



# Development and trend in the field of valvular heart disease in China: an analysis based on the National Natural Science Foundation of China

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**Background:** National Natural Science Foundation of China (NSFC) plays a vital role promoting advancement of science in China. The incidence and mortality rate of valvular heart disease (VHD) increase with aging population. Therefore, it is of significance to discuss the development and trend in the field of VHD and provide references for scholars to carry out further Foundations.

**Methods:** Internet-based Science Information System and other websites were used to search for projects supported by NSFC related to VHD in 2008–2019 and related information of applicants. Publications, citations and impact factors were queried by Google Scholar and InCites Journal Citation Reports 2.0 and analyzed by SPSS for Windows version 24.0. Key words extracted from these project titles were imported into Citespace for analysis.

**Results:** A total of 117 projects and related information were acquired. Although the annual amount of projects and funding has fluctuated in recent years, they still maintained an upward trend. Institutes were mainly distributed over Hubei Province, Shanghai and Jiangsu Province. Applicants characterized as senior title, male, cardiac surgeon have accounted for a larger proportion of projects, with a greater amount of funding. Through the analysis of keywords and subject distribution, molecular-biology-based mechanism study combined with tissue engineering has become the principal research hot spot and trend in recent years. Annual changes in output in scientific research were consistent with changes in the amount of funding.

**Conclusions:** This paper collated funding situation supported by NSFC in VHD, analyzed distribution of keywords and summarized the research trend, so as to supply guidance to researchers for advanced researches.

**Keywords:** National Natural Science Foundation of China (NSFC); valvular heart disease (VHD); project funded; statistical analysis

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## Introduction

It is estimated that more than 42 million people worldwide are suffering from valvular heart disease (VHD) (1). The incidence and mortality rate of VHD in industrialized countries are lower than the coronary heart disease and heart failure, nevertheless, with the development of aging population, attention should be paid to the increasing incidence of VHD. The morbidity of VHD in Chinese adults is approximately 5.3% to 7.7% (1). The prevalence of VHD increases with age gradually, especially after the age of 65 (2) and up to 16.1% for people over 65 years old in the United States (3). In an epidemiologic study of China, the standardized prevalence of VHD among the elderly population over the age of 60 was 2.05% in Hubei (4). Rheumatic valvular disease in Europe and North America are not common, instead of age-related degenerative valvular disease (5), while the incidence of the degenerative valvular disease and operation rate have been rising year by year. According to the 2018 Annual Report of Chinese Academy of Medical Sciences, the National Center for Cardiovascular Diseases, ratio of degenerative diseases has showed a trend of rising by years. It was predicted that the proportion of current degenerative diseases in China has exceeded that of rheumatic diseases, and has become the premier cause of valvular disease. At present, the dominating treatments of valvular disease include valve replacement and valve repair, but both have limitations. Since the 21st century, transcatheter aortic valve implantation (TAVI) has gradually emerged and become current research hot spot (6-8).

Founded in 1986, the National Natural Science Foundation of China (NSFC) has always attached importance to the foundation, cutting-edge research and talents, focusing on innovation teams and cross-disciplines. It annually screens and provides funding for scientific research projects, and has made important contributions to comprehensively cultivating Chinese source innovation capabilities. So far, application for NSFC has turned into the main approach in China to get financial support for researches, as well it has been deemed as a crucial indicator of Chinese scientific research development trend. Therefore, in order to figure out the development and trend in the field of VHD in China and carry out further researches, it is necessary to study general situation of NSFC.

## Methods

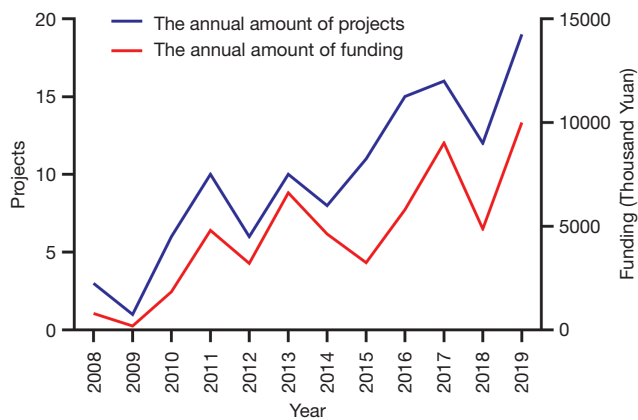
### *Data sources*

Internet-based Science Information System (<https://isisn.nsf.gov.cn/>), Science Network (<http://www.sciencenet.cn/>), MedSci (<http://www.medsci.cn/>), LetPub (<https://www.letpub.com.cn/>) and other websites were utilized as search engines. Project titles typed for retrieval were included for heart valve, aortic valve, mitral valve, pulmonary valve and tricuspid valve while time limitation was set up to 2008–2019. Finally, 117 search results and related information were obtained, which covered project name, person in charge, amount of funding, time of approval, subject code, application institution and project type. Personal information about applicants was obtained from their own institutions' websites.

Achievements of each project were reflected from three aspects: publications, citations of articles and impact factor (IF) of journal published. Google Scholar was queried to the number of publications for each project and citations of each paper received up to and including 17 February 2020. Papers included conference papers and journal papers in both Chinese and English. The 2018 impact factor for each journal was checked by the InCites Journal Citation Reports 2.0 (Web of Science™, Thomson Reuters, NY, USA).

### *Statistical methods*

Graphpad prism 8.0 was used to analyze and synthesize figures from the aspects of the annual number of projects, the annual amount of funding, subject classification, host person and the supporting institution. Key words extracted from the 117 projects approved by NSFC were imported into Citespace for analysis. Statistical calculations were performed using SPSS for Windows version 24.0 (SPSS Inc., Chicago, IL, USA). Publications, citations and IFs were expressed as median [interquartile range (range)], because they are not normal distribution by Kolmogorov-Smirnov test. Projects in progress were excluded when analyzing the differences in output between different types of projects. Comparison of multiple independent samples was performed using the Kruskal-Wallis test, with  $P < 0.05$  considered statistically significant.



