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Collaborative relationships in translational medical research among Chinese clinicians: an internet-based cross-sectional survey

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Abstract

Background: This study aimed to explore the collaborative relationship in translational medical research from the perspective of clinicians in China. The findings are expected to help practitioners optimize and experience the greatest advantages of collaboration.

Methods: We conducted a national internet-based survey from July 29 to October 12, 2020. Of the 806 responses, 804 were completed with valid responses (valid response rate = 99.8%). The collected data were presented as descriptive statistics and analyzed using nonparametric tests (including the Wilcoxon rank test and Kruskal–Wallis H test) and stepwise logistic regression.

Results: Of the 804 participants, 733 were either willing or very willing to collaborate in translational medical research. Clinicians' willingness was influenced by their current research type, role in current translational medical research, burdens of their present research, preferred partners for collaboration at the institutional or individual level, and preferences for independent or dependent relationships.

Conclusions: Clinicians should evaluate their time, role, burdens, personal preferences for research relationships, and appropriate partners based on their current translational medical research and its goals, before deciding to collaborate.

Keywords: Translational medicine, Translational medical research, Translational research, Collaboration, Clinician, China

Background

Translational medical research (TMR), which aims to bridge laboratory and clinical research [1], has experienced rapid development in the past 20 years [2]. In TMR, collaboration has become mainstream and is now

a fundamental requirement. TMR consists of a continuous process that begins with clinical discovery and medical research and leads to clinical application in patients [3]; it accommodates multiple disciplines and scientists in various fields. However, owing to the professional gap between laboratory scientists and clinicians and the differences among hospitals, universities, research centers, and industries [4–6], practitioners need to collaborate at an individual or institutional level to realize the goals of TMR.

Researchers have considered in depth the advantages and disadvantages of collaboration in TMR.

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Collaboration, especially in a multidisciplinary team, is widely recognized to be of great significance and necessity in TMR [7]. Although “translation” has different meanings for different stakeholders, the overall aim is to benefit humankind by promoting the application of clinical findings and laboratory achievements. Therefore, collaboration among clinicians, laboratory scientists, industrial scientists, biotechnologists, and politicians in different institutions can bring these stakeholders together, help them understand one another professionally, and motivate TMR [8, 9]. Among all the merits of collaboration in TMR, the most prominent is knowledge exchange, which can help elucidate scientific questions, promote laboratory research, and accelerate clinical application [3, 10–14]. A bibliometric research further confirmed the role of collaboration in TMR, especially in terms of knowledge exchange [15]. Therefore, based on such knowledge exchange and mutual understanding, collaboration between researchers and clinicians is crucial for the translation and application of laboratory biomedical discoveries to patients and to clinical practice [16–19]. Additionally, collaboration between researchers and industrial scientists can promote the development of medicine [20].

Collaboration in TMR also has its disadvantages and risks. For instance, collaboration in TMR among various partners could lead to greater time expenditure or delay of research plans, owing to diverse academic perspectives or scholarly disagreements [3, 21]. Collaboration also tends to cost more, including the time spent in negotiation and exchange, as well as the costs of communication and travel, contradictions in research design and results, and conflicts arising from result sharing [3, 14]. Some stakeholders also refuse to collaborate in TMR because of the risks of losing decision-making autonomy and frustration with partners [3].

Considering the characteristics of collaboration in TMR, different practices have been observed, including collaborations at the institutional and at individual levels [7]. In China, current collaborations in TMR mainly focus on the institutional level, such as the Sino–Cuban Joint Working Group on Biotechnology Cooperation [22], and the collaboration between Peking University Health Science Center and the University of Michigan Medical School [23]. However, from the perspective of individuals, their attitudes, viewpoints, willingness, and practice behaviors are important for collaboration in TMR; this is especially true for clinicians, who are situated at the juncture of laboratory and clinical research. This study therefore explored collaborative relationships in TMR from the perspective of clinicians to determine their willingness to collaborate, recognize preferred partners, and determine the factors influencing collaboration.

The results of this study provide key evidence for optimizing collaboration and realizing the greatest advantages of collaboration in TMR.

Methods

Study design

We designed an internet-based survey to explore the collaborative relationships in TMR among clinicians in China. The required sample size was determined to be at least 129, which was calculated with a confidence level of 95%, an admissible error of 0.1, and the probability of approval of TMR among clinicians of 74.9% [2]. A preliminary investigation involving 85 clinicians was conducted before the formal survey. Based on the preliminary participants’ responses, several items were revised to improve the reliability and validity of this questionnaire. The internal consistency of the formal questionnaire was examined using a Cronbach’s α coefficient, which was calculated as 0.930, indicating good reliability. Factorability was tested using the Kaiser–Meyer–Olkin test and Bartlett’s test of sphericity, which yielded values of 0.724 and 5103.91 ($p < 0.0001$), respectively, suggesting good validity.

The formal questionnaire included 24 items that were compiled through a review of references and consultations with experts. Information on demographic characteristics, current status of personal TMR, collaborative willingness in TMR, and perceptions of collaboration in TMR was collected. Items that collected participants’ perceptions were rated using a five-point Likert scale.

Regarding demographic characteristics, we analyzed the clinicians’ sex, age, educational level, professional title, and department. Regarding the current status of personal TMR, we asked about the clinicians’ research type (e.g., clinical, laboratory, or public health management), role in TMR (e.g., principal investigator [PI] or participant), research pressure (low or high), and communication methods used in collaborations (e.g., face-to-face, telephone, or WeChat). The scale of collaborative willingness in TMR contained five items, including willingness to collaborate and preferred collaboration partners at an institutional or individual level. Perceptions of collaboration in TMR were addressed via 11 items that focused on collaborative relationships, positive and negative aspects of collaboration, and factors that influence collaboration. The measure of collaborative relationships explored the preferences for independent or interdependent relationships [24].

Referring to the positive aspects of collaboration, items addressed understanding of collaboration advantages, extra resources made available through collaboration, and improved personal capabilities. The advantages of collaboration included additional funds or resources,

knowledge transfer, enhancement of reputation, increase in number of publications, improvement in publication quality, enrichment of academic influence, additional clinical resources, more equipment resources, new technologies, promotion of treatment capability, and acceleration of the research process [3, 9, 25]. Extra resources made available through collaboration referred to funds, patients, technologies, equipment, talents, and information. Personal capabilities could be improved in terms of communication, receiving new knowledge and technology, and control over research programs.

When considering the negative aspects, we focused on the disadvantages such as the costs, risks, and challenges of collaboration. Disadvantages included more time spent on communication, personal resource transfer to partners, loss of research autonomy and control, deviation from one's main research, and conflicts regarding key research points [3, 26]. Collaboration costs included the costs of selecting partners and collecting information, negotiation, implementation, and supervision [9]. The risks of collaboration were identified as the risks associated with coordinating all partners, an imbalance of duties and responsibilities among partners, and dropping out or breaking of promises by partners [27]. The challenges faced during collaboration referred to competition from other research organizations, the ethics review process, insufficient research funds, and the recruitment of project managers [28].

