinical evidence (3–4). A subsequent concept is Precision Public Health, which is described as “an emerging multidisciplinary field that uses genomics, big data, and machine learning/artificial intelligence to predict health risks and outcomes and to improve health at the population level.” (5) Demand for precision medicine and precision public health will continue to grow after the coronavirus disease 2019 (COVID-19) pandemic subsides, and it is therefore critical to examine the ELSI of genomics for public health (6). We conducted a scoping review of the landscape of ELSI of genomics research in the Chinese scientific literature and explored its public health

implications, including for capacity building and policy development.

METHODS

Our intent was to survey the landscape of ELSI of genomics research and practices in China. We identified studies through a systematic literature search in the three major Chinese citation databases: China National Knowledge Infrastructure (CNKI), Wanfang Database, and Beida Fabao (PKULaw). To be included, articles must be in Chinese and published between January 1, 2000, and December 31, 2020. Two groups of keywords (in Chinese characters) were used in our search*. Reflecting our dual foci on genomics and ELSI, we restricted our scoping review to studies described by one or more keywords from group 1 and one or more keywords from group 2.

We excluded studies related to non-human genome research, such as studies of genetically modified organisms; editorials, news, comments, and conference report collections; studies in settings other than the mainland of China; and articles not in Chinese.

Two reviewers (JX and LJ) independently screened titles and abstracts for eligibility. Inconsistent decisions were resolved through discussion and, when unable to be resolved, were reviewed and decided by the Principal Investigator (ZC).

RESULTS

The initial search yielded 657 articles; there were 37 duplicate records that were excluded. Title and abstract review excluded another 134 records because of wrong publication type (n=36), lack of relevance to human genetics (n=88), or non-Chinese language (n=10). Among the remaining 486 full-text articles, 420 were excluded because of lack of relevance to genomics (n=330), lack of relevance to ELSI (n=70), non-

* Group (1) 基因组学=genomics, 基因测序=genetic testing, 遗传学=genetics, 精准医学=precision medicine, 克隆=clone, and 基因图谱=genetic mapping; and Group (2) 经济学=economics, 伦理=ethics, 法律=law/legal, and 社会=society/social.

Chinese study population (n=17), and wrong outcome (n=3). We identified 23 additional articles by reviewing reference lists and conducting a manual search. In all, 89 studies were included for review and narrative synthesis (Figure 1). A complete list of the studies is in the Supplementary Material (available in <http://weekly.chinacdc.cn>).

Four themes emerged from our review: ethical considerations, regulatory framework, perceptions of genetic testing and genetic counseling among physicians and the general public, and future directions for genomics.

Ethical Considerations

Qiu and Zhai outlined ELSI issues related to China's precision medicine strategy, including

informed consent, independent ethics review, privacy protection, and equity in the use of precision medicine research (7). Chen et al. summarized ethical issues related to clinical genetics in China in seven settings — diagnosing hereditary genetic conditions, prenatal diagnosis, newborn screening, making prognoses with genetic information, identifying carriers of pathogenic variants, preimplantation genetic diagnosis, and whole-genome sequencing — and advocated for ethical considerations during genetic testing (8). Tao and Wang cautioned against discrimination in employment, marriage, education, and inclusion based on genetic information, and advocated for desensitization and deidentification of biomedical big data (9).