**Figure 1** The annual amount of projects and funding in the VHD field of NSFC in 2008–2019. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

## Results

### *Projects and funding increased year by year*

A total of 117 projects were obtained, including 61 general projects, 40 youth scientist projects, 11 projects for less developed regions, 2 key projects, 2 emergency projects and 1 international (regional) cooperation and exchange project. Regarding the annual scalar, the number of projects in the field of VHD fluctuated greatly, but the overall trend was upward, with 2019 (19 projects) being the most, and 2008–2012 being less. Regarding the annual funding, the amount of annual funding approved each year was generally increasing, with the most striking amounts of subventions in 2013, 2017 and 2019 (*Figure 1, Table S1*).

### *Host institutions from all over the country*

Affiliated institutions involved 47 universities. Huazhong University of Science and Technology has far surpassed other universities in both amount of projects and funding, reflecting the leading position of Huazhong University of Science and Technology in this field. Two other universities that performed excellently in terms of the amount of projects and funding were Shanghai Jiao Tong university and The Second Military Medical University (*Table S2*). More than half of institutions (26 universities) owned only one subsidized project during 2008–2019 (*Figure 2*). In term of the number of projects institutions gained each year, institutions with higher total funding in 2008–2019 have

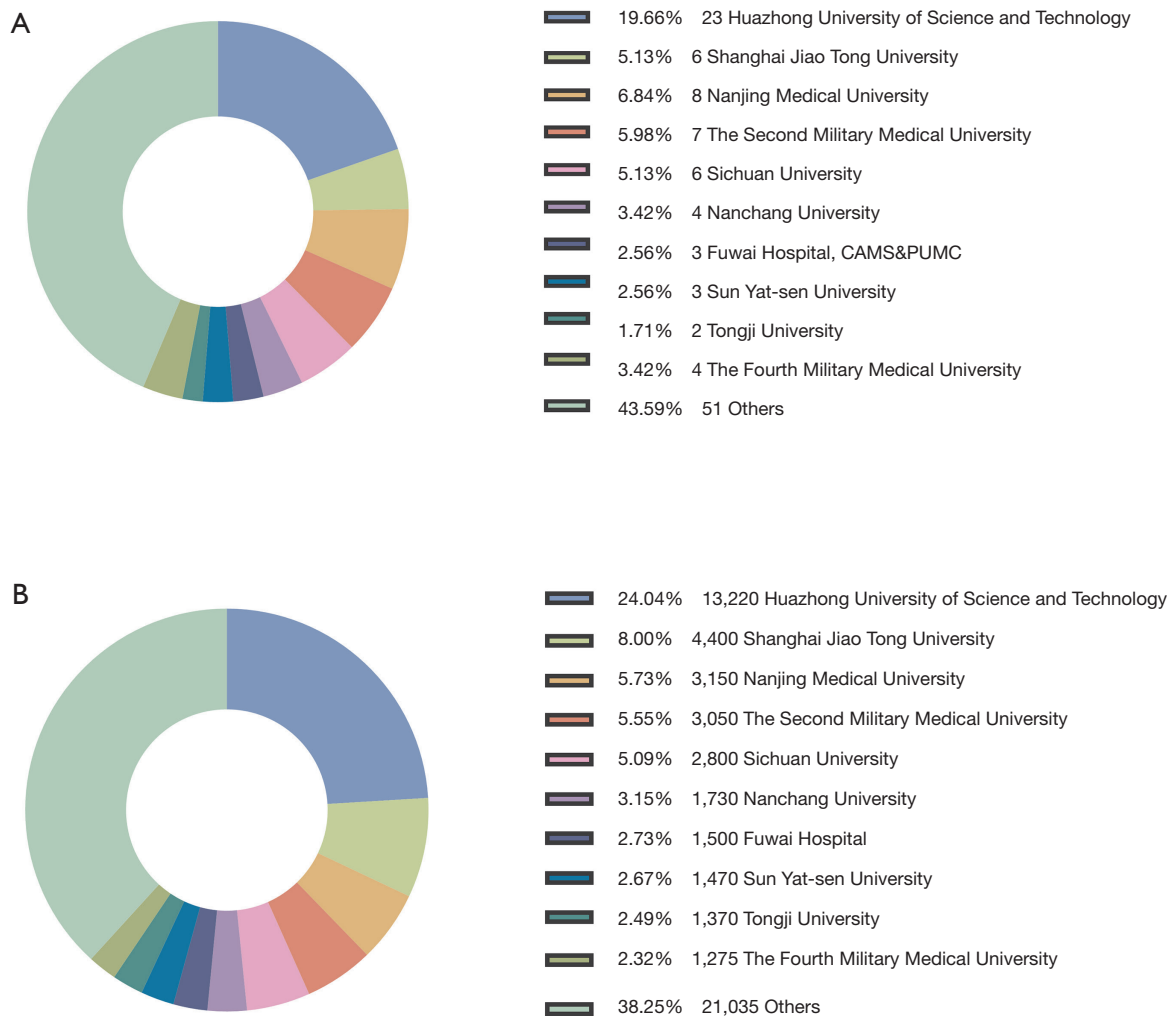
better time continuity in approved projects. Specifically, the top six institutions that have gotten funding most have approved projects for at least three consecutive years, or no more than three years in between (*Table S3*).

### *Characteristics of applicants funded*

Analyzing of researchers taking charge of projects, the top five scholars who won the funding most for the project in 2008–2019 were: Dr. Nianguo Dong (7.65 million yuan), Dr. Kun Sun (2.32 million yuan), Dr. Zhiyun Xu (1.9 million yuan), Dr. Qing Zhang (1.5 million yuan) and Dr. Jianliang Zhou (1.36 million yuan), indicating that these professors and scholars occupied important positions in the studying of VHD in China. Characteristics of scientists were classified by their titles, gender and professions respectively. Titles were divided into senior title (including professor and chief physician), deputy senior title (including associate chief physician and associate professor) and middle-level title (including attending doctor, lecturer and assistant professor). Professions contained clinician and researcher, while clinicians were further subdivided into different departments. Of all the applicants funded, senior title, male, clinicians and cardiac surgeon have led to a larger proportion of projects, with a greater amount of funding (*Table 1*).

