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Do Research Incentives Promote Researchers' Mental Health?

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ABSTRACT

Background: Researchers have a higher risk of anxiety and depression than the general population, so it is important to promote researchers' mental health. **Method:** Based on the data from 3210 global researchers surveyed by the journal Nature in 2021, confirmatory factor analysis, OLS regression and other regressions were used to explore the research incentive dimensions and their effects on researchers' mental health. **Results:** (1) Material incentive factors, work-family life balance factors, good organizational environment and spiritual motivation had significant positive effects on researchers' mental health. (2) The spiritual motivation could better promote researchers' mental health than the other factors. (3) Heterogeneity analysis showed that material incentive factors and spiritual motivation created more significant stimulating effects on the mental health of humanities and social sciences researchers. Work-family life balance factors were more effective in promoting the mental health of the mid-career group and the overtime group. **Conclusion:** Application of the four research incentives resulted in lower likelihood of anxiety or depression among researchers, and special attention should be paid to the role of the spiritual motivation. In order to promote researchers' mental health, different incentives should be applied to different researcher groups to better improve researchers' mental health.

KEYWORDS

Researchers; mental health; research incentive

Introduction

Researchers constitute the main force in promoting the strategy of innovation-driven development and building China into a strong country in science and technology. Compared with other groups, researchers are often faced with greater challenges and pressure. The "individual combat" and highly unpredictable research results easily produce loneliness and frustration among researchers, and the immeasurable work intensity behind complex experiments and academic production makes their mental state highly strained for a long time. The pressures of academic publication, making an impact, winning grants, seeking tenure, engaging the public, speaking out on social media, and influencing policy—compounded by lonely work environments and rigid hierarchies—have dramatically

increased the frequency of mental health problems among researchers [1]. According to the 2018 "China's National Mental Health Development Report", nearly 25% scientific researchers are prone to depression, and nearly half of them suffer from anxiety in varying degrees. This forms a stark contrast to the nearly ninety percent (88.3%) researchers surveyed in 2009 who reported good mental health [2]. A 2020 Nature survey of 4,000 global scientists found that about 80% of the respondents believed that intense competition deteriorated the work environment, and nearly half reported struggles with depression or anxiety [3]. Researchers' mental health has become an urgent issue for global attention and response.

"Incentive" is regarded as an important breakthrough to relieve the work pressure of researchers, make them maintain enthusiasm and innovation in scientific research work.



According to the viewpoint of organizational management, “incentive” means the efforts made by leaders and managers to mobilize the initiative, enthusiasm and creativity of employees and achieve the dual goals of organizational performance and individual development [4]. Accordingly, research incentive is viewed as the sum of all the material and spiritual conditions that help to stimulate researchers’ enthusiasm and innovation and boost the production and transformation of innovative results. Theoretically speaking, by meeting the internal and external motivation needs of researchers, research incentives can promote mental health. Most countries around the world encourage researchers from the aspects of material support, honorary titles and system guarantees. For example, the “Presidential Award for Young Scientists” (PECASE) set up by the US Federal Government and the National Science Foundation provides staged research grants totaling US \$300,000 to each awarded young scientist over five years [5]. The EU has set up the “Original Innovation Program” for early career and leading academics to support risky and influential research projects. Meanwhile, the EU’s “New Work-Life Balance Directive” issued on August 2019 sets new and stricter rules on parental leave, paternity leave and family care, as well as more flexible working conditions, so that people can better balance work and family life. Since 2018, China has stepped up efforts to reduce the burden and encourage researchers. The “Special Action to Reduce the Burden on Researchers 1.0” (2018), “Special Action to Reduce the Burden on Researchers 2.0” (2020) and the “Special Action to Reduce the Burden on Researchers 3.0” (2022) have been successively promulgated, proposing incentive measures from five aspects: “shouldering the main responsibility, increasing opportunities, reducing assessment, saving time, and strengthening body and mind”.

However, although existing studies have confirmed the promotional effect of incentives on original innovation [6], the extent to which research incentives can promote researchers’ mental health still lacks large-scale data and empirical studies. At the same time, Maslow’s hierarchy of needs theory, two-factor theory and ERG theory all reveal the type structure of incentives. For different groups of scientists, which types of incentives can better improve their mental health level requires further investigation. To investigate these issues, we have used the 2021 global careers job and salary satisfaction survey data of researchers published in *Nature* to empirically analyze the impact of research incentives on researchers’ mental health, and further explore the group heterogeneity behind the effect. The research conclusions are of significance for precisely formulating and implementing incentive policies for scientific research and effectively improving researchers’ mental health.

