

Public Knowledge about Monogenic Diseases and Attitudes Toward Expanded Carrier Screening in China

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Abstract

Background: Monogenic diseases affect about 10 in 1000 live births globally and account for 20% of infant mortality and 18% of pediatric hospitalizations. Many monogenic disorders could be prevented by offering expanded carrier screening (ECS) to the general population. The purpose of our study was to assess knowledge about monogenic diseases and attitudes toward ECS in China.

Methods: Chinese individuals were invited to complete an online survey from July 11 to September 10, 2020. A total of 1663 questionnaires were collected. Statistical analysis was performed using IBM SPSS Statistics 26. Descriptive statistics were computed for all items. Categorical data were reported as frequencies and percentages with differences assessed by chi-square test.

Results: The respondents' total awareness rate ranged from 3.3% to 55.2%. Medical practitioners had more knowledge than non-medical practitioners. Knowledge about monogenic diseases was positively correlated with educational level. Most respondents showed a positive attitude toward ECS: 54.4% of respondents thought ECS was necessary, and 80.5% wanted to know more about monogenic diseases.

Conclusions: Although the public had little knowledge about monogenic disease and ECS, most of them showed a positive attitude. Lack of knowledge is a barrier to application of ECS. Since pre-test counseling by a genetic counselor before ECS may not always be feasible, pre-test information may not be delivered by a trained genetic counselor. If clinicians are going to be the primary counselors, further education is necessary to improve their comfort and competence with this role.

Background

Although rare, monogenic disorders affect about 10 in 1000 live births globally(1) and account for 20% of infant mortality and 18% of pediatric hospitalizations(2).

Many monogenic disorders could be prevented by offering expanded carrier screening (ECS) to the general population(2). New advanced and decreasing costs of genetic analysis technologies such as next-generation sequencing (NGS) are enabling carrier screening research across a broader range of disorders(3–5).

In one of the earliest studies, Bell et al.(4) utilized NGS to screen for pathogenic mutations in 437 genes associated with severe genetic disorders. The authors reported that each patient's genome contained 2.8 recessive mutations on average(4). Another study showed that approximately one to two in every 100 couples are at risk of having a child with an autosomal or X-linked recessive genetic condition in the general population(6).

Increasing awareness of multiethnic backgrounds in the population, technological advances, and lower cost of multigene panel testing, have resulted in rapid development and clinical implementation of ECS(7).

The European Society of Human Genetics developed and published recommendations for the responsible implementation of ECS(3). In 2017, the American College of Obstetricians and Gynecologists (ACOG) reviewed ECS's role and suggested that ethnic-specific, pan-ethnic ECS are acceptable strategies for pre-pregnancy and prenatal carrier screening(8). Despite these recommendations, ECS is not a common practice in most countries(9–11). Public perception of genetic carrier screening is diversified(12–17).

In order to develop screening technology to meet the public's psychosocial and educational needs, healthcare providers need to understand public attitudes toward testing. The purpose of our study was to assess knowledge about monogenic diseases and attitudes toward ECS before commencing the practice.

Methods

Couples visiting the hospital for antenatal care were invited to complete an online survey by scanning a QR code from July 11 to September 10, 2020. A total of 1663 questionnaires were collected.

Prior to data collection, online informed consent was obtained from all participants. Their confidentiality was protected by each participant being assigned a unique identification (ID) number that was used on all data collection and statistical analyses. The Institutional Ethics Committee approved this survey.

Questionnaires were designed to assess the awareness of monogenic diseases and acceptance of ECS. They also compared the relevant knowledge of medical and non-medical practitioners.

Statistical analysis was performed using IBM SPSS Statistics 26. Descriptive statistics were computed for all items. Categorical data were reported as frequencies and percentages. The differences were assessed using the chi-square test, with $P < 0.01$ considered significant.