Factors that influence collaboration included those related to the implementation and the success of the collaboration. The former involved factors such as geographical locations, funds, technologies, information, academic status, mutual relationships, and partners' cooperation patterns [29]. The latter included explicit collaboration aims, specific collaboration periods, appropriate partners, clear collaboration rules, clear-cut benefit distribution rules, explicit risk-taking rules, maintaining cooperative network relationships, establishing coordination and supervision mechanisms, specific penalty rules for violations of the collaboration agreement, and definite rules for dealing with disputes or emergencies [30, 31].

Data collection

The formal internet-based investigation was conducted from July 29 to October 12, 2020. Of the 806 questionnaires distributed at random to clinicians nationally, 804 were returned with valid responses (valid response rate = 99.8%). The inclusion criteria were (1) clinicians should have TMR experience, (2) all clinicians should voluntarily participate, (3) participating clinicians should complete the survey online and provide informed consent. Those who were not clinicians, did not have TMR experience, or could not complete the online survey

were excluded from this investigation. Only completed questionnaires could be submitted to the online survey system.

Statistical analyses

Our statistical analyses were performed using SAS 8.2 (SAS Institute Inc., Cary, NC, USA) and PASW Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, IL, USA). The descriptive statistics, univariate analysis, and multivariate analysis were implemented step by step. First, we employed frequency and percentage to obtain detailed descriptions in the descriptive statistics. Second, the univariate analysis was conducted to confirm the influence of one factor on collaborative willingness in TMR. If $p < 0.05$, the influence was statistically significant. Third, by including all factors with statistical significance in the univariate analysis, we used a stepwise logistic regression model to determine the influence of multiple factors on collaborative willingness in TMR. In particular, descriptive statistics were used to describe the basic characteristics of the participants. Nonparametric tests, including the Wilcoxon rank test and Kruskal–Wallis H test, were used to test participants' willingness to collaborate in TMR. A stepwise logistic regression analysis was used to analyze the factors influencing the willingness to collaborate in TMR, with inclusion and exclusion criteria of 0.10 and 0.15, respectively. All tests were two-tailed, with $p < 0.05$ considered to be statistically significant.

Based on the results of the univariate analyses, only factors with a statistically significant influence on collaborative willingness in TMR among clinicians were included in the logistic regression analysis.

Results

Basic characteristics of participating clinicians

Of the 804 participants, 57.5% were men and nearly half were 31–40 years old. Most had a master's degree and an intermediate professional title and worked in non-surgical departments. More than a third (38.1%) of participants were engaged in clinical studies at the time of the survey and most acted as a project participant (not PI). Almost half of participants reported a relatively heavy research burden (based on the five-point Likert scale). The most popular communication method was WeChat (an instant messaging application), with 63.8% reporting using it "often" or "always."

More participants preferred collaborating with individuals rather than with institutions, and the most popular institution type was research institutes. However, their preferences for individuals and institutions varied across different stages of the research. In the research application stage, the most preferred institutions and individuals were research institutes and laboratory scientists,

Table 1 Basic characteristics of participating clinicians

| Characteristic | N (%) |
|---------------------------------------------------------------------------|------------|
| Sex | |
| Male | 462 (57.5) |
| Female | 342 (42.5) |
| Age (year) | |
| 20–30 | 220 (27.4) |
| 31–40 | 399 (49.6) |
| 41–50 | 154 (19.2) |
| 51–60 | 30 (3.7) |
| > 60 | 1 (0.1) |
| Educational level | |
| Junior college degree | 19 (2.4) |
| Bachelor's degree | 232 (28.9) |
| Master's degree | 281 (35.0) |
| Doctor's degree | 272 (33.8) |
| Professional title | |
| Junior | 249 (31.0) |
| Intermediate | 342 (42.5) |
| Associate senior | 157 (19.5) |
| Senior | 56 (7.0) |
| Department | |
| Surgical department | 259 (32.2) |
| Non-surgical department | 310 (38.6) |
| Medical technology department | 149 (18.5) |
| Management department | 86 (10.7) |
| Current research type | |
| Clinical research | 306 (38.1) |
| Laboratory research | 51 (6.3) |
| Clinical and laboratory research | 217 (27.0) |
| Public health management research | 41 (5.1) |
| Do not conduct research | 189 (23.5) |
| Role in current research | |
| National PI | 86 (10.7) |
| Provincial PI | 58 (7.2) |
| City-level PI | 60 (7.5) |
| Department-level PI | 49 (6.1) |
| Project participants | 304 (37.8) |
| No project support | 247 (30.7) |
| Current research pressure | |
| Very low | 31 (3.9) |
| Low | 38 (4.7) |
| Moderate | 206 (25.6) |
| High | 376 (46.8) |
| Very high | 153 (19.0) |
| Preferred collaboration partners at the institutional or individual level | |
| Institutions | 380 (47.3) |
| Individuals | 413 (51.4) |
| Uncertain | 11 (1.4) |
| Preferred partners of collaboration in the research application stage | |
| University | 585 (72.8) |

Table 1 (continued)

| Characteristic | N (%) |
|---------------------------------------------------------------------------------|------------|
| Hospital | 386 (48.0) |
| Research institute | 586 (72.9) |
| Industry | 225 (28.0) |
| Community | 106 (13.2) |
| Preferred partners of collaboration in the research implementation stage | |
| University | 430 (53.5) |
| Hospital | 488 (60.7) |
| Research institute | 573 (71.3) |
| Industry | 344 (42.8) |
| Community | 174 (21.6) |
| Preferred partners of collaboration in the research achievement promotion stage | |
| University | 324 (40.3) |
| Hospital | 453 (56.3) |
| Research institute | 388 (48.3) |
| Industry | 555 (69.0) |
| Community | 354 (44.0) |
| Preferred partners of collaboration in the research application stage | |
| Laboratory scientist | 632 (78.6) |
| Clinical scientist | 579 (72.0) |
| Industrial staff | 225 (28.0) |
| Community staff | 159 (19.8) |
| Health management scientist | 213 (26.5) |
| Preferred partners of collaboration in the research implementation stage | |
| Laboratory scientist | 516 (64.2) |
| Clinical scientist | 620 (77.1) |
| Industrial staff | 357 (44.4) |
| Community staff | 260 (32.3) |
| Health management scientist | 258 (32.1) |
| Preferred partners of collaboration in the research achievement promotion stage | |
| Laboratory scientist | 334 (41.5) |
| Clinical scientist | 470 (58.5) |
| Industrial staff | 542 (67.4) |
| Community staff | 434 (54.0) |
| Health management scientist | 431 (53.6) |
| Preferred research relationship | |
| Independent | 406 (50.5) |
| Interdependent | 398 (49.5) |

respectively. In the research implementation stage, preferences were for collaboration with research institutes and clinical scientists. In the research achievement promotion stage, preferences were for industrial partners and industrial staff. The number of clinicians who favored independent relationships was nearly equal to those who favor interdependent relationships.

Among the advantages of collaboration, improvement in reputation was the most recognized (93.8% agreed or strongly agreed), followed by improved publication

quality (93.5%), promotion of knowledge transfer (92.8%), and increased number of publications (92.8%). Information resources were the most recognized extra resources made available by collaboration. The personal capability to receive new knowledge and technology was considered the most positive influence of collaboration.