Literature Review

The existing researches to researchers mainly focus on the dimensions of “burden reduction” [7], “scientific innovation” [8], “achievement transformation” [9] and “scientific research evaluation” [10], with insufficient research specifically focusing on researchers’ mental health which is of vital importance.

Research on the factors influencing mental health is generally carried out on individual factors and environmental factors. In terms of individual factors, the “Mental Health Blue Book: China’s National Mental Health Development Report” released by the Institute of Psychology of the Chinese Academy of Sciences in 2020 shows that an individual’s socioeconomic status, gender and age will all affect his mental health. Comparatively speaking, older groups with higher income, education and occupational prestige report higher levels of mental health [11]. In addition, physical health [12], education level and social interaction [13], social status [14], social support level [15], isolation and perfectionism [16] are also key variables affecting individual mental health. In terms of environmental factors, geographical location, working conditions and environment, and living environment can provide effective prediction of individual mental health status. For example, residents living in towns or in eastern China report higher levels of mental health [17]. The increase in working hours produces a series of effects on workers’ psychology, physiology and work-life balance: Long working hours are considered as the root cause of pain [18], and increased working hours squeeze life time, leading to work-life imbalance [19]. Under mandatory overtime, this imbalance is exacerbated [20], increasing the individual’s risk of mental health problems. Additionally, evidence shows that adversity has a significant positive predictive effect on individual depression and pressure [21].

The factors influencing researchers’ mental health certainly overlap with other populations, such as gender, age, education level, etc., all proven to be individual level factors [22]. However, as the core force in scientific and technological innovation, researchers shoulder important missions, face high pressure and uncertainty in scientific and technological innovation work, leading to group differences in the factors influencing their mental health. This is mainly reflected in environmental factors. Researchers’ mental health is more directly affected by the characteristics, environment and conditions of scientific research at the micro level. To date, the main factors leading to researchers’ mental health deterioration include: difficulty in balancing work and life [23], low social support, high psychological needs and low decision-making power [24], the gap between job income expectation and reality [25], neglect and isolation among peers perceived in scientific research [26], “Inadaptation” with academia [27], negative coping style [28] in case of setbacks and difficulties in work. From the perspective of promoting researchers’ mental health, some studies have found that good working conditions, higher welfare benefits, good remuneration, sound relationship with colleagues [29], as well as scientific research and the innovation atmosphere and rigorous academic atmosphere [30] can effectively improve researchers’ job satisfaction and relieve the sense of depression and anxiety at work. These factors with a positive impact on researchers’ working enthusiasm and innovation vitality are called “motivators” in the field of organizational management and behavioral science. However, in the field of research on researchers’ mental health, insufficient attention is given to motivating factors and there is a lack of systematic sorting from the theoretical perspective.

To sum up, compared with the attention paid to the mental health of other groups, insufficient research has been done on the factors influencing researchers' mental health; studies are mainly based on the analysis of small sample survey results, lacking the empirical support of large-scale transnational data. Secondly, existing studies have observed the explanatory validity of incentive factors with regard to researchers' mental health, but researches are scattered and lack systematic theoretical construction. In view of this, proceeding from the incentive theory, this study systematically analyzes the incentive factors for scientific research, including the group heterogeneity reflected in the effects of research incentives on researchers' mental health.

Theories and Research Hypothesis

Motivation theory is an important theory in management, psychology and behavioral science. So far, there has been a basic consensus that the concept of incentive has multiple dimensions and levels [31]. Maslow's "Hierarchy of Needs Theory" is a representative of the early incentive theories, which divides human needs into five levels: physiology, safety, social interaction, respect and self-fulfillment. After the realization of lower level needs, a higher level of needs will form, which is both a process of demand satisfaction and a process of motivation [32]. Based on Maslow's hierarchy of needs theory, Clayton Alderfer proposed a new humanistic theory of needs, which divides people's core needs into Existence, Relatedness and Growth needs. However, in contrast to Maslow who believed that people's need satisfaction followed the rigid ladder rise pattern, Alderfer argued that people may have more than one needs at the same time. If the satisfaction of higher level needs is inhibited, then people will develop more intense desire for lower level needs [33]. Herzberg's "two-factor theory" refers to the factors that can affect employee satisfaction and stimulate work enthusiasm as "motivating factors", and names the environment-related factors including company's policies and management style, superior supervision, wages and benefits as "health factors" which easily cause employee dissatisfaction and cannot stimulate work enthusiasm [34]. Pinder divided incentives into external incentives and internal incentives. External incentives include salary incentives, assessment incentives and promotion incentives, while internal incentives include innovation incentives, achievement incentives and social incentives. He believed that internal incentives performed better than external incentives [35].