### *Funding from different departments and disciplines*

Subject code was picked up for each project when applications were submitted, so that the projects would be examined professionally by code-related specialists. Subject codes from the 117 projects involved 5 departments and 29 disciplines (*Table S4*). To be more specific, 5 departments included Medical Science Department (H), Biological Science Department (C), Mathematical Sciences Department (A), Information Science Department and Engineering (F) and Materials Science Department (E). And “valvular heart disease” (H0210) is the primary application direction among all of subject codes, followed by “Biological Materials” (C1002) (*Figure 3*). However, for the sake of elaborating classification, we rearranged the subject categories artificially by analyzing the titles of the projects. Finally, in the classification of “valvular heart disease”, it was known that 9 items can be classified into biomechanics and tissue engineering research, 62 items



**Figure 2** The amount of projects and funding for application institution in the VHD field of NSFC in 2008–2019. (A) The amount of projects; (B) the amount of funding. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

were molecular-biology-based mechanism studies for heart valves disease and 5 items researches were combine biomechanics and tissue engineering with molecular-biology-based mechanism study. Therefore, after manual adjustment, “valvular heart disease” (mainly molecular-biology-based mechanism study) won 62 projects and the amount of 25.355 million yuan for funding. “Biomechanics and tissue engineering” won 21 items and the amount of 13.655 million yuan for funding, while biomechanics and tissue engineering with the combination of mechanism research studies won 5 items and the amount of 1.67 million yuan for funding. The only two key projects were related to tissue engineering and biological materials, while the only international (regional) cooperation and exchange project

was correlated to molecular-biology-based mechanism study on aortic valve disease. This showed that in the field of VHD in 2008–2019, projects supported by NSFC have paid close attention to molecular-biology-based mechanism study and “biomechanics and tissue engineering” research. Moreover, molecular-biology-based mechanism study has gotten more supports from the aspect of the amount of projects and funding.

#### *Cultivating an increasing number of research teams and youth scientists*

From 2008 to 2019, there were 61 general projects supported by NSFC in the VHD field, with a total funding

**Table 1** The amount of scientist, grant and funding under different characteristics of applicants

Characters	N			Funding (thousand yuan)		
	Scientist	Grant	Grant/scientist	Total	Average	Median [IQR (range)]
<b>Title</b>						
Senior title	40	52	1.30	34,060	655	570 [500–622.5 (100–2,970)]
Deputy senior title	24	28	1.17	11,240	401.4	420 [230–550 (180–730)]
Middle title	34	37	1.09	9,700	262.2	210 [200–280 (170–570)]
<b>Gender</b>						
Female	24	25	1.04	9,510	380.4	280 [200–510 (100–1,500)]
Male	74	92	1.24	45,490	494.5	500 [227.5–570 (100–2,970)]
<b>Profession</b>						
Clinician	73	91	1.25	44,390	487.8	380 [210–570 (100–2,970)]
Researcher	25	26	1.04	10,610	408.1	440 [232.5–565 (100–730)]
<b>Department of clinician</b>						
Cardiac surgery	43	59	1.37	28,660	485.8	500 [210–570 (100–2,970)]
Cardiology	19	21	1.11	9,880	470.5	380 [210–570 (200–1,500)]
Ultrasound	4	4	1.00	1,340	335	280 [230–385 (230–550)]
Nephrology	3	3	1.00	930	310	–
Pediatrics	2	2	1.00	2,890	1,445	–
Gastroenterology	1	1	1.00	370	370	–
Intensive care medicine	1	1	1.00	320	320	–

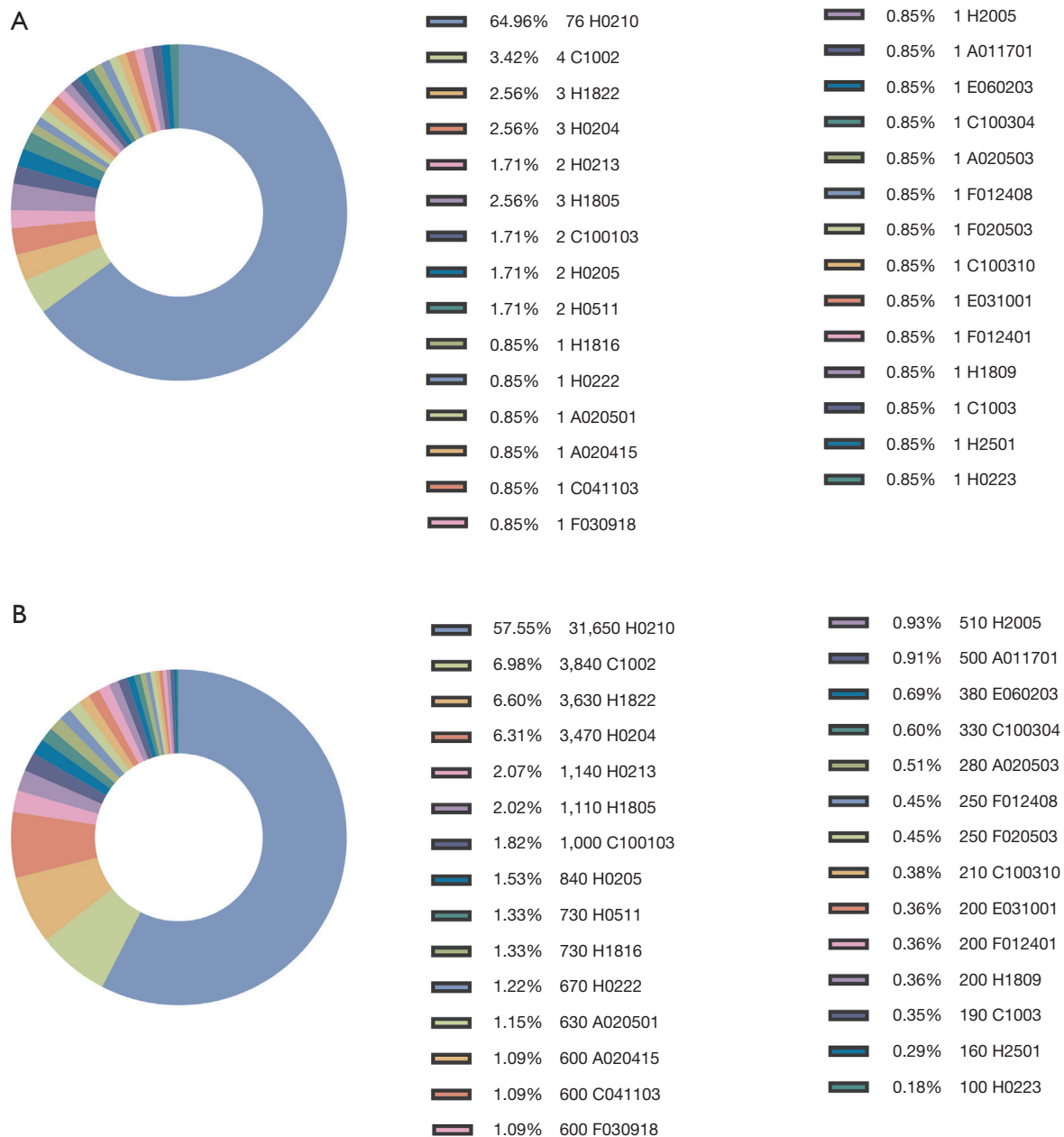
IQR, interquartile range.