Results

Demographic data

Table 1 summarizes the demographics of the respondents. In the whole cohort, 89.6% ($n = 1490$) was female and 10.4% ($n = 173$) was male. Marital status reported by the respondents was as follows: 90 (5.4%) single, 1550 (93.2%) married, 22 (1.3%) divorced, and 1 (0.1%) widowed. Age was divided into four groups: ≤ 25 , 26–34, 35–44, and ≥ 45 years. The level of education reported by respondents included 14 (0.8%) no education or primary education, 193 (11.6%) lower secondary education, 135 (8.1%) technical secondary education, 120 (7.2%) upper secondary education, 389 (23.4%) college education, 646 (38.8%) undergraduate education, and 166 (10.0%) graduate education. In the respondents, 672 (40.4%) did not have children, and the remaining 991 (59.6%) had one or more living children. In the respondents, 149 (9.0%) had a family history of a genetic condition, and the remaining 1514 (91.0%) did not. In the individuals surveyed, 971 (58.4%) were currently pregnant (partner or self), 105 (6.3%) were considering a future pregnancy, and 587 (35.3%) did not plan to be pregnant. In the respondents, 292 (17.6%) were medical practitioners and 1371 (82.4%) were not.

Table 1
Demographic characteristics of the study population

Characteristic	No (%)
Gender	
Female	1490 (89.6)
Male	173 (10.4)
Marital status	
Single	90 (5.4)
Married	1550 (93.2)
Divorced	22 (1.3)
Widowed	1 (0.1)
Age (years)	
≤25	141 (8.5)
26–34	926 (55.7)
35–44	483 (29.0)
≥45	113 (6.8)
Educational level	
No education or primary education	14 (0.8)
Lower secondary education	193 (11.6)
Technical secondary education	135 (8.1)
Upper secondary education	120 (7.2)
College education	389 (23.4)
Undergraduate education	646 (38.8)
Graduate education	166 (10.0)
Number of children	
None	672 (40.4)
One or more	991 (59.6)
Family history of a genetic condition	
Yes	149 (9.0)
No	1514 (91.0)

Characteristic	No (%)
Considering a future pregnancy	
Currently pregnant (partner or self)	971 (58.4)
Yes	105 (6.3)
No	587 (35.3)
Medical practitioners or not	
Yes	292 (17.6)
No	1371 (82.4)
Total	1663 (100)

Knowledge about monogenic diseases and ECS

The total awareness rates of the respondents were low, with 35.7%, 26.1%, 3.3%, 23.3%, 24.1%, 55.2%, and 23.4% for questions Q1–Q7, respectively (Table 2).

Table 2
Cross analysis of awareness between medical and non-medical practitioners

Questions	Non-medical practitioners	medical practitioners	Total	P value
Q1. Have you ever heard of monogenic diseases?				
No	1018(74.3)	52(17.8)	1070(64.3)	< 0.01
Yes	353(25.7)	240(82.2)	593(35.7)	
Q2. Diabetes and hypertension have a familial tendency, whether they belong to monogenic diseases?				
Yes/Not sure	1097(80.0)	132(45.2)	1229(73.9)	< 0.01
No	274(20.0)	160(54.8)	434(26.1)	
Q3. What is the combined incidence of monogenic diseases?				
Wrong (1/10 or 1/1000) or Not sure	1331(97.1)	277(94.9)	1608(96.7)	> 0.05
1/100	40(2.9)	15(5.1)	55(3.3)	
Q4. Can you distinguish dominant monogenic diseases from recessive monogenic diseases?				
No	1130(82.4)	145(49.7)	1275(76.7)	< 0.01
Yes	241(17.6)	147(50.3)	388(23.3)	
Q5. What's the probability of having an affected child in each pregnancy when couples are both carriers for the same AR disorder?				
Wrong (50% or 100%) or Not sure	1122(81.8)	140(47.9)	1262(75.9)	< 0.01
25%	249(18.2)	152(52.1)	401(24.1)	
Q6. Whether measures can be taken to avoid having an affected child in each pregnancy when couples are both carriers for the same AR disorder?				
No/Not sure	686(50.0)	59(20.2)	745(44.8)	< 0.01
Yes	685(50.0)	233(79.8)	918(55.2)	
Q7. Have you heard of expanded carrier screening?				
No	1118(81.5)	156(53.4)	1274(76.6)	< 0.01
Yes	253(18.5)	136(46.6)	389(23.4)	

Cross-analysis of medical and non-medical practitioners

Table 2 shows the differences between medical and non-medical practitioners for seven items (Q1–Q7). The awareness rate of every item was higher for medical compared to non-medical practitioners. Six questions had significant differences ($P < 0.01$) but Q3 did not ($P > 0.05$).

Comparison of awareness rates for different educational backgrounds

The degree of awareness increased with the increase in educational level, especially in those with a college degree or beyond (Fig. 1). There were significant differences among respondents with different educational backgrounds ($P < 0.01$).