Despite the different structural dimensions of motivation concepts in the above theories, there are some intersections and overlaps, which are enlightening for understanding research incentive in the field of scientific research. Nonetheless, there are some limitations: first, the deconstruction of the research incentive dimensions needs to be discussed in the context of scientific research; second, the above motivation theories tend to focus on the motivation of individual behavior, but the extent to which it can promote individual mental health remains to be verified. Therefore, based on the "total life space" of researchers, our

study used incentive theory to systematically sort out the incentive factors for researchers in existing researches and policies, divided the research incentives into four levels, material incentive factors, work-family life balance factors, organizational environment and spiritual motivation, to explore the effects of different dimensions of research incentive on researchers' mental health.

The effect of material incentive factors on researchers' mental health

Material incentive factors are the basic element of research incentives, including salary, benefits, research funds, organizational financial resources. Several studies have noticed the important impact of material incentive factors on the mental health of workers in general. A meta-analysis' reveals the negative impact of lower income on mental health exceeds the positive effect of higher income on mental health [36]. Meanwhile, income inequality poses a far greater threat to mental health than it does to physical health [37]. This study hereby infers that, compared to the general staff, researchers have higher reliance and demand for material incentive factors such as research start-up funds and organizational financial resources. Scientific research funds and organizational financial resources create hard constraint conditions in scientific research activities, which decide the feasible activities and achievement space of scientific research. In particular, research in the field of natural science has a rigid demand for research funds and advanced instruments, equipment and laboratories. In case of insufficient research funds and infrastructure support, it will be difficult for researchers to carry out research according to their own planning and needs, and there is very little possibility of completing research results with significant innovative value, so they will naturally feel frustrated, powerless and anxious, which affects mental health. Hence, by strengthening the material financial incentives for researchers and providing guarantee for the continuous development of scientific research work, it will help reduce the anxiety and sense of powerlessness among researchers [38]. In view of this, hypothesis H1 is proposed.

H1: Material incentive factors create a positive impact on researchers' mental health.

The effect of organizational environment on researchers' mental health

Organizational environment motivation refers to the factors that can stimulate researchers' working enthusiasm and creativity in the organizational environment, including interpersonal relationships, working environment and conditions, organizational culture and development prospects. Existing studies have shown that organizational environment, interpersonal relationship, work pressure and job expectation have significant effects on employees' mental health [39]. Good interpersonal relationships can not only improve mental health, but also indirectly improve individual life satisfaction [40]. Under more comfortable and safer perceived working environment, the job burnout sense is lower and mental health is better [41]. Uncomfortable environments will trigger individual defense mechanisms and associated stress responses that can lead to

stress or anxiety [42]. In addition, some studies have also noticed the impact of organizational culture on employees' mental health, finding that good organizational cultures can relieve employee burnout, depression and other psychological distress [43]. The diverse, inclusive and innovative organizational culture constitutes a hidden mechanism that tolerates mistakes and failures, encourages highly uncertain scientific research, reduces researchers' frustration when they fail and increases their confidence and enthusiasm for scientific research. Therefore, hypothesis H2 is proposed.

H2: Good organizational environment which is comfort, safe and inclusive create a positive impact on researchers' mental health.

The effect of Work-Family Life Balance Factors on Researchers' Mental Health

The work-family balance factor advocates giving researchers more time off and more opportunities to return to family life. A study examining scientists' work patterns finds that, overtime at night and intense work have become the norms for scientists [44]. Academic career and family life are important components of the "total life space" of researchers. Researchers not only undertake scientific and technological innovation work to pursue self-value and a sense of achievement, but also want more time to take on family responsibilities and feel emotionally attached to family members. Excessive dedication to research work means that the time and energy for family and personal life is lost, which easily leads to the imbalance and conflict between the two roles. Low work efficiency and unbalanced family relations make researchers feel irreconcilable pressure and prone to negative emotions such as anxiety, tension and distress [45]. Greenhaus believed that work-life balance can allow the relationship between the two roles to reach a harmonious state [46]. If resources dominated by one role can fully meet the needs of the other role, individuals can perform the two roles more effectively [47]. Accordingly, it can be inferred that work-family life balance factors can effectively transform the loss of family role and work role into gains, increase researchers' happiness index and promote their mental health. Based on this, hypothesis H3 is proposed.

H3: Work-family life balance factors create a positive impact on researchers' mental health.