of 34.37 million yuan, an average of 563,442 yuan for each project. There were 40 youth scientist projects with an amount of 8.34 million yuan and each project received an average of 208,500 yuan (Table S5). In recent years, the numbers of projects in both general projects and youth scientist projects have been on the rise, showing growing strength of Chinese research teams and youth scientists (Figure 4). From the perspective of provinces, general projects and youth scientist projects were concentrated in Shanghai city, Hubei province and Jiangsu province (Table S6), and the only two key projects are both from Hubei province (Professor Nianguo Dong), and the only international (regional) cooperation and exchange project was tendered from Shanghai (Figure 5).

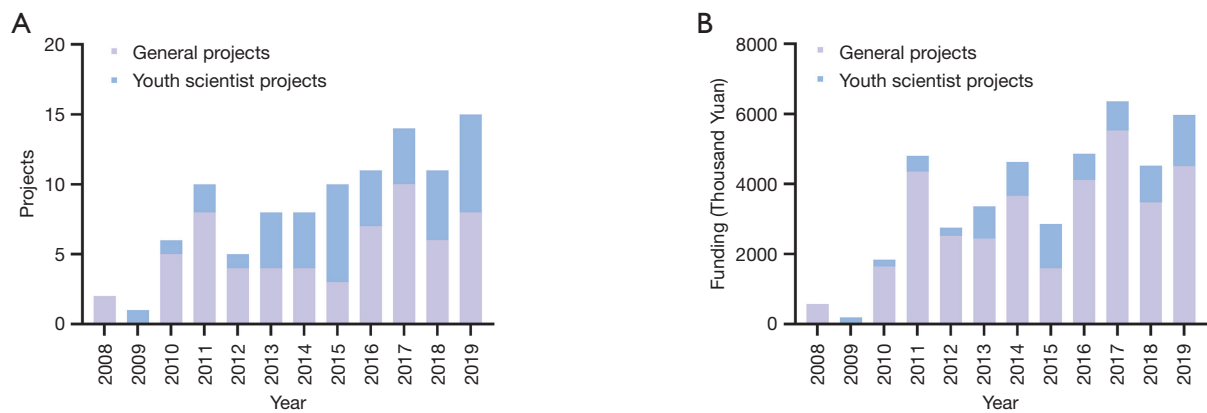
#### **Evolution of research directions and hot spots**

The general keywords included valve, calcification, aortic

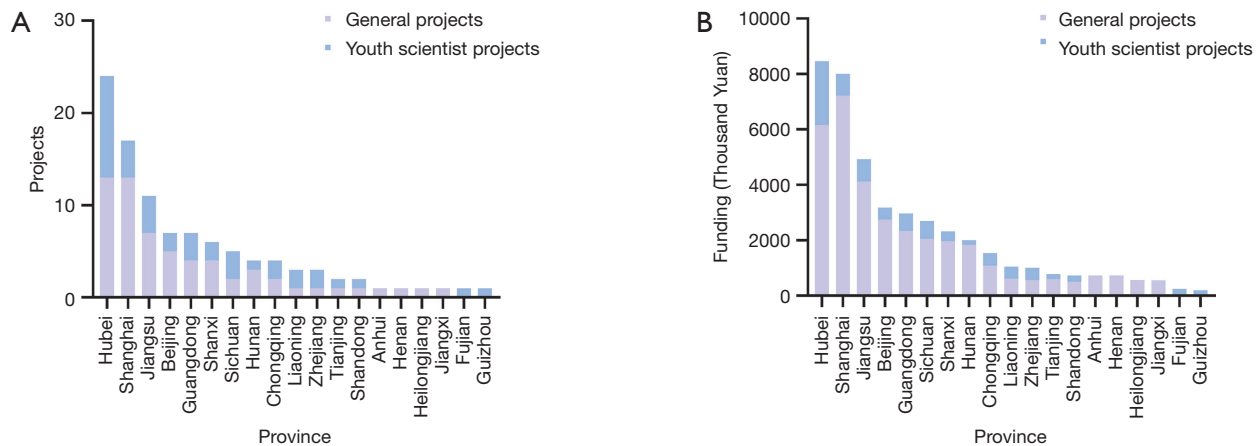
valve, mechanism, regulation, differentiate, mesenchymal cell and osteogenesis. From the color change and scattergram in Figure 6, it can be known that keywords for different periods all covered valve, calcification, aortic valve, mechanism and regulation, that is, projects in the VHD from 2008–2019 were conducted around the above keywords. Specifically, when it comes to 2008–2010, they were mainly valve, mechanism, regulation, modification, signal, scaffold, decellularization, tissue engineering. The orientation of these keywords was relatively systematic and not refined, but at the same time the keynote of the projects funded by NSFC in this field in 2008–2019. In 2011–2013, they were added to calcification, aortic valve, scaffold, endothelium, stenosis, warfarin, individualization based on the keywords of 2008–2010, tending to be research and exploration of tissue engineering and drug research. The keywords for 2014–2016 were mitral valve, differentiation, pathway, osteogenesis, experiment, target etc., and had a