Likely spurred by the 1996 cloning of Dolly the

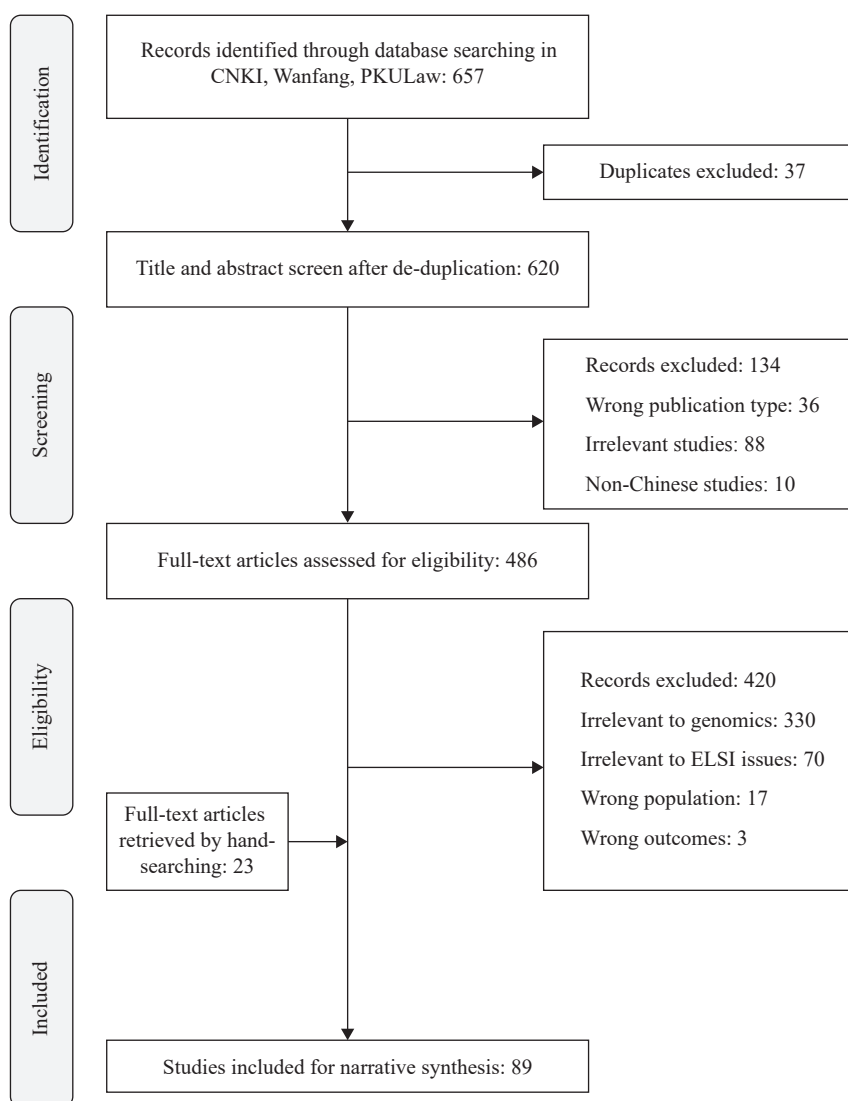


FIGURE 1. Flow chart for literature search of ethical, legal, and social implications of genomics in China. Abbreviation: ELSI=ethical, legal, and social implications; CNKI=China National Knowledge Infrastructure.

sheep, 50 studies had “cloning” in their titles, with additional papers discussing cloning as a component of genomics research. An emerging consensus is a ban on reproductive cloning while allowing the exploration of cloning for research and therapeutics (10).

Regulatory Framework

Research interests in ELSI of genomics in China have grown after the revelation of genetically edited babies (1), with particular attention to informed consent and privacy protection (9,11–12). Other areas of interest include gene patents and over-the-counter genetic testing (GT) (12–14). Recent literature cautions against discrimination based on genetic information (12). Such issues require legal or regulatory oversight and warrant additional discussions.

Wang and colleagues used text analysis to outline key issues on ethical oversight related to GT, including data security and sharing, privacy protection, standard operating procedures, and regulations for clinical use of GT and genetic counseling (GC). Seven regulations require informed consent, and two require informed consent on data reuse. These seven regulations stress protection of patient privacy, but provide limited practical guidance. The article by Wang et al. provides a detailed list of the regulations, and recommends strengthening the existing legal and regulatory framework on ethical issues related to GT, stressing the adaptability, agility, and sensitivity of ethics governance; and providing ethics training for precision medicine practitioners. The “Rule on Human Genetic Resources Management, People’s Republic of China” outlines regulations on collection, preservation, use, provision, services, governance, and legal responsibilities concerning human genetic resources. (9,11)

Perceptions of GT/GC among Physicians and the General Public

A new line of research examines perceptions of GT/GC among physicians and the general public (15–20). Niu and colleagues conducted a stratified random sample survey of Changsha city residents during June–July, 2012 and found positive attitudes toward GT/GC (73.4% of the 399 respondents) but a low level of understanding of GC (19). They found married people and college educated people were more likely to have positive attitudes toward GT. Xu and Zhang assessed public perception and attitude toward GT in Guangzhou City and found limited knowledge

of GT among respondents (20). They predicted higher demand for GT but expressed caution about uncertainties related to wide adoption of GT, given limited familiarity with GT/GC and existing concerns over ethics and privacy protection (20). Cao and colleagues presented quantitative analyses of survey data on the perception of precision medicine and its applications in Shanghai Municipality and Lanzhou City from November 2018 to April 2019 (21). The authors surveyed 2,250 residents and found that residents were attentive to privacy protections, informed consent, and pricing of precision medicine treatment (21). Li et al. found limited knowledge of GT (78.2% of the respondents reported either “never heard of GT” or “just heard about the term GT”) among 1,647 households in Xiacheng District, Hangzhou City (17). Family history, age, and knowledge and attitude toward GT were strongly associated with demand for GT services (17).

Cui and colleagues assessed the perception, attitude, and adoption of precision medicine among 434 clinicians in 48 hospitals across 12 provincial-level administrative divisions (PLADs) (15). Consistent with prior studies, they found limited knowledge of precision medicine among the clinicians. However, 92.6% of the clinicians surveyed believed that precision medicine has clinical utility, and 90.3% would recommend GT to patients who would benefit (15). Bai et al. surveyed 45 physicians in nine public hospitals on knowledge and attitudes toward GT and bioethics (18). They found that young, junior, male physicians tended to have positive views of GT and genetic therapy (18).

Future Directions

The development of ELSI of genomics research can be summarized by the three principles of ethics development for precision medicine that were proposed by Tao and Wang — privacy protection, database development and sharing, and shared responsibility and governance (9). Tao and Wang had four recommendations for future directions: developing ethical principles and rules for precision medicine, providing training on precision medicine ethics, strengthening ethics review for precision medicine research, and developing legal and regulatory framework governing precision medicine.

Guan pointed to a lack of governance on market entry, GC, and licensing and accreditation of genetic counselors in China, as the existing legal requirements and regulations have primarily focused on technology

and laboratory oversight (13). Wu highlighted challenges for clinical guidelines in the era of precision medicine (22).

DISCUSSION AND PUBLIC HEALTH IMPLICATIONS

Our scoping review leads to five critical assessments. First, Chinese researchers have increasingly attended to the key ELSI issues in genomics research and practices, as evidenced by the expanding body of literature on this topic (Figure 2). Second, empirical investigation of ELSI of genomics remains scant. Studies have surveyed attitudes and preferences toward GT/GC among physicians, patients, and the public, with a heavy representation of populations in the south and east of China and in one city (Lanzhou), but no national survey exists. Third, China's regulatory framework over genomics research and precision medicine has been responsive to the growing demand, but with varying pace. Currently, no regulations on over-the-counter GT/GC exist in China (13). Fourth, there has been no research on reimbursement for GT/GC services. Fifth, GC is an emerging field that requires coordinated effort for capacity building and regulatory oversight in China (13).