The effect of spiritual motivation on researchers' mental health

Spiritual motivation is a kind of internal motivation. It can be achieved by giving researchers autonomy and opportunities to conduct interesting and meaningful research, or gaining a sense of accomplishment and honor. Scientific research achievements carry the condensed wisdom and sweat of researchers. Through transformation and implementation, other applied research contributes to the national science and technology strategy as well as social and economic development. Regardless of its forms, it is an important way for researchers to achieve self-worth, gain a sense of efficacy and achievement. In addition, the autonomy of researchers, especially their freedom to choose interested research subjects, is more evident in academia than in any other field, which is the main reason why researchers choose to

pursue research and strive for it all their lives [48]. It is thus inferred that, autonomy, efficacy, achievement, recognition and value realization are important psychological needs and internal motivations for researchers. When the ability needs, relational needs and autonomy needs are met, there will be higher degree of individual self-motivation and mental health [49]. Based on this, hypothesis H4 is proposed.

H4: Spiritual motivation create a positive impact on researchers' mental health.

Heterogeneous Effects of Different Research Incentive Dimensions on Researchers' Mental Health

Researches have shown that internal motivation is superior to external motivation for researcher's behavior, and the most important part of internal motivation is growth incentive, that is, the growth and transformation of oneself in research work [50]. Weber regarded "academy" as a kind of aspiration, a profession to be engaged in under the call of God [51]. With a strong spiritual value implication, such spiritual demand is "the passion for justice behind reason, the thirst for truth behind science, and the longing for better things behind criticism" [52]. Accordingly, researchers generally have a high level of cultural cultivation and spiritual pursuit, who often work hard under their interest in scientific research, self-psychological satisfaction, and pursuit of good reputation. Although most of the time, they only toil in silence, when years of research work are completed, they often create great academic value and practical significance [53], gain a great sense of self-efficacy, which creates positive implications for mental health. In view of this, hypothesis H5 is proposed.

H5: The effect of different research incentive dimensions on researchers' mental health is heterogeneous, and spiritual motivation is superior to material incentive factor.

Group Heterogeneity in the Effect of Research Incentive on Researchers' Mental Health

Different groups and different professions have different working environment, work pressure and different types of needs, which lead to heterogeneous effects of incentives on mental health. First, disciplinary attributes and fields constitute a natural dividing line for researchers. Different disciplinary cultures, knowledge production methods and work characteristics create researchers with different demand tendencies. Compared with science and engineering disciplines, emotions have a more central importance for humanities and social sciences, and sensitive and emotional humanities and social sciences researchers focus more on spiritual satisfaction [54]. That is, researchers in different discipline fields may have different responsiveness to mental health incentives. Second, researchers have to go through different career stages, and those in different career stages may have different types of reliance on mental health incentive factors. Early in their careers, survival pressure makes researchers place more emphasis on material incentive factors, and as most scientists move into mid-career, family plays a more important role in their identity construction and self-expression [55]. The pursuit for spiritual incentive may be greater in later career. Finally, work overtime is the norm for researchers. In 2020,

CACTUS surveyed the “Overtime Map” of the world, finding that 31% researchers work more than 50 h per week and 13% work more than 60 h per week [56]. In this survey, 61% of mid-career researchers worked more than their contract work hours. In the most serious case, some work more than 80 h per week. Overtime is essentially a drain on work enthusiasm and can significantly reduce job satisfaction and sense of efficacy. Researchers who work overtime frequently may need to find physical and mental comfort and rest from other channels, so family becomes the “haven” for them to relieve stress. It can be thus inferred that researchers who work overtime frequently more need to be motivated by the family-work balance factors. In view of this, hypothesis H6 is proposed.

H6: Research incentive has heterogeneous effects on researcher groups.

H6a: Research incentive has heterogeneous effects on researchers of different disciplines.

H6b: Research incentive has heterogeneous effects on researchers of different career stages.

H6c: Research incentive has heterogeneous effects on researchers with different work intensities.

Research Design

Data source

The data used in this study came from the Nature Careers job and salary satisfaction survey 2021. The questionnaire covered the subjects of personal background information, basic job information, salary and job satisfaction of scientific researchers, and a total of 3210 valid samples were studied, including professors, lecturers, post-doctors, researchers, etc. Among them, American samples accounted for 31.46% (1,010 people), British samples accounted for 13.64% (438 people), German samples accounted for 5.73% (184 people), Chinese (mainland) samples accounted for 4.58% (147 people), Spanish samples accounted for 3.46% (111 people), Canadian samples accounted for 3.43% (110 people), Brazilian samples accounted for 3.33% (107 people), Australian samples accounted for 3.15% (101 people) and samples of other countries accounted for 31.22% (1002 people). In terms of gender, 48.44% (1,555) were male and 49.16% (1,578) were female.