**Figure 3** The amount of projects and funding for subject code in the VHD field of NSFC in 2008–2019. (A) The amount of projects; (B) the amount of funding. H0210, Valvular Heart Disease; C1002, Biological Materials; H1822, Tissue Engineering and Regenerative Medicine; H020, Cardiac Dysplasia and Congenital Heart Disease; H0213, Heart/Vascular Transplantation and Assisted Circulation; H1805, Medical Ultrasound and Acoustic Contrast Agents; C100103, Biomechanics and Biorheology of the Blood Circulation System; H0205, Abnormal ECG Activity and Arrhythmia; H0511, Renal Failure, H1816, Interventional Medicine and Engineering; H0222, New Technologies for Diagnosis and Treatment of Circulatory Diseases; A020501, System Dynamics of Tissue and Organ; A020415, Computational Fluid Dynamics; C041103, Experimental Animals; F030918, Wearable, Medical and Service Robot Systems; H2005, Clinical Molecular Biological Examination; A011701, Numerical Calculation of Partial Differential Equation; E060203, Internal Flow of Fluid Machinery; C100304, Tissue Engineered Blood Vessels and Myocardium; A020503, Biomechanics, Biomaterials and Motion Biomechanics; F012408, Modeling and Simulation of Biological Information System; F020503, Virtual and Augmented Reality; C100310, 3D construction of Artificial Organs and Simulated Tissues; E031001, Tissue Engineering Material; F012401, Bioelectronics; H1809, Medical Image Data Processing and Analysis; C1003, Tissue Engineering; H2501, Gereology; H0223, Other Scientific Problems of Circulatory System Diseases. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.



**Figure 4** The annual amount of projects and funding for general projects and youth scientist projects in the VHD field of NSFC in 2008–2019. (A) The annual amount of projects; (B) the annual amount of funding. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.



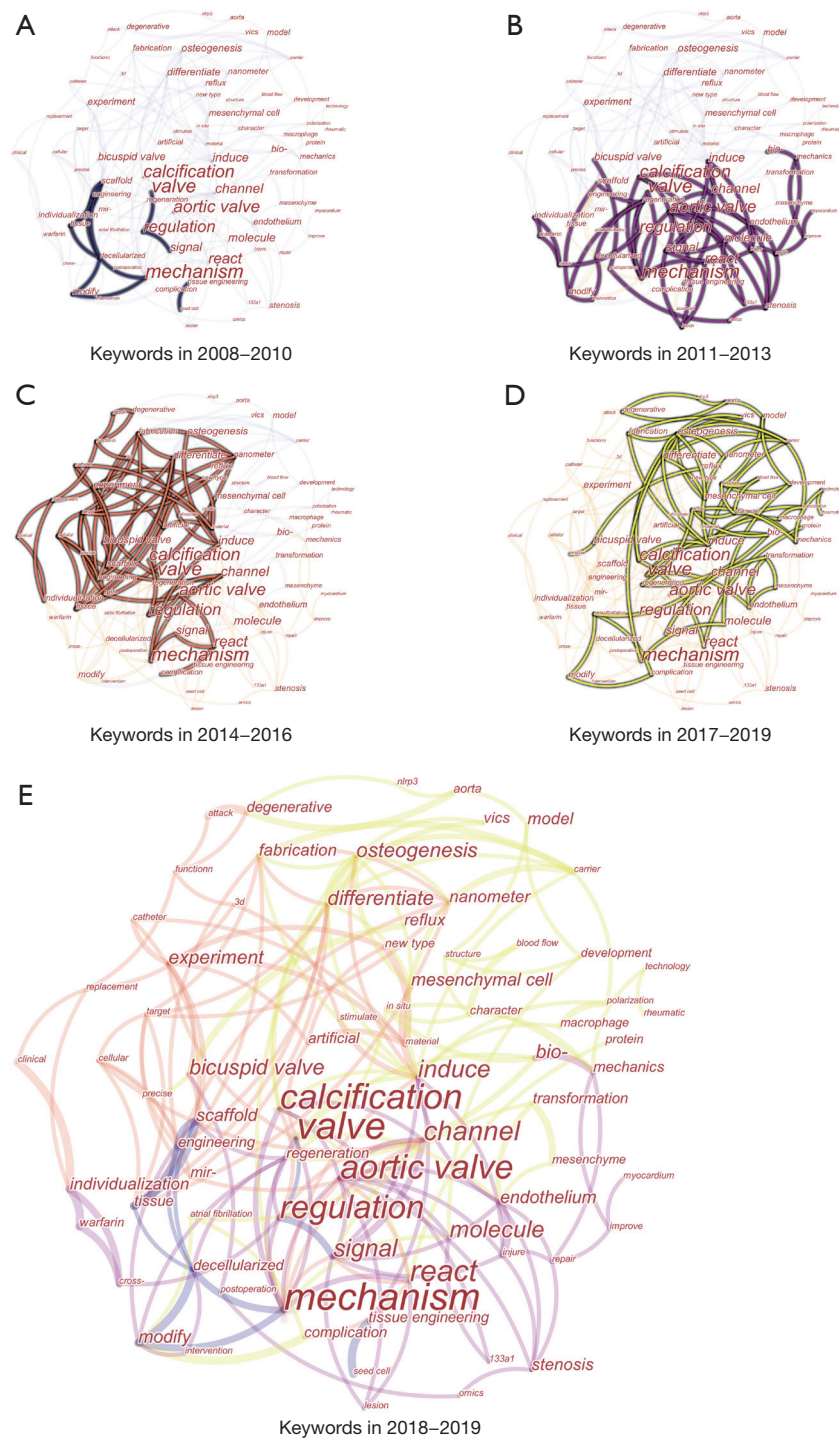
**Figure 5** The amount of projects and funding for each province general projects and youth scientist projects in the VHD field of NSFC in 2008–2019. (A) The amount of projects; (B) the amount of funding. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