Attitudes toward ECS

Although overall the respondents had little knowledge about monogenic diseases and ECS, most had a positive attitude. Of respondents, 54.4% suggested that ECS was necessary, and 80.5% wanted more information about monogenic diseases (Table 3). Additionally, 51.7% of respondents thought that more pre-test counseling was needed, and 44.8% thought they would follow the provider's advice. Concerning the form of information access, 46.5% selected communicating directly with doctors, 17.9% preferred webinars, 17.3% favored brochures in outpatient waiting areas, 11.4% chose discussing with a nurse, and 6.8% opted for self-web search.

Table 3
Attitudes toward ECS

Questions	No (%)
Whether it is necessary to screen people with monogenic diseases to prevent the birth of children with monogenetic genetic diseases?	
Necessary	905(54.4)
Unnecessary	12(0.7)
Follow the provider's advice	577(34.7)
Not sure	169(10.2)
Would you like to know more about monogenic diseases?	
Yes	1339(80.5)
No	324(19.5)
Do you need more counseling before selecting for expanded carrier screening?	
Yes	860(51.7)
No	58(3.5)
Follow the provider's advice	745(44.8)
In what form do you wish to obtain more information about monogenic diseases and ECS?	
Communicate directly with doctors	774(46.5)
Brochures in outpatient waiting area	288(17.3)
Webinar	298(17.9)
Self-web search	113(6.8)
Discuss with a nurse	190(11.4)

Comparison of attitudes toward ECS for different educational backgrounds

For people with technical secondary education or beyond, the percentage who thought ECS was necessary increased with educational level (Fig. 2). In contrast, the proportion of people who would choose to follow the provider's advice decreased with the rise of educational level. For people with technical secondary education or beyond, as the education level increased, more people chose to consult before ECS, and fewer people chose to follow the provider's advice (Fig. 3).

The number of diseases, strategy, period, and cost of screening when considering ECS

The questionnaire also asked respondents about the number of diseases to be screened: 58.1% suggested the more, the better; 34.1% preferred the most common ones; and 5.6% thought the less, the better. The remaining 2.2% made no comments. When asked about screening strategy, 83.0% preferred simultaneous screening of couples, while 17% preferred step-by-step screening (one partner is screened first, and then the other if the partner is a carrier). Most respondents chose premarital (43.1%) and preconception (33.1%) counseling. For an acceptable price, 71% chose less than 1,000 yuan (100 Euro). All of the above are listed in Table 4.

Table 4

The number of diseases, strategy, period, and cost of screening when considering ECS

Questions	No (%)
If you are screening for carriers of a single gene, what is the number of diseases you want to screen for?	
The more the better	967(58.1)
Screen only the most common ones	567(34.1)
The less the better	93(5.6)
None	36(2.2)
Which screening strategy do you prefer?	
Simultaneous screening of couples	1380(83.0)
One partner is screened first, and then the other if the partner is a carrier	283(17.0)
When do you think it is the best time to screen for monogenetic diseases?	
Neonatal or childhood	234(14.1)
Student hood	83(5.0)
Premarital	717(43.1)
Preconception	551(33.1)
After pregnancy	78(4.7)
Acceptable price range for screening single gene carriers (CNY)	
<1000	1180(71.0)
1000–1500	274(16.5)
1500–2000	117(7.0)
2000–2500	92(5.5)
Why do you refuse to be screened for a single genetic disease carrier?	
The more you know, the more you may worry	585(35.2)
Economic reasons	554(33.3)
Not interested	108(6.5)
Other	416(25.0)

Reasons for rejecting ECS

Among the respondents, 35.2% rejected ECS because the more they knew, the more they were likely to worry, 33.3% rejected ECS for economic reasons, 6.5% for lack of interest, and 25% for other reasons (Table 4).

Discussion

Main findings

Lack of knowledge is a barrier to the use of ECS. This study showed that only a small number of people in the study population knew about monogenic diseases and ECS (Table 2). Most of them wanted to get information through direct communication with doctors (Table 3). However, if a patient has little knowledge about ECS, their doctor needs to provide them with information. Benn et al. reported that only one-third of providers were comfortable with pre-test counseling, and less than 25% were satisfied with reviewing results. The main concerns included the time needed for counseling and coordinating follow-up studies and comfort with counseling after a positive result(18). A recent study reported that the lack of comfort with ECS counseling and varying beliefs surrounding ECS continue to hinder its utilization(19).