Of all the disadvantages of collaboration, the transfer of personal resources was considered to be the worst, with 60.1% of the participants agreeing or strongly agreeing. Most participants recognized that the cost, risk, and

Table 2 Basic characteristics of participating clinicians

| Characteristic | N (%) | | | | |
|-------------------------------------------------------------|--------------------------|-----------------|------------------|--------------|-----------------------|
| Communication methods used in collaboration | Almost no | Seldom | Sometimes | Often | Always |
| Face-to-face | 65 (8.1) | 114 (14.2) | 299 (37.2) | 266 (33.1) | 60 (7.5) |
| Telephone | 59 (7.3) | 85 (10.6) | 239 (29.7) | 345 (42.9) | 76 (9.5) |
| WeChat | 57 (7.1) | 52 (6.5) | 182 (22.6) | 406 (50.5) | 107 (13.3) |
| Email | 83 (10.3) | 115 (14.3) | 244 (30.3) | 289 (35.9) | 73 (9.1) |
| Research record, research abstract, memorandum | 93 (11.6) | 108 (13.4) | 246 (30.6) | 280 (34.8) | 77 (9.6) |
| Videoconference | 113 (14.1) | 128 (15.9) | 259 (32.2) | 248 (30.8) | 56 (7.0) |
| Face-to-face group meeting | 82 (10.2) | 116 (14.4) | 292 (36.3) | 258 (32.1) | 56 (7.0) |
| Mobile short message | 118 (14.7) | 118 (14.7) | 248 (30.8) | 267 (33.2) | 53 (6.6) |
| Preferred partners of collaboration | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| University | 2 (0.2) | 4 (0.5) | 47 (5.8) | 465 (57.8) | 286 (35.6) |
| Hospital | 2 (0.2) | 10 (1.2) | 80 (10.0) | 479 (59.6) | 233 (29.0) |
| Research institute | 1 (0.1) | 1 (0.1) | 36 (4.5) | 479 (59.6) | 287 (35.7) |
| Industry | 2 (0.2) | 32 (4.0) | 202 (25.1) | 390 (48.5) | 178 (22.1) |
| Community | 8 (1.0) | 50 (6.2) | 225 (28.0) | 374 (46.5) | 147 (18.3) |
| Advantages of collaboration | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| Additional funds or resources | 7 (0.9) | 9 (1.1) | 102 (12.7) | 453 (56.3) | 233 (29.0) |
| Promoted knowledge transfer | 7 (0.9) | 5 (0.6) | 46 (5.7) | 482 (60.0) | 264 (32.8) |
| Enhanced institution reputation | 6 (0.7) | 6 (0.7) | 80 (10.0) | 471 (58.6) | 241 (30.0) |
| Increased number of publications | 5 (0.6) | 3 (0.4) | 50 (6.2) | 474 (59.0) | 272 (33.8) |
| Improved publication quality | 4 (0.5) | 2 (0.2) | 46 (5.7) | 464 (57.7) | 288 (35.8) |
| Enriched academic influence | 4 (0.5) | 3 (0.4) | 43 (5.3) | 475 (59.1) | 279 (34.7) |
| Additional clinical resources | 6 (0.7) | 8 (1.0) | 53 (6.6) | 463 (57.6) | 274 (34.1) |
| More equipment resources | 5 (0.6) | 8 (1.0) | 61 (7.6) | 456 (56.7) | 274 (34.1) |
| New technologies | 4 (0.5) | 3 (0.4) | 64 (8.0) | 470 (58.5) | 263 (32.7) |
| Promoted treatment capability | 5 (0.6) | 3 (0.4) | 71 (8.8) | 468 (58.2) | 257 (32.0) |
| Accelerated research process | 4 (0.5) | 6 (0.7) | 51 (6.3) | 457 (56.8) | 286 (35.6) |
| Extra resources made available through collaboration | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| Funds | 4 (0.5) | 17 (2.1) | 132 (16.4) | 474 (59.0) | 177 (22.0) |
| Patients | 6 (0.7) | 23 (2.9) | 107 (13.3) | 475 (59.1) | 193 (24.0) |
| Technologies | 4 (0.5) | 4 (0.5) | 44 (5.5) | 494 (61.4) | 258 (32.1) |
| Equipment | 4 (0.5) | 5 (0.6) | 56 (7.0) | 492 (61.2) | 247 (30.7) |
| Talents | 5 (0.6) | 8 (1.0) | 83 (10.3) | 487 (60.6) | 221 (27.5) |
| Information | 5 (0.6) | 3 (0.4) | 44 (5.5) | 507 (63.1) | 245 (30.5) |
| Personal capabilities influenced by collaboration | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| Improved skills of communication | 2 (0.2) | 3 (0.4) | 59 (7.3) | 543 (67.5) | 197 (24.5) |
| Improved skills of receiving new knowledge and technology | 2 (0.2) | 2 (0.2) | 55 (6.8) | 522 (64.9) | 223 (27.7) |
| Improved skills of controlling over research programs | 1 (0.1) | 8 (1.0) | 115 (14.3) | 503 (62.6) | 177 (22.0) |
| Disadvantages of collaboration | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| More time spent on communication | 9 (1.1) | 74 (9.2) | 171 (21.3) | 469 (58.3) | 81 (10.1) |
| Personal resource transfer | 12 (1.5) | 99 (12.3) | 210 (26.1) | 418 (52.0) | 65 (8.1) |
| Loss of research autonomy and control | 11 (1.4) | 103 (12.8) | 219 (27.2) | 382 (47.5) | 89 (11.1) |
| Deviation from one's main research | 14 (1.7) | 103 (12.8) | 262 (32.6) | 358 (44.5) | 67 (8.3) |
| Conflicts regarding key research points | 10 (1.2) | 69 (8.6) | 242 (30.1) | 403 (50.1) | 80 (10.0) |
| Costs of collaboration | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| Costs of selecting partners and collecting information | 2 (0.2) | 6 (0.7) | 74 (9.2) | 572 (71.1) | 150 (18.7) |
| Costs of negotiation | 1 (0.1) | 10 (1.2) | 106 (13.2) | 536 (66.7) | 151 (18.8) |
| Costs of implementation | 2 (0.2) | 5 (0.6) | 86 (10.7) | 552 (68.7) | 159 (19.8) |
| Costs of supervision | 1 (0.1) | 7 (0.9) | 119 (14.8) | 522 (64.9) | 155 (19.3) |