Conventional wisdom has it that genomics and

precision medicine occur at the individual level, and therefore there is no clearly defined role for public health (23). However, genomics and precision medicine involve multiple levels of interventions, including patient-provider relationships, families, communities, and reimbursement policies (23). Precision public health was a key tool in the COVID-19 response by helping to provide the right interventions for the right populations and by helping to reduce health disparities (24). With predictive analytics, genomics extends its reach from precision medicine to precision public health (25). The Evaluation of Genomic Applications in Practice and Prevention Initiative provides an example of precision public health practice (26). Our review offers important implications for the emerging field of precision public health in China by assessing the landscape of ELSI of genomics in China.

Our review has two important limitations. First, we limited our search to studies published in Chinese. While this was by design to identify studies more relevant to the genomics research and practice in China, we may have missed important literature on ELSI of genomics published in other languages by Chinese authors. Second, we did not assess study quality because most retrieved studies were qualitative in nature. As the literature on ELSI of genomics in China continues to expand, we will revisit this topic

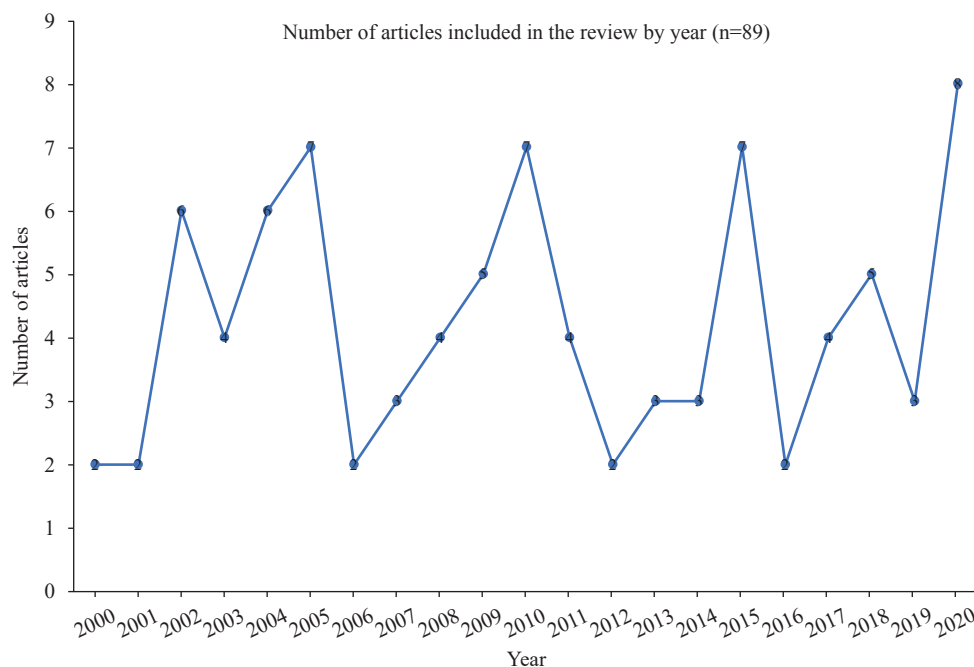


FIGURE 2. Number of publications on ethical, legal, and social implications of genomics in Chinese language included in our review by year of publication.

and update our review.

CONCLUSIONS

We conducted a scoping review of studies on ELSI of genomics in the Chinese language and identified four broad themes of the literature — ethical considerations, regulatory framework, perceptions of genomics and precision medicine, and future directions. We conclude that ELSI of genomics is a growing field and is highly relevant to public health in China.