Our cross-analysis showed that medical practitioners had a significantly higher degree of awareness compared to non-medical practitioners. However, medical practitioners had deficient awareness of the combined incidence of monogenic disease, with only 5.1% of them correctly answering the relevant question (Q3, Table 2), compared with 2.9% of non-medical practitioners ($P > 0.05$). Since specified pre-test counseling by a genetic counselor before each ECS may not always be feasible, pre-test information may be delivered through a provider without genetics training. In many cases, providers do not offer patients carrier screening due to a lack of confidence and knowledge concerning genetics(20). As genetic technologies evolve and are more incorporated into clinical practice, clinicians' knowledge is essential.

Although the overall respondents had little knowledge about monogenic disease and ECS, most showed a positive attitude (Table 3). This is consistent with the findings of several studies(13, 15–17, 21).

The main limitation of pre-test counseling for ECS is that it is impractical to thoroughly discuss all the diseases and conditions included in the panel. This is in contrast to pre-test counseling for classical carrier screening programs, which includes information regarding the natural history, detection rates, and prior and posterior carrier probabilities of a limited number of diseases. Thus, the use of ECS necessitates modification of this model(22).

There was one very interesting finding. Although highly educated people had more knowledge of ECS than less-educated people, when asked if they would like to know more background or get more consultation, they seemed more eager to learn. In our data, highly educated people were more likely to choose "necessary" (they wanted more information before making a decision); however, less-educated people were more likely to choose "follow the provider's advice" (indicating passive acceptance).

The provider's personal opinion is critical to the people who tended to follow the provider's advice. Especially for complex consultations such as ECS, it is time-consuming to achieve fully informed consent. Even highly educated people may not be able to fully understand ECS through consultation. The final choice may be related to the provider's preference.

Some findings in our study were consistent with the recommendations of ACOG, suggesting that carrier screening and counseling should ideally be performed before pregnancy(23); in our study, most respondents chose premarital (43.1%) and preconception (33.1%). ACOG also suggested concurrent screening for the patient and her partner if there are time limitations for decisions about prenatal diagnostic evaluation(23). In our survey, 83.0% preferred the simultaneous screening of couples.

Strengths and limitations

The strengths of our study include that all surveys were anonymous, increasing the likelihood of truthful responses. Furthermore, the survey was distributed nationally, giving a wide geographic distribution of thoughts and beliefs. One limitation is that all the questions were pre-set in the answers' scope, thus limiting the respondents' answers and may omit some detailed and in-depth information. For example, among the reasons for rejecting ECS, due to the limited options we provided, 25% of the respondents chose "other reasons". Given that the survey was electronically distributed, the responses could not be clarified.

Conclusion

Our study showed that, although the public had little knowledge about monogenic diseases and ECS, most showed a positive attitude toward it. Lack of knowledge is a barrier to the application of ECS. Since pre-test counseling by a genetic counselor before ECS may not always be feasible, an experienced genetic counselor may not deliver the pre-test information. If clinicians are going to be the primary counselors, further education is required to improve their comfort and competence with this role.

Abbreviations

ECS: expanded carrier screening; NGS: next-generation sequencing; ACOG: The American College of Obstetricians and Gynecologists

Declarations

Ethics approval and consent to participate

This survey was approved by the Ethics committee of the Third Affiliated Hospital of Guangzhou Medical University and Zhejiang Xiaoshan Hospital. Prior to the data collection, online informed consent was acquired from all participants.

Consent for publication

Not applicable.

Availability of data and materials

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Jing Yang and Min Chen participated in proposal writing, designed the study, acquired the data, coordinated and supervised data collection, performed the statistical analysis, drafted and finalized the manuscript. Heli Wu, Wei Shen, Jianmei Han, Yuxia Fu participated in data collection and the statistical analysis. Jimei Sun and Wenyan Wu participated in proposal writing, data collection. All authors have read and approved the manuscript.

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Not applicable.