Table 2 (continued)

| Characteristic | N (%) | | | | |
|-----------------------------------------------------------------------------------------|-------------------------|--------------------|-----------------|------------------|-----------------------|
| | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree |
| Risks of collaboration | | | | | |
| Risks of coordinating the relationship among all partners | 2 (0.2) | 5 (0.6) | 98 (12.2) | 561 (69.8) | 138 (17.2) |
| Risks of having unbalanced duties and responsibilities undertaken by different partners | 1 (0.1) | 5 (0.6) | 94 (11.7) | 543 (67.5) | 161 (20.0) |
| Risks of dropping out or breaking of promises by partners | 1 (0.1) | 10 (1.2) | 108 (13.4) | 512 (63.7) | 173 (21.5) |
| Challenges of collaboration | | | | | |
| Competition from other research organizations | 2 (0.2) | 12 (1.5) | 115 (14.3) | 519 (64.6) | 156 (19.4) |
| Ethics review process | 2 (0.2) | 30 (3.7) | 135 (16.8) | 505 (62.8) | 132 (16.4) |
| Insufficient research funds | 1 (0.1) | 20 (2.5) | 145 (18.0) | 497 (61.8) | 141 (17.5) |
| Recruitment of project managers | 3 (0.4) | 4 (0.5) | 94 (11.7) | 506 (62.9) | 197 (24.5) |
| Factors influencing collaboration | | | | | |
| Geographical locations of partners | 5 (0.6) | 20 (2.5) | 105 (13.1) | 517 (64.3) | 157 (19.5) |
| Funds of partners | 1 (0.1) | 11 (1.4) | 121 (15.0) | 501 (62.3) | 170 (21.1) |
| Technologies of partners | 2 (0.2) | 6 (0.7) | 50 (6.2) | 496 (61.7) | 250 (31.1) |
| Information resources of partners | 2 (0.2) | 5 (0.6) | 56 (7.0) | 502 (62.4) | 239 (29.7) |
| Academic status of partners | 2 (0.2) | 6 (0.7) | 84 (10.4) | 495 (61.6) | 217 (27.0) |
| Mutual relationships of partners | 1 (0.1) | 8 (1.0) | 92 (11.4) | 495 (61.6) | 208 (25.9) |
| Cooperation patterns of partners | 1 (0.1) | 4 (0.5) | 69 (8.6) | 529 (65.8) | 201 (25.0) |
| Factors influencing successful collaboration | | | | | |
| | Very unimportant | Unimportant | Moderate | Important | Very important |
| Set explicit collaboration aims | 2 (0.2) | 1 (0.1) | 50 (6.2) | 493 (61.3) | 258 (32.1) |
| Set specific collaboration periods | 3 (0.4) | 4 (0.5) | 94 (11.7) | 506 (62.9) | 197 (24.5) |
| Choose appropriate partners | 1 (0.1) | 2 (0.2) | 50 (6.2) | 480 (59.7) | 271 (33.7) |
| Establish clear collaboration rules | 1 (0.1) | 5 (0.6) | 60 (7.5) | 492 (61.2) | 246 (30.6) |
| Set clear-cut benefit distribution rules | 2 (0.2) | 8 (1.0) | 91 (11.3) | 464 (57.7) | 239 (29.7) |
| Set explicit risk-taking rules | 1 (0.1) | 3 (0.4) | 90 (11.2) | 474 (59.0) | 236 (29.4) |
| Maintain cooperative network relationships | 1 (0.1) | 8 (1.0) | 117 (14.6) | 497 (61.8) | 181 (22.5) |
| Establish coordination and supervision mechanisms | 1 (0.1) | 5 (0.6) | 95 (11.8) | 488 (60.7) | 215 (26.7) |
| Set penalty rules for violations of the collaboration agreement | 2 (0.2) | 10 (1.2) | 114 (14.2) | 475 (59.1) | 203 (25.2) |
| Set rules for dealing with disputes or emergencies | 2 (0.2) | 4 (0.5) | 93 (11.6) | 488 (60.7) | 217 (27.0) |

challenge of collaboration were the costs of selecting partners and collecting information (89.8%), the risks of unbalanced duties and responsibilities among partners (87.5%), and the challenge of recruiting project managers (87.4%), respectively.

The professional technological input of partners was the factor that most influenced desire to collaborate; 92.8% of participants expressed agreement in this respect. For successful collaboration, having explicit collaboration aims (93.4%) and appropriate partners (93.4%) were considered equally important (Tables 1 and 2).

Collaborative willingness in TMR among clinicians

Univariate analysis of influential factors

Of the 804 participants, 429 (53.4%) were willing and 304 (37.8%) were very willing to collaborate in TMR, while 14 (1.7%) were unwilling and 57 (7.1%) were uncertain. To explore the relationships between the various factors and clinicians' collaborative willingness in TMR,

we performed nonparametric tests. The results (Tables 3 and 4) indicated that 25 factors were statistically significant; these include clinicians' age, education level, professional title, current research type, role in the current TMR, present research pressure, face-to-face communication in collaboration, preferred collaboration partners at the institutional or individual level, and preferences for independent or interdependent relationships. The recognized advantages of collaboration; extra resources brought by collaboration; personal capabilities that might be improved, and perceived disadvantages; costs, risks, and challenges of collaboration; and the factors related to the implementation and success of the collaboration were also factors (all p -values < 0.05).

Logistic regression analysis of willingness to collaborate in TMR

Based on the results of the univariate analyses, only the factors that had a statistically significant influence on

Table 3 Univariate analysis of factors influencing willingness to collaborate in TMR among clinicians

| Characteristic | Willingness of collaboration in TMR | | | | | Statistic | P-value |
|---------------------------------------------|-------------------------------------|-----------|-----------|---------|--------------|-----------|----------|
| | Very unwilling | Unwilling | Uncertain | Willing | Very willing | | |
| Sex | 9 | 5 | 57 | 429 | 304 | -1.479 | 0.139 |
| Male | 3 | 3 | 30 | 243 | 183 | | |
| Female | 6 | 2 | 27 | 186 | 121 | | |
| Age (year) | | | | | | 9.562 | 0.049* |
| 20–30 | 3 | 1 | 26 | 117 | 73 | | |
| 31–40 | 2 | 3 | 17 | 219 | 158 | | |
| 41–50 | 3 | 1 | 9 | 77 | 64 | | |
| 51–60 | 1 | 0 | 5 | 15 | 9 | | |
| >60 | 0 | 0 | 0 | 1 | 0 | | |
| Educational level | | | | | | 22.161 | <0.0001* |
| Junior college degree | 0 | 1 | 4 | 7 | 7 | | |
| Bachelor's degree | 5 | 1 | 33 | 123 | 70 | | |
| Master's degree | 3 | 3 | 10 | 159 | 106 | | |
| Doctor's degree | 1 | 0 | 10 | 140 | 121 | | |
| Professional title | | | | | | 10.213 | 0.017* |
| Junior | 3 | 2 | 32 | 128 | 84 | | |
| Intermediate | 3 | 3 | 17 | 192 | 127 | | |
| Associate senior | 1 | 0 | 4 | 88 | 64 | | |
| Senior | 2 | 0 | 4 | 21 | 29 | | |
| Department | | | | | | 5.685 | 0.128 |
| Surgical department | 1 | 2 | 14 | 134 | 108 | | |
| Non-surgical department | 4 | 2 | 21 | 175 | 108 | | |
| Medical technology department | 2 | 0 | 8 | 82 | 57 | | |
| Management department | 2 | 1 | 14 | 38 | 31 | | |
| Current research type | | | | | | 27.285 | <0.0001* |
| Clinical research | 1 | 2 | 15 | 179 | 109 | | |
| Laboratory research | 0 | 0 | 0 | 27 | 24 | | |
| Clinical and laboratory research | 3 | 0 | 7 | 109 | 98 | | |
| Public health management research | 1 | 0 | 2 | 21 | 17 | | |
| Do not conduct research | 4 | 3 | 33 | 93 | 56 | | |
| Role in current research | | | | | | 34.147 | <0.0001* |
| National PI | 0 | 0 | 2 | 38 | 46 | | |
| Provincial PI | 1 | 0 | 0 | 28 | 29 | | |
| City-level PI | 1 | 0 | 2 | 25 | 32 | | |
| Department-level PI | 1 | 1 | 3 | 22 | 22 | | |
| Project participants | 1 | 1 | 13 | 196 | 93 | | |
| No project support | 5 | 3 | 37 | 120 | 82 | | |
| Current research pressure | | | | | | 44.411 | <0.0001* |
| Very low | 1 | 3 | 9 | 9 | 9 | | |
| Low | 0 | 1 | 2 | 25 | 10 | | |
| Moderate | 5 | 0 | 21 | 123 | 57 | | |
| High | 2 | 1 | 18 | 214 | 141 | | |
| Very high | 1 | 0 | 7 | 58 | 87 | | |
| Communication methods used in collaboration | | | | | | | |
| Face-to-face | 9 | 5 | 57 | 429 | 304 | 19.615 | 0.001* |
| Telephone | 9 | 5 | 57 | 429 | 304 | 6.415 | 0.170 |
| WeChat | 9 | 5 | 57 | 429 | 304 | 13.868 | 0.008 |