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REFERENCES

- Wang C, Zhai XM, Zhang XQ, Li LM, Wang JW, Liu DP. Genetically edited babies: Chinese academy of medical sciences' response and action. *Lancet* 2019;393(10166):25–6. [http://dx.doi.org/10.1016/S0140-6736\(18\)33080-0](http://dx.doi.org/10.1016/S0140-6736(18)33080-0).
- National Research Council. *Toward precision medicine: building a knowledge network for biomedical research and a new taxonomy of disease*. Washington: The National Academies Press. 2011. <http://dx.doi.org/10.17226/13284>.
- Wu JR. Retrospect and perspective for precision medicine during 5-year period: I. *Med Philos* 2021;42(20):1–4,10. <http://dx.doi.org/10.12014/j.issn.1002-0772.2021.20.01>. (In Chinese).
- Wu JR. Retrospect and perspective for precision medicine during 5-year period: II. *Med Philos* 2021;42(21):19–25,30. <http://dx.doi.org/10.12014/j.issn.1002-0772.2021.21.05>. (In Chinese).
- Khoury MJ, Holt KE. The impact of genomics on precision public health: beyond the pandemic. *Genome Med* 2021;13(1):67. <http://dx.doi.org/10.1186/s13073-021-00886-y>.
- Zhong A, Darren B, Loiseau B, He LQB, Chang T, Hill J, et al. Ethical, social, and cultural issues related to clinical genetic testing and counseling in low- and middle-income countries: a systematic review. *Genet Med* 2021;23(12):2270–80. <http://dx.doi.org/10.1038/s41436-018-0090-9>.
- Qiu RZ, Zhai XM. Precision medicine: ethical and regulatory challenges. *Chin Med Ethics* 2017;30(4):401–11. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2017&filename=XNLX201704001>. (In Chinese).
- Chen Y, Qian J, Li H. Ethical issues in clinical genetic testing in China. *Med Philos (Humanistic Soc Med Ed)* 2010;31(2):23–5. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFD2010&filename=YXZX201002014>. (In Chinese).
- Tao YS, Wang GY. Construction of precision medicine ethics: conception, principles and paths. *Stud Sci Sci* 2020;38(6):961–7. <https://d.wanfangdata.com.cn/periodical/kxxyj202006001>. (In Chinese).
- Liu JL. The basis and method for regulating clone technology under the perspective of criminal law. *Trib Political Sci Law* 2015;33(4):48–59. <https://d.wanfangdata.com.cn/periodical/zflzt-zgzfdxxb201504004>. (In Chinese).
- Wang Q, Ding XR, Duan JY, Li L, Meng LY, Wang GY. A study of China's policies and regulations on ethical supervision of genetic testing - Based on the perspective of precision medicine. *Stud Sci Sci* 2019;37(4):577–81,596. <http://dx.doi.org/10.16192/j.cnki.1003-2053.2019.04.001>. (In Chinese).
- Yang YF. The basis, practice and direction of legal regulation of genetics research. *J Southwest Pet Univ (Soc Sci Ed)* 2015;17(2):87–91. <https://d.wanfangdata.com.cn/periodical/xnsydxsb-sk201502014>. (In Chinese).
- Guan J. Legal and ethical issues involved in the application of molecular genetics examination in the genomic era. *Chin Med Ethics* 2018;31(3):273–7. <https://d.wanfangdata.com.cn/periodical/zgyxllx201803001>. (In Chinese).
- Zhao GM. Reflections on the development of genetics and social ethics. *J Beijing Polytech Univ (Soc Sci Ed)* 2002;2(1):6–11. <https://d.wanfangdata.com.cn/periodical/bjgydxsb-shkx200201002>. (In Chinese).
- Cui FF, He XY, Shi JM, Zhai YK, Ma QQ, Zhao J. The investigation on knowledge, attitude and practice about precision medicine and associated influencing factors in clinicians. *J Med Postgrad* 2021;34(3):282–6. <http://dx.doi.org/10.16571/j.cnki.1008-8199.2021.03.012>. (In Chinese).
- Xue D, Bai J, Wang JP, Fan ZP, Feng XS, Zhou P. Attitudes and choices of clinicians towards ethical dilemmas in genetic testing counseling: based on scenario analysis. *Chin Hosp Manage* 2015;35(4):74–7. <https://d.wanfangdata.com.cn/periodical/zgyylj201504029>. (In Chinese).
- Li JT, Yang L, Tan XH, Yang CBX, Lin JC. Study on intention and impact factors of gene testing in communities residents. *Prog Mod Biomed* 2010;10(5):925–8. <https://d.wanfangdata.com.cn/periodical/swcx201005036>. (In Chinese).
- Bai J, Zhou P, Xue D, Da QD, Ji J. Influence factors of the cognition of genetic technology and bioethics among physicians in Shanghai. *Chin Hosp Manage* 2013;33(1):29–32. <https://d.wanfangdata.com.cn/periodical/zgyylj201301012>. (In Chinese).
- Niu YI, Yang YM, Li YJ, Tang Q, Zhang YX, Xu LY, et al. Study on knowledge and attitudes about genetic testing and the influencing factors in Changsha. *Pract Prev Med* 2015;22(1):13–6. <https://d.wanfangdata.com.cn/periodical/syfyx201501005>. (In Chinese).
- Xu Y, Zhang M. Investigation and analysis of public awareness in gene detection for consumers. *J Guangdong Pharm Univ* 2018;34(5):637–42. <https://d.wanfangdata.com.cn/periodical/guangdxyxb201805019>. (In Chinese).
- Cao SY, Wei XF, Du ZH, Xu YP, Chen HH, Xue D. Perception of ethics in precision medicine and its practice in Shanghai and Lanzhou. *Chin Health Resour* 2020;23(5):468–72. <http://www.journalchr.com/CN/abstract/abstract3237.shtml>. (In Chinese).
- Wu JR. Challenges for clinical guidelines in the era of precision medicine. *Med Philos* 2021;42(3):6–9,20. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDLAST2021&filename=YXZX202103003>. (In Chinese).
- Khoury MJ, Bowen MS, Clyne M, Dotson WD, Gwinn ML, Green RF, et al. From public health genomics to precision public health: a 20-year journey. *Genet Med* 2018;20(6):574–82. <http://dx.doi.org/10.1038/gim.2017.211>.
- Rasmussen SA, Khoury MJ, Del Rio C. Precision public health as a key tool in the COVID-19 response. *JAMA* 2020;324(10):933–4. <http://dx.doi.org/10.1001/jama.2020.14992>.
- Khoury MJ, Engelgau M, Chambers DA, Mensah GA. Beyond public health genomics: can big data and predictive analytics deliver precision public health? *Public Health Genom* 2018;21(5-6):244–50. <http://dx.doi.org/10.1159/000501465>.
- Evaluation of Genomic Applications in Practice and Prevention (EGAPP) Working Group. The EGAPP initiative: lessons learned. *Genet Med* 2014;16(3):217–24. <http://dx.doi.org/10.1038/gim.2013.110>.