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Figures

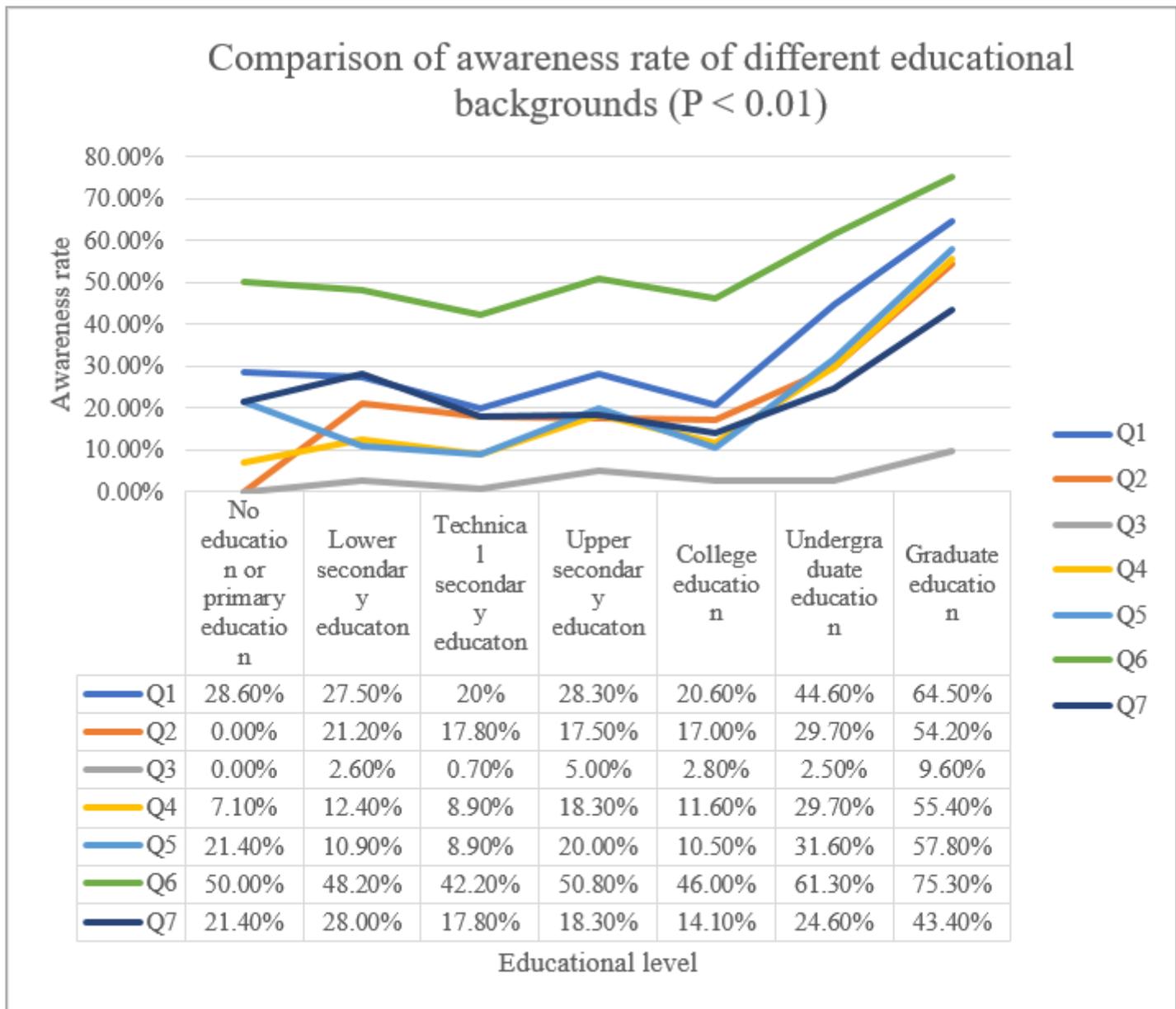
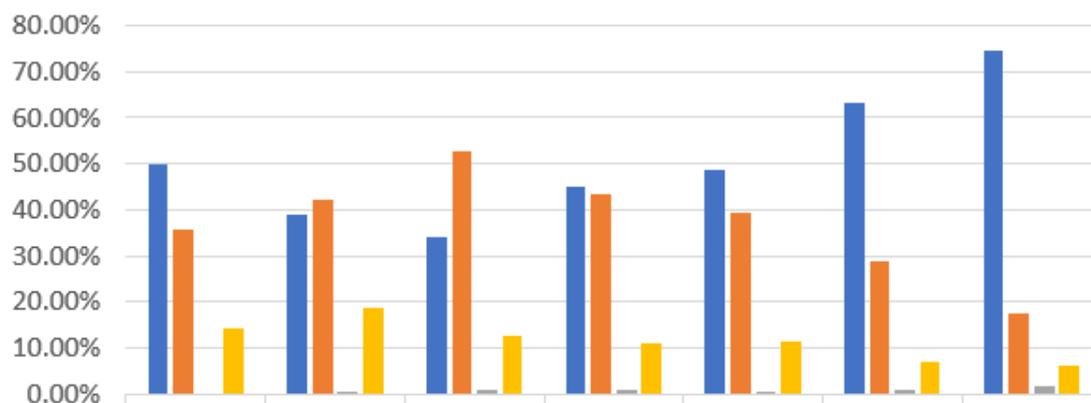