Table 3 (continued)

| Characteristic | Willingness of collaboration in TMR | | | | | Statistic | P-value |
|---------------------------------------------------------------------------------|-------------------------------------|-----------|-----------|---------|--------------|-----------|----------|
| | Very unwilling | Unwilling | Uncertain | Willing | Very willing | | |
| Email | 9 | 5 | 57 | 429 | 304 | 5.748 | 0.219 |
| Research record, research abstract, memorandum | 9 | 5 | 57 | 429 | 304 | 2.710 | 0.608 |
| Videoconference | 9 | 5 | 57 | 429 | 304 | 6.342 | 0.175 |
| Face-to-face group meeting | 9 | 5 | 57 | 429 | 304 | 4.749 | 0.314 |
| Mobile short message | 9 | 5 | 57 | 429 | 304 | 5.133 | 0.274 |
| Preferred collaboration partners at the institutional or individual level | | | | | | 39.784 | <0.0001* |
| Institutions | 3 | 0 | 22 | 190 | 165 | | |
| Individuals | 4 | 3 | 29 | 238 | 139 | | |
| Uncertain | 2 | 2 | 6 | 1 | 0 | | |
| Preferred partners of collaboration | | | | | | | |
| University | 9 | 5 | 57 | 429 | 304 | 64.543 | <0.0001* |
| Hospital | 9 | 5 | 57 | 429 | 304 | 43.938 | <0.0001* |
| Research institute | 9 | 5 | 57 | 429 | 304 | 68.770 | <0.0001* |
| Industry | 9 | 5 | 57 | 429 | 304 | 33.436 | <0.0001* |
| Community | 9 | 5 | 57 | 429 | 304 | 19.394 | 0.001* |
| Preferred partners of collaboration in the research application stage | | | | | | | |
| University | 7 | 2 | 31 | 297 | 248 | -4.853 | <0.0001* |
| Hospital | 5 | 2 | 25 | 184 | 170 | 3.176 | 0.002* |
| Research institute | 7 | 2 | 38 | 301 | 238 | -2.764 | 0.006* |
| Industry | 4 | 1 | 15 | 103 | 102 | 2.326 | 0.020* |
| Community | 2 | 1 | 9 | 43 | 51 | 1.672 | 0.095* |
| Preferred partners of collaboration in the research implementation stage | | | | | | | |
| University | 5 | 3 | 22 | 201 | 199 | -5.217 | <0.0001* |
| Hospital | 6 | 2 | 28 | 247 | 205 | -3.225 | 0.001* |
| Research institute | 6 | 2 | 38 | 294 | 233 | -2.702 | 0.007* |
| Industry | 5 | 0 | 18 | 169 | 152 | -16.779 | <0.0001* |
| Community | 2 | 1 | 9 | 72 | 90 | 4.011 | <0.0001* |
| Preferred partners of collaboration in the research achievement promotion stage | | | | | | | |
| University | 3 | 2 | 17 | 157 | 145 | 3.431 | 0.001* |
| Hospital | 8 | 2 | 26 | 223 | 194 | -3.166 | 0.002* |
| Research institute | 4 | 1 | 29 | 193 | 161 | 1.828 | 0.068 |
| Industry | 6 | 2 | 29 | 292 | 226 | -3.277 | 0.001* |
| Community | 4 | 1 | 19 | 169 | 161 | 4.035 | <0.0001* |
| Preferred partners of collaboration in the research application stage | | | | | | | |
| Laboratory scientist | 5 | 2 | 37 | 331 | 257 | -3.998 | <0.0001* |
| Clinical scientist | 8 | 1 | 38 | 301 | 231 | -2.070 | 0.039* |
| Industrial staff | 4 | 0 | 18 | 102 | 101 | 2.015 | 0.044* |
| Community staff | 4 | 2 | 17 | 74 | 62 | -0.686 | 0.493 |
| Health management scientist | 3 | 1 | 13 | 87 | 109 | 4.194 | <0.0001* |
| Preferred partners of collaboration in the research implementation stage | | | | | | | |
| Laboratory scientist | 4 | 1 | 32 | 268 | 211 | -2.859 | 0.004* |
| Clinical scientist | 1 | 3 | 17 | 101 | 62 | -1.601 | 0.109 |
| Industrial staff | 5 | 1 | 27 | 174 | 150 | 1.765 | 0.078 |
| Community staff | 4 | 1 | 19 | 127 | 109 | 0.925 | 0.355 |

Table 3 (continued)

| Characteristic | Willingness of collaboration in TMR | | | | | Statistic | P-value |
|------------------------------------------------------------------------|-------------------------------------|-----------|-----------|---------|--------------|-----------|----------|
| | Very unwilling | Unwilling | Uncertain | Willing | Very willing | | |
| Health management scientist | 4 | 1 | 12 | 125 | 116 | 2.973 | 0.003* |
| Preferred partners of collaboration in the achievement promotion stage | | | | | | | |
| Laboratory scientist | 3 | 1 | 25 | 166 | 139 | 1.674 | 0.094 |
| Clinical scientist | 7 | 1 | 33 | 248 | 181 | -0.457 | 0.648 |
| Industrial staff | 5 | 1 | 33 | 275 | 228 | -3.899 | <0.0001* |
| Community staff | 5 | 2 | 29 | 225 | 173 | -1.314 | 0.189 |
| Health management scientist | 4 | 1 | 23 | 211 | 192 | -4.501 | <0.0001* |

*Indicates statistically significant results ($p < 0.05$)

collaborative willingness in TMR among clinicians were included in the logistic regression analysis. The logistic regression analysis results (Table 5) suggested that clinicians' current research type, role in the current TMR, present research pressure, preferred collaboration partners at the institutional or individual level, and preferences for independent or interdependent relationships were statistically significant factors. Greater willingness to collaborate in TMR was associated with clinicians who were not conducting research (compared with those engaged in clinical research, odds ratio [OR]=0.424), those who were acting as project participants (compared with national PI, OR=0.396), and those who were more willing to collaborate with individuals or without explicit preferences at the institutional or individual level (compared with those who were more willing to collaborate with institutions; OR=0.554 and 0.011, respectively). However, less willingness to collaborate in TMR was associated with clinicians with heavier research burdens (compared with those with low burden, OR=2.591), those preferring to collaborate with hospitals in the research implementation stage (compared with those without such preference, OR=1.422), and those tending to opt for an interdependent research relationship (compared with those tending to be independent, OR=1.495).