SUPPLEMENTARY MATERIALS

LIST OF STUDIES

Ethical Considerations (50)

1. He YJ. The ethical predicament and its countermeasures about therapeutic clone-technology. *Chin J Soc Med* 2007;24(3):196 – 8. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=GWSY200703020&DbName=CJFQ2007>. (In Chinese).
2. Wang RH, Liu GC, Ma J. A juristical control on human cloning research. *Northwest Popul J* 2008;29(3):42 – 6. <http://dx.doi.org/10.3969/j.issn.1007-0672.2008.03.007>. (In Chinese).
3. Luo Y, Zhang JZ. Reflection on the legislative environment of human cloning technology in China. *Chin Med Ethics* 2009;22(4):100 – 1. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200904050&DbName=CJFQ2009>. (In Chinese).
4. Wang HC, Wei HM. Crossing the -A prospective exploration on the Civil legal issues of clone. *Legal Syst Soc* 2009(16):96 – 7. <http://dx.doi.org/10.19387/j.cnki.1009-0592.2009.16.053>. (In Chinese).
5. Xie HD, Yuan D, Lin XG. Ethical reflection about scientific and technological progress-Taking cloning technology as the case. *Entrepreneur World* 2009;(10):194 – 5. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=QYJT200910116&DbName=CJFQ2009>. (In Chinese).
6. Liao HG, Luo YG. On the potential influence of reproductive cloning on sex ethics. *Chin Med Ethics* 2009;22(2):41 – 2. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200902018&DbName=CJFQ2009>. (In Chinese).
7. Zhang CM. The analysis on the choices of public policy of human cloning. *J Dialect Nat* 2010;32(6):52 – 60. <http://dx.doi.org/10.15994/j.1000-0763.2010.06.007>. (In Chinese).
8. Song W, Niu W, Cao ZD. The influence of cloning technology on current legal system. *Sci-Technol Law* 2010;87(5):29 – 33. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=KJFL201005007&DbName=CJFQ2010>. (In Chinese).
9. Mao YF. Ethical defense of therapeutic cloning. *J Shenyang Inst Eng (Soc Sci)* 2010;6(4):516 – 8. [http://dx.doi.org/10.13888/j.cnki.jsie\(ss\).2010.04.011](http://dx.doi.org/10.13888/j.cnki.jsie(ss).2010.04.011). (In Chinese).
10. Gao H. Ethical dilemma caused by human cloning. *J Jishou Univ (Soc Sci Ed)* 2011;32(2):36 – 9. <http://dx.doi.org/10.13438/j.cnki.jdxh.2011.02.027>. (In Chinese).
11. Chen SZ, Zhang LS. Ethical dilemma and countermeasures of cloning technology. *Coastal Enterp Sci Technol* 2011;(11):14 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YQKJ201111007&DbName=CJFQ2011>. (In Chinese).
12. Wu H, He JH. An ethical and legal review of reproductive cloning. *J Ningbo Univ (Lib Arts Ed)* 2011;24(6):116 – 9. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=NBDS201106025&DbName=CJFQ2011>. (In Chinese).
13. Tang Z. On the ethics of human cloning. *J Liaoning Med Univ (Soc Sci Ed)* 2011;9(3):14 – 6. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=JZYK201103006&DbName=CJFQ2011>. (In Chinese).
14. Qiao ZD, Wang LY. Bioethical argument by cloning technique. *Chin Bull Life Sci* 2012;24(11):1302 – 7. <http://dx.doi.org/10.13376/j.cbls/2012.11.015>. (In Chinese).
15. Tang BP, Wang X. Rethinking of the essence of human cloning and its ethics. *Theory Reform* 2013(6):29 – 33. <http://dx.doi.org/10.13553/j.cnki.llygg.2013.06.006>. (In Chinese).
16. Liu MY. Ethical thoughts on human cloning. *Jiannan Class* 2013;(9):252. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=JNWJ201309161&DbName=CJFQ2013>. (In Chinese).
17. Ji AM. Considerations on the ethical foundations of human cloning technology. *J Chuzhou Univ* 2014;16(1):6 – 10. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=CZSB201401003&DbName=CJFQ2014>. (In Chinese).
18. Xiao S. Should humans be cloned—Based on the perspective of relationship between technology and ethics. *Theory Res* 2014;(25):88 – 9,108. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=LYBT201425042&DbName=CJFQ2014>. (In Chinese).
19. Bai XF. Ethical analysis of human cloning. *J Foshan Univ (Soc Sci Ed)* 2014;32(1):13 – 6. <http://dx.doi.org/10.13797/j.cnki.jfosu.1008-018x.2014.0003>. (In Chinese).
20. Chen YL. Ethical thinking on human cloning. *Business* 2015;(52):132. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=SHNG201552115&DbName=CJFQ2015>. (In Chinese).
21. Liu JL. The basis and method for regulating clone technology under the perspective of criminal law. *Trib Political Sci Law* 2015;33(4):48 – 59. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=ZFLT201504005&DbName=CJFQ2015>. (In Chinese).
22. Yang P. Impact of cloning technology on bioethics. *Kejifeng* 2018(31):242. <http://dx.doi.org/10.19392/j.cnki.1671-7341.201831206>. (In Chinese).
23. Yu YB. Clone and human. *J Beijing Inst Technol (Soc Sci Ed)* 2000(1):13 – 7. <http://dx.doi.org/10.15918/j.jbitss1009-3370.2000.01.004>. (In Chinese).
24. Guo JZ, Yuan H, Xie XX. Progressing of clone-technology in medical and its subsequent social ethics problems. *Chin Med Ethics* 2002;15(5):55 – 6. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200205032&DbName=CJFQ2002>. (In Chinese).
25. Chen H, Yu X, Hu GR, Feng JQ. New thoughts on the ethics of human cloning. *Chin Med Ethics* 2003;17(4):48. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200304026&DbName=CJFQ2003>. (In Chinese).
26. Jia J. Legal thoughts on human cloning research. *J Shandong Youth Admin Cadres' Coll* 2004(2):133 – 4. <http://dx.doi.org/10.16320/j.cnki.sdqzzyxb.2004.02.054>. (In Chinese).
27. Yang R. Impact of cloning technology on bioethics. *Gansu Theory Res* 2004;(2):43 – 6. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=GLXK200402011&DbName=CJFQ2004>. (In Chinese).
28. Fan R. Ethical reflection on cloning technology. *J Hebei Youth Admin Cadres Coll* 2010;22(1):48 – 50. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=QNGX201001015&DbName=CJFQ2010>. (In Chinese).
29. Wang RJ, Zhou YY, Li JQ, Lv Y, Liu ZW. Rethinking the ethics of human cloning. *Chin Med Ethics* 2008;21(3):77 – 9. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200803031&DbName=CJFQ2008>. (In Chinese).
30. Zhang J. Legislative thought on "Cloning Haman Being". *J Guizhou Univ Ethnic Minorities (Philos Soc Sci)* 2006;(2):107 – 9. <https://kns.cnki.net/>