Figure 1

Comparison of awareness rate of different educational backgrounds

Whether it is necessary to screen people with monogenetic diseases to prevent the birth of children with monogenetic genetic diseases?



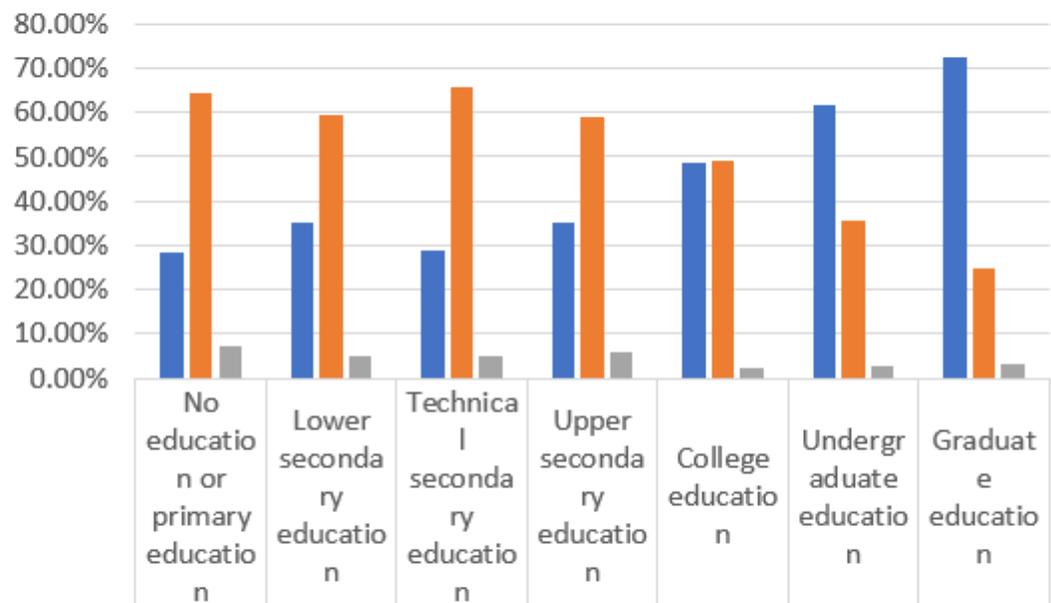
	No education or primary education	Lower secondary education	Technical secondary education	Upper secondary education	College education	Undergraduate education	Graduate education
■ Necessary	50.00%	38.90%	34.10%	45.00%	48.80%	63.30%	74.70%
■ Follow the provider's advice	35.70%	42.00%	52.60%	43.30%	39.30%	28.80%	17.50%
■ Unnecessary	0.00%	0.50%	0.70%	0.80%	0.30%	0.80%	1.80%
■ Not sure	14.30%	18.70%	12.60%	10.80%	11.60%	7.10%	6.00%

■ Necessary ■ Follow the provider's advice ■ Unnecessary ■ Not sure

Figure 2

Comparison of the attitudes of different educational backgrounds toward ECS

Do you need more counseling before selecting for expanded carrier screening?



■ Yes	28.60%	35.20%	28.90%	35.00%	48.60%	61.60%	72.30%
■ Follow the provider's advice	64.30%	59.60%	65.90%	59.20%	49.10%	35.40%	24.70%
■ No	7.10%	5.20%	5.20%	5.80%	2.30%	2.90%	3.00%

■ Yes ■ Follow the provider's advice ■ No

Figure 3

Comparison of the attitudes of different educational backgrounds toward counseling

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Questionnaire07112020YJ.docx](#)