Discussion

The results of our survey indicated that clinicians' current research situation—including the research type, role, and pressure—preferred partners, and preferences for the research relationship were key factors that influenced their willingness to collaborate in TMR. Moreover, clinician's cognition on translational medicine has an impact on their willingness to collaborate in TMR. Clinicians with more positive attitudes and more knowledge will be more likely to take measures in collaborating in TMR.

Those who were not engaged in any research at the time and who were participants in current research

programs were more willing to collaborate in TMR, which could be explained by their research pressure or lack thereof. Collaborations in TMR would impose an additional research burden on clinicians, as they would be required to spend more time in communication and resource reallocation [32]. Therefore, clinicians with heavy research loads would be less likely to collaborate in TMR, while those with more time and fewer research responsibilities would be more willing to collaborate. In addition, considering the advantages of TMR collaboration in terms of promoting knowledge transfer and increasing research achievements, clinicians not currently involved in any research or whose involvement was only as a participant would seek more knowledge exchange and increased research achievements through collaboration, which represent incentives for collaboration in TMR [3]. Considering the disadvantages of collaboration, it was shown to weaken control over the research program, which was unacceptable for those undertaking national research projects because such a disadvantage outweighed the merits mentioned above. It is worth noting that some demographic characteristics—such as age, education level, and professional title—would have an indirect effect on clinicians' willingness to collaborate. For example, younger clinicians and those with junior professional titles would be more willing to collaborate due to having more time and fewer research responsibilities as well as for possible knowledge transfer and gaining research achievements. Clinicians with a higher education level would be more willing to collaborate because they may have greater demands for and possibilities of knowledge exchange and research achievements.

Clinicians who preferred individuals as partners, rather than institutions, were more willing to collaborate in TMR. Institutional arrangements are perceived to inhibit collaboration [13], with the compartmentalization of institutions being a main obstruction to collaboration

Table 4 Univariate analysis of factors influencing willingness to collaborate in TMR among clinicians

| Characteristic | Willingness of collaboration in TMR | | | | | Statistic | P-value |
|-----------------------------------------------------------------------------------------|-------------------------------------|-----------|-----------|---------|--------------|-----------|-----------|
| | Very unwilling | Unwilling | Uncertain | Willing | Very willing | | |
| Preferred research relationship | 9 | 5 | 57 | 429 | 304 | 3.326 | 0.001* |
| Independent | 6 | 5 | 29 | 236 | 130 | | |
| Interdependent | 3 | 0 | 28 | 193 | 174 | | |
| Advantages of collaboration | | | | | | | |
| Additional funds or resources | 9 | 5 | 57 | 429 | 304 | 52.917 | < 0.0001* |
| Promoted knowledge transfer | 9 | 5 | 57 | 429 | 304 | 77.588 | < 0.0001* |
| Enhanced institution reputation | 9 | 5 | 57 | 429 | 304 | 53.686 | < 0.0001* |
| Increased number of publications | 9 | 5 | 57 | 429 | 304 | 77.190 | < 0.0001* |
| Improved publication quality | 9 | 5 | 57 | 429 | 304 | 72.425 | < 0.0001* |
| Enriched academic influence | 9 | 5 | 57 | 429 | 304 | 84.365 | < 0.0001* |
| Additional clinical resources | 9 | 5 | 57 | 429 | 304 | 62.820 | < 0.0001* |
| More equipment resources | 9 | 5 | 57 | 429 | 304 | 61.191 | < 0.0001* |
| New technologies | 9 | 5 | 57 | 429 | 304 | 78.946 | < 0.0001* |
| Promoted treatment capability | 9 | 5 | 57 | 429 | 304 | 70.646 | < 0.0001* |
| Accelerated research process | 9 | 5 | 57 | 429 | 304 | 92.024 | < 0.0001* |
| Extra resources made available through collaboration | | | | | | | |
| Funds | 9 | 5 | 57 | 429 | 304 | 25.898 | < 0.0001* |
| Patients | 9 | 5 | 57 | 429 | 304 | 40.559 | < 0.0001* |
| Technologies | 9 | 5 | 57 | 429 | 304 | 42.761 | < 0.0001* |
| Equipment | 9 | 5 | 57 | 429 | 304 | 40.517 | < 0.0001* |
| Talents | 9 | 5 | 57 | 429 | 304 | 37.620 | < 0.0001* |
| Information | 9 | 5 | 57 | 429 | 304 | 49.440 | < 0.0001* |
| Personal capabilities influenced by collaboration | | | | | | | |
| Improved skills of communication | 9 | 5 | 57 | 429 | 304 | 54.406 | < 0.0001* |
| Improved skills of receiving new knowledge and technology | 9 | 5 | 57 | 429 | 304 | 53.967 | < 0.0001* |
| Improved skills of controlling over research programs | 9 | 5 | 57 | 429 | 304 | 41.469 | < 0.0001* |
| Disadvantages of collaboration | | | | | | | |
| More time spent on communication | 9 | 5 | 57 | 429 | 304 | 18.015 | 0.001* |
| Personal resource transfer | 9 | 5 | 57 | 429 | 304 | 24.200 | < 0.0001* |
| Loss of research autonomy and control | 9 | 5 | 57 | 429 | 304 | 33.797 | < 0.0001* |
| Deviation from one's main research | 9 | 5 | 57 | 429 | 304 | 31.963 | < 0.0001* |
| Conflicts regarding key research points | 9 | 5 | 57 | 429 | 304 | 25.058 | < 0.0001* |
| Costs of collaboration | | | | | | | |
| Costs of selecting partners and collecting information | 9 | 5 | 57 | 429 | 304 | 18.997 | 0.001* |
| Costs of negotiation | 9 | 5 | 57 | 429 | 304 | 18.080 | 0.001* |
| Costs of implementation | 9 | 5 | 57 | 429 | 304 | 30.360 | < 0.0001* |
| Costs of supervision | 9 | 5 | 57 | 429 | 304 | 46.453 | < 0.0001* |
| Risks of collaboration | | | | | | | |
| Risks of coordinating the relationship among all partners | 9 | 5 | 57 | 429 | 304 | 16.594 | 0.002* |
| Risks of having unbalanced duties and responsibilities undertaken by different partners | 9 | 5 | 57 | 429 | 304 | 12.497 | 0.014* |
| Risks of dropping out or breaking of promises by partners | 9 | 5 | 57 | 429 | 304 | 26.837 | < 0.0001* |
| Challenges of collaboration | | | | | | | |
| Competition from other research organizations | 9 | 5 | 57 | 429 | 304 | 22.726 | < 0.0001* |
| Ethics review process | 9 | 5 | 57 | 429 | 304 | 22.512 | 0.000* |
| Insufficient research funds | 9 | 5 | 57 | 429 | 304 | 24.195 | < 0.0001* |
| Recruitment of project managers | 9 | 5 | 57 | 429 | 304 | 28.471 | < 0.0001* |