- kcms/detail/detail.aspx?FileName=GZMZ200602030&DbName=CJFQ2006. (In Chinese).
31. Zhao J. Seeking rationality and surmounting for gene technique. *Acta Univ Med Nanjing (Soc Sci)* 2005;5(4):313 – 5. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YKNS200504012&DbName=CJFQ2005>. (In Chinese).
 32. Li M, Li GY. An analysis of bioethical issues caused by therapeutic cloning. *Med Soc* 2005;18(9):43 – 5. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXSH200509016&DbName=CJFQ2005>. (In Chinese).
 33. Liu HL, Zhu XZ. On the development of cloning technology and advancement of technological ethics. *J Suzhou Univ Sci Technol (Soc Sci)* 2005;22(3):61 – 5. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=SZTD200503014&DbName=CJFQ2005>. (In Chinese).
 34. Lei RP. Ethical reflection on cloning technology. *J Huazhong Univ Sci Technol (Soc Sci Ed)* 2005(3):119 – 24. <http://dx.doi.org/10.19648/j.cnki.jhustss1980.2005.03.023>. (In Chinese).
 35. Qiao XB. Thoughts on cloning technology from ethics angle. *Acta Univ Med Nanjing (Soc Sci)* 2005;5(1):51 – 4. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YKNS200501014&DbName=CJFQ2005>. (In Chinese).
 36. Jin DY. New ethical view on cloning technique. *Acta Univ Med Nanjing (Soc Sci)* 2005;5(1):55 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YKNS200501015&DbName=CJFQ2005>. (In Chinese).
 37. Zhao YH, Chen F. Ethical dilemma and social construction of clone technology. *Sci Technol Results Summarize* 2004;(1):30 – 1. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=KJCH200401011&DbName=CJFQ2004>. (In Chinese).
 38. Zhao LP. Ethical reviewing of “Cloning”. *J Changchun Teach Coll* 2004;23(1):23 – 5. <http://dx.doi.org/10.3969/j.issn.1008-178X.2004.01.007>. (In Chinese).
 39. Luo SH. The human body clones' legal policy and system establishment. *Sci-Technol Law* 2003;(4):70 – 6. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=KJFL200304016&DbName=CJFQ2003>. (In Chinese).
 40. Guo JZ, Zhu YN, Ge HF. Rethinking of social and ethical problems on cloned human. *Chin Med Ethics* 2003;16(4):39 – 41. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200304022&DbName=CJFQ2003>. (In Chinese).
 41. Guo H. On the human cloning experiment and the three principles of ethics. *J Southwest China Norm Univ (Philos Soc Sci Ed)* 2003;29(3):55 – 8. <http://dx.doi.org/10.13718/j.cnki.xdsk.2003.03.011>. (In Chinese).
 42. Xu DK. On the prospect of human cloning based on ethical consideration. *J Tibet Univ* 2002;17(3):35 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XZDX200203010&DbName=CJFQ2002>. (In Chinese).
 43. Xu ZL. On the ethical consideration of the technique of cloning man and human life. *Med Philos* 2002;23(9):31 – 4. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXZX200209008&DbName=CJFQ2002>. (In Chinese).
 44. Wang FM. Legal and ethical thoughts on human cloning. *Journal of Heilongjiang Coll Educ* 2002;21(1):159 – 60. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=HLJB200201083&DbName=CJFQ2002>. (In Chinese).
 45. Cheng CL, Li H, Jin XX, Peng CX. Ethical reflections on the “human Cloning”. *J Wuhan Univ Sci Technol (Soc Sci Ed)* 2001;3(4):85 – 6,120. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=WHKS200104037&DbName=CJFQ2001>. (In Chinese).
 46. Chen MQ. Ethical think on clone's social significance. *Theory Observe* 2001;(1):23 – 6. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=LLGC200101004&DbName=CJFQ2001>. (In Chinese).
 47. Bouma III H. Ethical thoughts on human cloning. Wang Y, trans. *Med Philos* 2000;21(6):56 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXZX200006021&DbName=CJFQ2000>. (In Chinese).
 48. Gan DJ, Long Y. The differentiation of bioethics and solutions to the dilemma of therapeutic cloning. *Med Philos* 2015;36(3A):26 – 8. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXZX201503007&DbName=CJFQ2015>. (In Chinese).
 49. Meng FZ. The impact of human clone technology development on constitutional value and legislative response. *J Political Sci Law* 2017;(6):30 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=ZFLC201706004&DbName=CJFQ2017>. (In Chinese).