limited links with previous keywords, inclined to molecular-biology-based mechanism study for tissue engineering. The keywords of 2017–2019 covered differentiation, osteogenesis, mesenchymal cell, nano-, novel, VICs, mechanics, model and degeneration, squinting towards combination of tissue engineering and deepened mechanism study. It could be learned from complicity and the number of four-period keywords that researches in the field of VHD were from the shallower to the deeper and would become more mature in future. In present, investigators may focus more on the application of new tissue engineering materials in VHD, and predictably the role and mechanism

of different factors in valve calcification will increase the proportion (Figure 6).

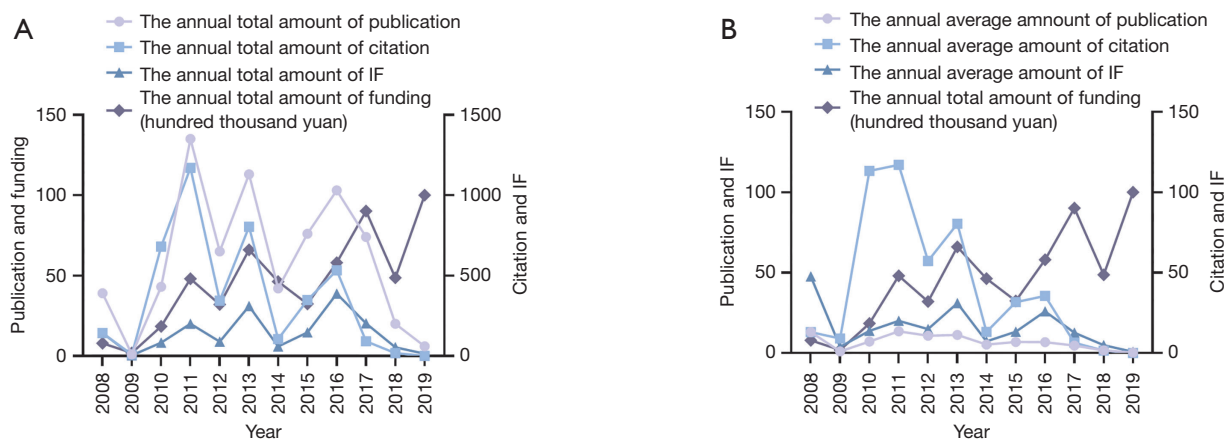
#### *Research output is consistent with input*

In 2008–2016, annual changes in totals and averages of publication, citation and IF were consistent with changes in funding. However, in 2017–2019, projects were still ongoing and the articles are waiting to be produced and cited (Figure 7). From the output analysis of general projects, youth scientist projects and projects for less developed regions, there was no statistical correlation between the



**Figure 6** Keywords in the VHD field of NSFC in 2008–2019. A dot represents a keyword, and a line between dots represents the connection between two keywords. The font size of the word next to the dot represents the frequency of the keyword. The larger the font, the higher the frequency of the keyword. The colors of lines indicate that the connection between the keywords lines represent occurred at different times. Blue represents the connection between the keywords in 2008–2010. Purple represents the connection between the keywords in 2011–2013. Pink represents the connection between the keywords in 2014–2016. Yellow represents the connection between the keywords in 2017–2019. In *Figure 6A* to *Figure 6D*, lines in different colors are made bold to highlight the connections between keywords in different period of time. (A) In 2008–2010; (B) in 2011–2013; (C) in 2014–2016; (D) in 2017–2019; (E) in 2008–2019. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.





**Figure 7** The annual amount of publication, citation, IF and funding in the VHD field of NSFC in 2008–2019. (A) The annual total amount of publication, citation, IF and funding; (B) the annual average amount of publication, citation, IF and the annual total amount of funding. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

**Table 2** Output of projects with different type of project

Terms	General project	Youth scientist projects	Projects for less developed regions	P
N (%)	30 (25.64)	24 (20.51)	4 (3.42)	–
Funding amount (thousand yuan)	560 [380–695 (160–1,500)]	200 [180–230 (170–280)]	420 [340–470 (220–500)]	<0.001
Publication	7 [4–12 (1–28)]	6 [2–12 (0–44)]	10 [9–13 (7–17)]	0.304
Citation	34.50 [7.00–88.75 (0–581)]	25.00 [8.75–84.00 (0–320)]	41.50 [33.50–48.25 (17.00–61.00)]	0.796
IF	8.81 [3.72–16.93 (0.00–79.08)]	13.80 [5.03–20.53 (0.00–155.45)]	16.80 [11.05–19.27 (0.25–20.27)]	0.560

Data represented as median [interquartile range (range)].

amount of output and the amount of funding (*Table 2*).

## Discussion

As is well known, NSFC plays a vital role promoting advancement of science in China, meanwhile NSFC is also regarded as hints of the prospective researches. Hence, it is of great importance to investigate funding of NSFC. This article counted the basic information of 117 projects subsidized by NSFC in the direction of VHD from 2008 to 2019, analyzing the number of bidding projects and the amount of funding from year, institution, subject classification and conditions of general projects as well as youth scientist projects. The year and province of the general projects as well as youth scientist projects were compared. What's more, the keywords analysis of projects' titles was carried out using software. At length, through the above analysis, it was concluded that although the annual number and the amount of funding of approved

projects has fluctuated in recent years, they were on the rise. The principal research institutes were distributed over Hubei, Shanghai and Jiangsu. Institutions with higher total funding in 2008–2019 have better time continuity in approved projects. Applicants with special characteristics, such as senior title, male, clinicians and cardiac surgeon, have applied for more projects with greater amount of funding. Through the analysis of keywords and subject distribution, the researches in the field of VHD were mostly in molecular-biology-based mechanism study and tissue engineering research. In recent years, molecular-biology-based mechanism study based on tissue engineering research has become the principal research hot spot and trend. The annual projects output was related to the fluctuation of annual funding before 2017, while the output beyond 2017 remained to be observed.