Table 4 (continued)

| Characteristic | Willingness of collaboration in TMR | | | | | Statistic | P-value |
|-----------------------------------------------------------------|-------------------------------------|-----------|-----------|---------|--------------|-----------|-----------|
| | Very unwilling | Unwilling | Uncertain | Willing | Very willing | | |
| Factors influencing collaboration | | | | | | | |
| Geographical locations of partners | 9 | 5 | 57 | 429 | 304 | 15.695 | 0.004* |
| Funds of partners | 9 | 5 | 57 | 429 | 304 | 23.437 | 0.000* |
| Technologies of partners | 9 | 5 | 57 | 429 | 304 | 66.833 | < 0.0001* |
| Information resources of partners | 9 | 5 | 57 | 429 | 304 | 58.321 | < 0.0001* |
| Academic status of partners | 9 | 5 | 57 | 429 | 304 | 38.837 | < 0.0001* |
| Mutual relationships of partners | 9 | 5 | 57 | 429 | 304 | 37.916 | < 0.0001* |
| Cooperation patterns of partners | 9 | 5 | 57 | 429 | 304 | 37.277 | < 0.0001* |
| Factors influencing successful collaboration | | | | | | | |
| Set explicit collaboration aims | 9 | 5 | 57 | 429 | 304 | 65.751 | < 0.0001* |
| Set specific collaboration periods | 9 | 5 | 57 | 429 | 304 | 41.773 | < 0.0001* |
| Choose appropriate partners | 9 | 5 | 57 | 429 | 304 | 50.887 | < 0.0001* |
| Establish clear collaboration rules | 9 | 5 | 57 | 429 | 304 | 49.138 | < 0.0001* |
| Set clear-cut benefit distribution rules | 9 | 5 | 57 | 429 | 304 | 36.000 | < 0.0001* |
| Set explicit risk-taking rules | 9 | 5 | 57 | 429 | 304 | 45.529 | < 0.0001* |
| Maintain cooperative network relationships | 9 | 5 | 57 | 429 | 304 | 38.086 | < 0.0001* |
| Establish coordination and supervision mechanisms | 9 | 5 | 57 | 429 | 304 | 43.148 | < 0.0001* |
| Set penalty rules for violations of the collaboration agreement | 9 | 5 | 57 | 429 | 304 | 65.377 | < 0.0001* |
| Set rules for dealing with disputes or emergencies | 9 | 5 | 57 | 429 | 304 | 32.935 | < 0.0001* |

*Indicates statistically significant results (p < 0.05)

[7]. Therefore, considering the uncertainty of the potential cooperative institutions, clinicians may be inclined to think that collaborating with individuals would avoid risks such as inappropriate institutional arrangements and structural isolation among different institutions. Moreover, face-to-face communication among clinicians who choose to collaborate with individuals is more likely, which would further promote their willingness to collaborate with individuals. In terms of the benefits of collaborating, working with individuals would also help individual scientists expand the scope and sample size of their research and improve efficiency [9], which is another motivation for collaborating with individuals. Further, considering the preferred institution in the research implementation phase, clinicians who preferred to collaborate with hospitals tended to be more unwilling to collaborate in TMR. A previous study indicated that enhancing the impact of clinical therapy and policy is the core objective of TMR [8]. However, realizing this goal is not easy and it can be time consuming. Such delays may lead to changes, beyond expectations, after collaboration, which consequently impede collaboration in TMR [3]. Thus, although the original aim of collaborating with hospitals was to increase influence by accelerating the

clinical application process of research achievements, it would cost more time to realize such translation, which could lead to higher potential risks. The gap between reality and the ideal circumstances would undermine these clinicians' willingness to collaborate.

Clinicians who are inclined to be independent in research relationships were more willing to collaborate in TMR. Our results confirmed those of other studies and suggested that the advantages of collaboration would not promote collaboration in TMR [3]. Instead, clinicians who are inclined to be in independent research relationships were less likely to depend on benefits from collaboration, and this tendency facilitated their collaborative willingness. In addition, clinicians who prefer an independent research relationship were more receptive to competing with partners for funds, talent, reputation, and extra support. Such effective and positive competition among partners would promote creativity and excellence [32], which was another form of encouragement for these clinicians to collaborate in TMR.

The results of our study showed that the factors that influenced collaboration in TMR primarily concerned current research characteristics, collaborative partners, and relationships with partners. The advantages and

Table 5 Logistic regression analysis of the collaborative willingness in TMR

| Characteristic | Estimate | Wald Chi-Square | P-value | OR | 95% Wald confidence limits | |
|--------------------------------------------------------------------------------------------------|----------|-----------------|----------|--------|----------------------------|----------|
| | | | | | Lower | Upper |
| Current research type | | | | | | |
| Clinical research | Ref | | | | | |
| Laboratory research | 0.433 | 1.603 | 0.205 | 1.541 | 0.789 | 3.011 |
| Clinical and laboratory research | 0.300 | 2.030 | 0.154 | 1.350 | 0.893 | 2.041 |
| Public health management research | 0.331 | 0.709 | 0.400 | 1.393 | 0.644 | 3.012 |
| Do not conduct research | -0.858 | 8.909 | 0.003* | 0.424 | 0.241 | 0.745 |
| Role in current research | | | | | | |
| National PI | Ref | | | | | |
| Provincial PI | -0.277 | 0.508 | 0.476 | 0.758 | 0.354 | 1.624 |
| City-level PI | -0.436 | 1.285 | 0.257 | 0.647 | 0.305 | 1.374 |
| Department-level PI | -0.583 | 2.041 | 0.153 | 0.558 | 0.251 | 1.242 |
| Project participants | -0.926 | 10.108 | 0.002* | 0.396 | 0.224 | 0.701 |
| No project support | -0.496 | 1.799 | 0.180 | 0.609 | 0.295 | 1.257 |
| Current research pressure | | | | | | |
| Very low | Ref | | | | | |
| Low | 0.151 | 0.079 | 0.779 | 1.163 | 0.407 | 3.323 |
| Moderate | 0.002 | 0.000 | 0.997 | 1.002 | 0.421 | 2.383 |
| High | 0.253 | 0.333 | 0.564 | 1.288 | 0.545 | 3.043 |
| Very high | 0.952 | 4.247 | 0.039* | 2.591 | 1.048 | 6.406 |
| Preferred collaboration partners at the institutional or individual level | | | | | | |
| Institutions | Ref | | | | | |
| Individuals | -0.591 | 13.579 | 0.00* | 0.554 | 0.405 | 0.758 |
| Uncertain | -4.545 | 42.277 | <0.0001* | 0.011 | 0.003 | 0.042 |
| Willing to collaborate with industry | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | 3.142 | 1.892 | 0.169 | 23.156 | 0.263 | >999.999 |
| Uncertain | 2.965 | 1.722 | 0.190 | 19.389 | 0.231 | >999.999 |
| Disagree | 3.534 | 2.451 | 0.118 | 34.250 | 0.411 | >999.999 |
| Strongly disagree | 3.143 | 1.969 | 0.161 | 23.168 | 0.287 | >999.999 |
| Preference for collaborating with hospitals in the research implementation stage | | | | | | |
| No | Ref | | | | | |
| Yes | 0.352 | 4.241 | 0.040* | 1.422 | 1.017 | 1.988 |
| Preference for collaborating with community in the research achievement promotion stage | | | | | | |
| No | Ref | | | | | |
| Yes | 0.332 | 3.691 | 0.055 | 1.393 | 0.993 | 1.955 |
| Preference for collaborating with health management scientists in the research application stage | | | | | | |
| No | Ref | | | | | |
| Yes | 0.367 | 3.575 | 0.059 | 1.444 | 0.987 | 2.112 |
| Preferred research relationship | | | | | | |
| Independent | Ref | | | | | |
| Interdependent | 0.402 | 6.175 | 0.013* | 1.495 | 1.089 | 2.052 |
| Receive additional funds or resources by collaboration | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | -2.433 | 0.707 | 0.400 | 0.088 | <0.001 | 25.436 |
| Uncertain | -2.529 | 0.806 | 0.369 | 0.080 | <0.001 | 19.934 |