Regulatory Framework (9)

50. Yang QF, Jiang N. Ethical and legal issues on the development of biotechnology. *J Chengdu Munic Party Coll CPC* 2009;(1):85 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=CDDX200901024&DbName=CJFQ2009>. (In Chinese).
51. Chen Y, Qian J, Li H. Ethical issues in clinical genetic testing in China. *Med Philos (Humanistic Soc Med Ed)* 2010;31(2):23 – 5. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXZX201002014&DbName=CJFQ2010>. (In Chinese).
52. Liang GD. New consideration about the challenge of modern bio-technology to the traditional life ethics. *J Jixi Univ* 2012;12(5):134,138. <http://dx.doi.org/10.16792/j.cnki.1672-6758.2012.05.059>. (In Chinese).
53. Guan J. Legal and ethical issues involved in the application of molecular genetics examination in the genomic Era. *Chin Med Ethics* 2018;31(3):273 – 7. <http://dx.doi.org/10.12026/j.issn.1001-8565.2017.03.01>. (In Chinese).
54. Tao YS, Wang GY. Construction of precision medicine ethics: conception, principles and paths. *Stud Sci Sci* 2020;38(6):961 – 7. <http://dx.doi.org/10.16192/j.cnki.1003-2053.2020.06.001>. (In Chinese).
55. Tao YS, Wang GY. Precision medicine ethics: a new area of contemporary bioethics research. *J Dialectics Nat* 2019;41(7):93 – 9. <http://dx.doi.org/10.15994/j.1000-0763.2019.07.012>. (In Chinese).
56. Wang Q, Ding XR, Duan JY, Li L, Meng LY, Wang GY. A study of China's policies and regulations on ethical supervision of genetic testing-Based on the perspective of precision medicine. *Stud Sci Sci* 2019;37(4):577 – 81,596. <http://dx.doi.org/10.16192/j.cnki.1003-2053.2019.04.001>. (In Chinese).
57. Yang YF. The basis, practice and direction of legal regulation of genetics research. *J Southwest Pet Univ (Soc Sci Ed)* 2015;17(2):87 – 91. <http://dx.doi.org/10.11885/j.issn.1674-5094.2014.06.13.07>. (In Chinese).
58. Lv BB. Gene, ethics and its law matters. *Sci Technol Law* 2002;(1):58-63. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=KJFL200201008&DbName=CJFQ2002>. (In Chinese).

Perception of Genetic Testing (9)

59. Cao SY, Wei XF, Du ZH, Xu YP, Chen HH, Xue D. Public perceptions of ethical issues in precision medicine and its technology utilization, evidence from Shanghai and Lanzhou. *Chin Health Resour* 2020;23(5):468 – 72. <http://dx.doi.org/10.13688/j.cnki.chr.2020.20001>. (In Chinese).
60. Xue D, Bai J, Wang JP, Fan ZP, Feng XS, Zhou P. Attitudes and choices of clinicians towards ethical dilemmas in genetic testing counseling: based on scenario analysis. *Chin Hosp Manage* 2015;35(4):74 – 7. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YYGL201504040&DbName=CJFQ2015>. (In Chinese).
61. Xu Y, Zhang M. Investigation and analysis of public awareness in gene detection for consumers. *J Guangdong Pharm Univ* 2018;34(5):637 – 42. <http://dx.doi.org/10.16809/j.cnki.2096-3653.2018070303>. (In Chinese).
62. Li JT, Yang L, Tan XH, Yang CBX, Lin JC. Study on intention and impact factors of gene testing in communities residents. *Prog Mod Biomed*

- 2010;10(5):925 – 8. <http://dx.doi.org/10.13241/j.cnki.pmb.2010.05.002>. (In Chinese).
63. Li JT, Yang L, Tan XH, Li JX, Han YM. Survey on health organizations' standpoint of developing gene testing service. *J Community Med* 2010;8(9):4 – 6. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=SQYX201009002&DbName=CJFQ2010>. (In Chinese).
64. Niu YJ, Yang YM, Li YJ, Tang Q, Zhang YX, Xu LY, et al. Study on knowledge and attitudes about genetic testing and the influencing factors in Changsha. *Pract Prev Med* 2015;22(1):13 – 6. <http://dx.doi.org/10.3969/j.issn.1006-3110.2015.01.004>. (In Chinese).
65. Zhu CX, Wang QB, Bo L. A survey on the current situation of knowledge and attitudes towards genetic testing in 204 neurology patients. *J Nurs (China)* 2018;25(19):44 – 7. <http://dx.doi.org/10.16460/j.issn1008-9969.2018.19.044>. (In Chinese).
66. Cui FF, He XY, Shi JM, Zhai YK, Ma QQ, Zhao J. The investigation on knowledge, attitude and practice about precision medicine and associated influencing factors in clinicians. *J Med Postgrad* 2021;34(3):282 – 6. <http://dx.doi.org/10.16571/j.cnki.1008-8199.2021.03.012>. (In Chinese).
67. Bai J, Zhou P, Xue D, Da QD, Ji J. Influence factors of the cognition of genetic technology and bioethics among physicians in Shanghai. *Chin Hosp Manage* 2013;33(1):29 – 32. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YYGL201301010&DbName=CJFQ2013>. (In Chinese).