The VHD arena has been a remarkably progressive of evolution in recent scores of years, including the new concepts of nature history of disease, improvements in

diagnostic imaging and developments of transcatheter or surgical therapies (9). As such, since 2008 to 2019, the researches progress of NSFC in the field of VHD has been deepening ceaselessly, and the major focus was about aortic valve disease. Especially in the past three years, the proportion of projects related to aortic valve disease was striking. Furthermore, the research center around molecular-biology-based mechanism study and tissue engineering were closely related to the advancement and limitations of current treatments for aortic valve diseases. Prosthetic valve durability and anticoagulation problems in traditional valve replacement surgery bothered both doctors and patients badly. From another side, though TAVI could bring less trauma, several complications and conundrums have been inevitably encountered, such as paravalvular leaks, vascular complications, risk for stroke, permanent pacemaker implantation and so on (10,11). Tissue engineering heart valves with good regenerative potential and biological compatibility may be capable of avoiding age-related degradation and calcification. And it was considered as a latent solution to obtain long-term artificial valve prosthesis, along with profound value of research and broad application foreground. Chinese scholars have engaged a lot in this research, committed to its clinical application and made initial progress (12), however, there was still a long way to go before these researches can be translated into clinical utilization and finally produce tissue engineered heart valves for intervention. The iterative update of tissue engineering heart valves cannot only rely on the renewal of biological materials and the novel design of valve prosthesis structure, but also need to focus on the research of the basic mechanism research closely related to tissue engineering, such as valve cell regeneration, because it is momentous to provide a more solid foundation for tissue engineering heart valves. In this regard, we believe that the combination of tissue engineering and molecular-biology-based mechanism study is still the research hot spot and trend in the next few years, with proteomics and genomics being gradually deepening. Besides, the update of biological tissue engineering materials will be developed towards precision medicine.

In addition, preventive measures and early intervention measures for degenerative valvular disease are still lacking and needed, owing to finite knowledge of pathophysiology of aortic valve degenerative disease and the restricted candidates for aortic valve replacement. In fact, early

prevention and intervention are of great significance in improving the quality of life and life expectancy of patients with degenerative valvular disease. Now there is a consensus that calcific aortic valve disease is an actively multifactor-resulting process rather than a degenerative condition (13,14). On this basic, several researchers have proposed TGF- $\beta$ , G-protein-coupled receptors, Cadherin-11, NOTCH1 mutations and Lp(a) could serve as promising therapeutic targets (15-19). If Chinese scholars increase their investment in the research on the pharmacotherapy of VHD, it is expected to fill the void. On the other hand, improvements of the treatments will directly lead to the development of diagnostic techniques. The diagnosis and grading by Doppler echocardiography and symptoms may not meet the clinical needs in the future. Accordingly, research on new diagnostic techniques and those sensitive and stable markers should also attract the attention of scholars in related fields. For instance, Dweck *et al.* have proposed that  $^{18}\text{F-NaF}$  uptake could represent a novel marker of plaque vulnerability and predict risk of cardiovascular events (20). Oury *et al.* have brought forward that specific miRNA signatures, coupling with imaging data, may be a practicable biomarker for progression of disease or recovery after aortic valve replacement (21). Lindman *et al.* have confirmed the potential value of some biomarkers in helping clinical decision making (22).

## Conclusions

In the present study, a total of 117 projects and affiliated information were obtained and analyzed. The annual amount of projects and funding showed an upward trend. Host institutes were largely distributed among Hubei Province, Shanghai and Jiangsu Province. Applicants with special characteristics, such as senior title, male, clinicians and cardiac surgeon, have applied for more projects and funding. Molecular-biology-based mechanism study based on tissue engineering research has drawn broad concern and focus in the VHD field. The annual project output was related to the fluctuation of annual funding.

In summary, we believe that the treatment goals of VHD are to: come up with prevention and early intervention measures, expand the scope of treatment, improve patients' quality of life, and increase life expectancy. The following projects applying for the NSFC should focus on the aforementioned objectives.

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## Footnote

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/atm.2020.03.165>). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The data comes from the databases, so ethical reviews are exempt.

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**Table S1** The annual amount of projects and funding in the VHD field of NSFC in 2008–2019

Year	Amount of projects	Amount of funding (thousand yuan)
2008	3	790
2009	1	190
2010	6	1,840
2011	10	4,800
2012	6	3,210
2013	10	6,610
2014	8	4,630
2015	11	3,240
2016	15	5,800
2017	16	9,020
2018	12	4,870
2019	19	10,000

VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

**Table S2** The amount of projects and funding for application institution in the VHD field of NSFC in 2008–2019

Institution	Amount of projects	Rank of the amount of projects	Amount of funding (thousand yuan)	Rank of the amount of funding
Huazhong University of Science and Technology	23	1	13,220	1
Shanghai Jiao Tong University	6	4	4,400	2
Nanjing Medical University	8	2	3,150	3
The Second Military Medical University	7	3	3,050	4
Sichuan University	6	5	2,800	5
Nanchang University	4	6	1,730	6
Fuwai Hospital, CAMS & PUMC	3	8	1,500	7
Sun Yat-sen University	3	9	1,470	8
Tongji University	2	13	1,370	9
The Fourth Military Medical University	4	7	1,275	10

VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

**Table S3** The annual amount of projects for application institution in the VHD field of NSFC in 2008–2019

Institution	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	SUM
Huazhong University of Science and Technology	2	–	2	1	1	3	2	3	1	2	2	4	23
Shanghai Jiao Tong University	–	–	1	–	–	–	–	–	1	3	1	–	6
Nanjing Medical University	–	–	–	3	1	–	–	–	–	1	1	2	8
The Second Military Medical University	–	–	–	–	–	2	–	1	1	1	2	–	7
Sichuan University	–	–	–	–	–	–	1	–	1	1	–	3	6
Nanchang University	–	–	–	–	1	–	–	–	1	1	1	–	4
Fuwai Hospital, CAMS & PUMC	–	–	–	–	–	–	1	–	–	–	–	2	3
Sun Yat-sen University	–	–	–	1	1	–	–	–	–	–	–	1	3
Tongji University	–	–	–	–	–	1	–	–	1	–	–	–	2
The Fourth Military Medical University	–	1	1	1	–	–	–	–	1	–	–	–	4
Guangxi Medical University	–	–	–	–	–	–	–	–	1	1	–	1	3
Kunming Medical University	1	–	–	–	–	1	–	–	–	–	–	1	3
Total	3	1	4	6	4	7	4	4	8	10	7	14	72

VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

**Table S4** The amount of projects and funding for subject code in the VHD field of NSFC in 2008–2019

Subject code	Subject classification	Amount of projects	Amount of funding (thousand yuan)
H0210	Valvular Heart Disease	76	31,650
C1002	Biological Materials	4	3,840
H1822	Tissue Engineering and Regenerative Medicine	3	3,630
H0204	Cardiac Dysplasia and Congenital Heart Disease	3	3,470
H0213	Heart/Vascular Transplantation and Assisted Circulation	2	1,140
H1805	Medical Ultrasound and Acoustic Contrast Agents	3	1,110
C100103	Biomechanics and Biorheology of the Blood Circulation System	2	1,000
H0205	Abnormal ECG Activity and Arrhythmia	2	840
H0511	Renal Failure	2	730
H1816	Interventional Medicine and Engineering	1	730
H0222	New Technologies for Diagnosis and Treatment of Circulatory Diseases	1	670
A020501	System Dynamics of Tissue and Organ	1	630
A020415	Computational Fluid Dynamics	1	600
C041103	Experimental Animals	1	600
F030918	Wearable, Medical and Service Robot Systems	1	600
H2005	Clinical Molecular Biological Examination	1	510
A011701	Numerical Calculation of Partial Differential Equations	1	500
E060203	Internal Flow of Fluid Machinery	1	380
C100304	Tissue Engineered Blood Vessels and Myocardium	1	330
A020503	Biomechanics, Biomaterials and Motion Biomechanics	1	280
F012408	Modeling and Simulation of Biological Information System	1	250
F020503	Virtual and Augmented Reality	1	250
C100310	3D construction of Artificial Organs and Simulated Tissues	1	210
E031001	Tissue Engineering Material	1	200
F012401	Bioelectronics	1	200
H1809	Medical Image Data Processing and Analysis	1	200
C1003	Tissue Engineering	1	190
H2501	Gereology	1	160
H0223	Other Scientific Problems of Circulatory System Diseases	1	100

H0210, Valvular Heart Disease; C1002 Biological Materials; H1822, Tissue Engineering and Regenerative Medicine; H020, Cardiac Dysplasia and Congenital Heart Disease; H0213, Heart/Vascular Transplantation and Assisted Circulation; H1805, Medical Ultrasound and Acoustic Contrast Agents; C100103, Biomechanics and Biorheology of the Blood Circulation System; H0205, Abnormal ECG Activity and Arrhythmia; H0511, Renal Failure, H1816, Interventional Medicine and Engineering; H0222, New Technologies for Diagnosis and Treatment of Circulatory Diseases; A020501, System Dynamics of Tissue and Organ; A020415, Computational Fluid Dynamics; C041103, Experimental Animals; F030918, Wearable, Medical and Service Robot Systems; H2005, Clinical Molecular Biological Examination; A011701, Numerical Calculation of Partial Differential Equation; E060203, Internal Flow of Fluid Machinery; C100304, Tissue Engineered Blood Vessels and Myocardium; A020503, Biomechanics, Biomaterials and Motion Biomechanics; F012408, Modeling and Simulation of Biological Information System; F020503, Virtual and Augmented Reality; C100310, 3D construction of Artificial Organs and Simulated Tissues; E031001, Tissue Engineering Material; F012401, Bioelectronics; H1809, Medical Image Data Processing and Analysis; C1003, Tissue Engineering; H2501, Gereology; H0223; Other Scientific Problems of Circulatory System Diseases. VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

**Table S5** The annual amount of projects and funding for general projects and youth scientist projects in the VHD field of NSFC in 2008–2019

Year	General project		Youth scientist projects	
	Amount of project	Amount of funding (thousand yuan)	Amount of project	Amount of funding (thousand yuan)
2008	2	570	0	0
2009	0	0	1	190
2010	5	1,640	1	200
2011	8	4,350	2	450
2012	4	2,520	1	230
2013	4	2,440	4	920
2014	4	3,660	4	970
2015	3	1,590	7	1,270
2016	7	4,110	4	750
2017	10	5,520	4	840
2018	6	3,470	5	1,050
2019	8	4,500	7	1,470

VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.

**Table S6** The amount of projects and funding for each province general projects and youth scientist projects in the VHD field of NSFC in 2008–2019

Province	General project		Youth scientist project	
	Amount of project	Amount of funding (thousand yuan)	Amount of project	Amount of funding (thousand yuan)
Anhui	1	730	0	0
Beijing	5	2,750	2	430
Chongqing	2	1,080	2	460
Fujian	0	0	1	250
Guangdong	4	2,340	3	630
Guizhou	0	0	1	200
Henan	1	730	0	0
Heilongjiang	1	570	0	0
Hubei	13	6,160	11	2,300
Hunan	3	1,830	1	170
Jiangsu	7	4,120	4	810
Jiangxi	1	550	0	0
Liaoning	1	620	2	430
Shandong	1	500	1	230
Shanxi	4	1,960	2	365
Shanghai	13	7,210	4	795
Sichuan	2	2,050	3	650
Tianjing	1	600	1	180
Zhejiang	1	570	2	440

VHD, valvular heart disease; NSFC, National Natural Science Foundation of China.