Table 5 (continued)

| Characteristic | Estimate | Wald Chi-Square | P-value | OR | 95% Wald confidence limits | |
|-----------------------------------------------------|----------|-----------------|---------|--------|----------------------------|-----------|
| | | | | | Lower | Upper |
| Agree | -1.716 | 0.374 | 0.541 | 0.180 | <0.001 | 43.947 |
| Strongly agree | -1.992 | 0.502 | 0.479 | 0.136 | <0.001 | 33.769 |
| Increase number of publications by collaboration | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | 2.641 | 0.537 | 0.464 | 14.024 | 0.012 | > 999,999 |
| Uncertain | -1.847 | 0.366 | 0.545 | 0.158 | <0.001 | 62.343 |
| Agree | -1.297 | 0.183 | 0.669 | 0.273 | <0.001 | 103.818 |
| Strongly agree | -0.964 | 0.102 | 0.750 | 0.381 | 0.001 | 143.427 |
| Accelerate research process by collaboration | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | 1.518 | 0.202 | 0.653 | 4.562 | 0.006 | > 999,999 |
| Uncertain | 3.789 | 1.248 | 0.264 | 44.205 | 0.057 | > 999,999 |
| Agree | 3.325 | 0.971 | 0.324 | 27.790 | 0.037 | > 999,999 |
| Strongly agree | 4.427 | 1.707 | 0.191 | 83.673 | 0.109 | > 999,999 |
| Extra funds made available through collaboration | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | 1.447 | 0.249 | 0.618 | 4.252 | 0.014 | > 999,999 |
| Uncertain | 0.314 | 0.012 | 0.912 | 1.368 | 0.005 | 360.494 |
| Agree | -0.048 | 0.000 | 0.987 | 0.953 | 0.004 | 245.458 |
| Strongly agree | -0.515 | 0.033 | 0.856 | 0.598 | 0.002 | 156.467 |
| Improve skills of communication by collaboration | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | -0.433 | 0.015 | 0.904 | 0.649 | <0.001 | 733.327 |
| Uncertain | -0.015 | 0.000 | 0.997 | 0.985 | 0.001 | 718.965 |
| Agree | -0.503 | 0.022 | 0.881 | 0.605 | <0.001 | 439.175 |
| Strongly agree | 0.330 | 0.010 | 0.922 | 1.390 | 0.002 | 999.381 |
| Lose research autonomy and control by collaboration | | | | | | |
| Strongly agree | Ref | | | | | |
| Agree | 0.387 | 0.207 | 0.549 | 1.472 | 0.279 | 7.775 |
| Uncertain | -0.192 | 0.053 | 0.818 | 0.825 | 0.161 | 4.233 |
| Agree | -0.424 | 0.261 | 0.610 | 0.654 | 0.128 | 3.336 |
| Strongly agree | -0.120 | 0.020 | 0.887 | 0.887 | 0.169 | 4.644 |

*Indicates statistically significant results (p < 0.05)

disadvantages of collaboration were not the main concerns for clinicians when deciding upon collaboration; this indirectly demonstrated that the decision to collaborate was dependent on the feasibility of collaboration (including the availability of time and suitable partners), and that most of the advantages and disadvantages were acceptable, meaning that no additional consideration was required. However, to promote collaboration in TMR, such factors mentioned above should be taken into consideration, which will be helpful to choose more suitable partners and take favorable measures at each stage of collaboration.

The present study has certain limitations. First, most questions in our internet-based survey were self-reported, a method that is prone to potential over- or under-estimation. Second, the study did not distinguish between multi-team systems collaboration and individual collaboration. The factors that influence multi-team systems collaboration and individual collaboration may differ; we will further explore this issue in a follow-up study. Third, we did not consider the role of innovation intermediaries in collaborative TMR. We will explore how innovation intermediaries affect collaborations among clinicians in translational medicine in subsequent studies.

Fourth, our survey ignored the leadership role of different agents in TMR. In further surveys, if the preferred partner was an individual (laboratory scientist, clinical scientist, industrial staff, community staff, or health management scientist), the leadership role of clinicians or these individuals should be investigated. If the preferred partner was an institution (university, hospital, research institute, industry, or community) the leadership role of clinicians or these institutions should also be considered.

Conclusions

Most Chinese clinicians who were enrolled in this study are willing to collaborate in TMR. Their willingness to collaborate was mainly based on the current TMR characteristics, potential partners, and inclinations regarding research relationships. To collaborate appropriately and foster the greatest advantages of collaboration in TMR, clinicians should seriously consider the advantages and disadvantages of collaboration. First, clinicians should evaluate their time, role, and research pressure based on their current TMR before deciding to collaborate. Personal preferences for research relationships should also be considered. Second, clinicians should fully consider the goals of their TMR during the entire process and in the different research phases, which would help them choose appropriate partners and address the various costs, risks, and challenges involved in collaborations. Third, several measures could be taken at the national level to accelerate collaboration in TMR, including supporting more resources (e.g., funds), providing training and education programs on the implementation and management of TMR, and giving specific regulations on the responsibilities and rights among partners in TMR.

Abbreviations

TMR: Translational medical research; PI: Principal Investigator.

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Authors' contributions

ML and WY conceived this study, analyzed and interpreted the data, and was the major contributors in writing the manuscript. BL, XX, and PZ conducted the survey and collected all the survey data. BT, CH, XL, and LZ revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval or consent to participate

This study was approved by the Second Military Medical University ethics committee (approval reference number: 2013LL058). All participants were informed of the study objectives and assured that their information and responses were kept confidential.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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