Future Directions (21)

68. Wang ZJ, Guo JH, Huang T. On the ethical problems caused by the present gene research. *J Hubei Univ (Philos Soc Sci)* 2007;(3):77-81. https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFD2007&filename=HDZS200703018&uniplatform=NZKPT&v=NBCTq2OO3s43nMAD3rH9sThE7bAlZsPaPzzBZMRQnau1O-q7eqYsDZjA2XUZD5_k. (In Chinese).
69. Qiu RZ, Zhai XM. Precision medicine: ethical and regulatory challenges. *Chin Med Ethics* 2017;30(4):401 – 11. <http://dx.doi.org/10.12026/j.issn.1001-8565.2017.04.01>. (In Chinese).
70. Qiu RZ. Ethical issues in the biomedical frontier. *Basic Clin Med* 2006;(5):449 – 55. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=JCYL200605000&DbName=CJFQ2006>. (In Chinese).
71. Shen MX. Five challenges and three theoretical dilemmas: on genetic ethics. *Med Philos (Humanistic Soc Med Ed)* 2008;29(3):10 – 4. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXZX200802005&DbName=CJFQ2008>. (In Chinese).
72. Wang XM, Liu X. Research on the ethical issues in personalized genomic medicine. *Stud Ethics* 2017(2):100 – 4. <http://dx.doi.org/10.15995/j.cnki.lkxyj.2017.02.017>. (In Chinese).
73. Zhao SY. Ethical issues in genetics research. In: *The 4th national academic papers report and gene science summit forum of China prenatal and postnatal association*. Shanghai: Scientific research and Academic Exchange Committee of China eugenics Association. 2008; p. 37 – 40. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YSYY200806001013&DbName=CPFD2008>. (In Chinese).
74. He HH. Ethical motivations and prevention of negative consequences in genetic engineering. *Wuhan Univ J (Philos Soc Sci)* 2020;73(5):44 – 52. <http://dx.doi.org/10.14086/j.cnki.wujss.2020.05.005>. (In Chinese).
75. Xin TZ. Modern genetic technology and genetic ethics. *Cangsang* 2007;(5):137 – 8. https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFD2007&filename=CHSO200705070&uniplatform=NZKPT&v=ipwRGsEGrlXc2h3k39Iy1LcgGZgXlrAqT2RsT_UVz_da7ymW7JnWK-fM9cN0tNqC. (In Chinese).
76. Zhao GM. Reflections on the development of genetics and social ethics. *J Beijing Polytech Univ (Soc Sci Ed)* 2002;2(1):6 – 11. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=BGYS200201001&DbName=CJFQ2002>. (In Chinese).
77. Sun YY. Current state of life ethics and relevant public policy. *Chin Med Ethics* 2005;18(3):18 – 21. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XNLX200503008&DbName=CJFQ2005>. (In Chinese).
78. Revel M. The ethical issues raised by behavioural genetics in humans. Wang DS, trans. *Med Philos* 2004;25(10):15 – 8. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=YXZX200410004&DbName=CJFQ2004>. (In Chinese).
79. Wu JR. The strategic purpose of "precision medicine": building a new taxonomy of disease. *Med Philos* 2018;39(1A):21 – 4,29. <http://dx.doi.org/10.12014/j.issn.1002-0077.2018.01a.05>. (In Chinese).
80. Wu JR. Retrospect and perspective for precision medicine during 5-year period: I. *Med Philos* 2021;42(20):1 – 4,10. <http://dx.doi.org/10.12014/j.issn.1002-0772.2021.20.01>. (In Chinese).
81. Wu JR. Retrospect and perspective for precision medicine during 5-year period: II. *Med Philos* 2021;42(21):19 – 25,30. <http://dx.doi.org/10.12014/j.issn.1002-0772.2021.21.05>. (In Chinese).
82. Wu JR. Properties of precision medicine. *Med Philos* 2016;37(8A):1 – 7,18. <http://dx.doi.org/10.12014/j.issn.1002-0772.2016.08a.01>. (In Chinese).
83. Wu JR. The ethical challenges for precision medicine. *Med Philos* 2020;41(12):1 – 6. <http://dx.doi.org/10.12014/j.issn.1002-0772.2020.12.01>. (In Chinese).
84. Wu JR. Personalized study pattern in the age of precision medicine. *Science* 2019;71(5):29 – 31. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=KXZZ201905007&DbName=CJFQ2019>. (In Chinese).
85. Wu JR. Alert "white elephant": economic concerns of precision medicine. *Sci Culture Rev* 2016;13(4):5 – 10. <https://kns.cnki.net/kcms/detail/detail.aspx?FileName=KXWP201604001&DbName=CJFQ2016>. (In Chinese).
86. Wu JR. Challenges for clinical guidelines in the era of precision medicine. *Med Philos* 2021;42(3):6 – 9,20. <http://dx.doi.org/10.12014/j.issn.1002-0772.2021.03.03>. (In Chinese).
87. Wu JR. An important methodological approach for precision medicine: real world evidence. *Med Philos* 2017;38(5A):1 – 4. <http://dx.doi.org/10.12014/j.issn.1002-0772.2017.05a.01>. (In Chinese).
88. Wu JR. Precision medicine based on systems biology. *Chin Bull Life Sci* 2015;27(5):558 – 63. <http://dx.doi.org/10.13376/j.cbls/2015074>. (In Chinese).