Variable measurement and descriptive statistics

Explained variable

The explained variable was researchers’ mental health, which was represented by the respondents’ 9 self-stated test items of “frequency of anxiety and depression”. 1–5 points were given based on scale from “always” to “never”. A higher score indicated better mental health.

Explanatory variable

The explanatory variable was research incentive, which was measured by respondents’ 19 self-stated satisfaction measures of “research incentive”. 1–5 points were given based on scale from “very dissatisfied” to “very satisfied”. A higher score indicated better outcome of the research incentive measures.

Control variable

Considering the complex and diverse factors affecting mental health, factors that can affect mental health such as age, gender, residential area, work form, scientific research field, expectation fulfillment degree and career stage were included as control variables on the basis of data availability in order to reduce the endogenous problems caused by missing variables. For points, (1) Ages “18–21” “22–25” “26–30” “31–40” “41–50” “51–60” “61–70” “71–80” “80+” were assigned values of 1–9 points respectively; (2) In terms of gender: 0 was assigned to female and 1 to male; (3) In terms of residential area: 0 was assigned to Asia, 1 to Europe, 2 to Africa, 3 to America and 4 to Oceania; (4) In terms of work form, 0 was assigned to freelance work, 1 to contract full-time job, 2 to contract part-time job, 3 to permanent full-time job, 4 to permanent part-time job; (5) In terms of scientific research field, 0 was assigned to humanities and social sciences, 1 to science and engineering, 2 to agricultural food, 3 to medicine and health, and 4 to others; (6) In terms of expectation fulfillment degree, 1 was assigned to unfulfilled, 2 to uncertain, and 3 to fulfilled; (7) In terms of career stage, the early, middle and late stages were assigned values of 1–3, respectively. The descriptive statistics of the variables are shown in Table 1.

Analytical methods

Since many variables are involved in research incentives and mental health and a strong correlation is exhibited, this study first adopted exploratory factor analysis to reduce and simplify the structure of research incentive and mental health variables. At the same time, confirmatory factor analysis tested the reliability and validity of the measurement model to guarantee the analysis foundation of this study. Then, OLS regression and quantile regression models were used to measure the impact of research incentives on researchers’ mental health and verify the robustness of the results. Finally, grouping regression and seemingly unrelated regression were used to thoroughly analyze the group heterogeneity behind the effects of various research incentive dimensions on mental health.

Results of Empirical Analysis

Reliability and validity test

This study tested the reliability and validity of research incentive and mental health scales, finding that the Cronbach’s α internal consistency coefficients of each scale were 0.948 and 0.886. KMO values reached 0.914 and 0.892, and Bartlett’s sphericity test was significant, indicating that the measurement items had good reliability and validity for factor analysis. The results of exploratory factor analysis showed that, after excluding the test items with unqualified factor loading¹, research incentive is divided into four dimensions, which are named according to the content of the test items: material incentive factors, work-family life balance factors, spiritual motivation and good organizational

¹ The three test items, “supervisor guidance”, “relationship with colleagues” and “communication with supervisor”, were excluded.

TABLE 1

Variable description and descriptive statistics

Variable name	Sample size (N)	Mean	Standard deviation
Mental health			
MH1. I feel exhausted	3160	2.82	1.03
MH2. I lack empathy	3144	3.58	0.99
MH3. I easily get irritated by my colleagues	3155	3.53	0.99
MH4. My colleagues don't appreciate me	3148	3.51	1.16
MH5. I feel lonely	3152	3.48	1.25
MH6. I feel underachieved	3162	2.75	1.20
MH7. I don't feel like getting what I want from my job	3158	3.02	1.20
MH8. I feel like being in the wrong organization and profession	3143	3.55	1.29
MH9. I feel like lacking motivation and willingness to complete part of the work	3159	3.31	1.16
Research incentive			
RI1. Salary/compensation	2905	3.16	1.33
RI2. Benefits (protection system such as insurance)	2434	3.47	1.25
RI3. Availability of research funding	2341	3.00	1.28
RI4. Organizational financial resources	2548	3.21	1.28
RI5. Small scale benefits	907	2.93	1.29
RI6. Supervisor instruction	1940	3.40	1.32
RI7. Work-life balance	2940	3.47	1.26
RI8. Work-family compatibility	2188	3.43	1.29
RI9. Maternity/paternity leave	1295	3.41	1.28
RI10. Vacation	2710	3.79	1.18
RI11. Work interest	3124	4.05	1.09
RI12. Job significance	3050	3.95	1.13
RI13. Earned achievement	3089	3.71	1.21
RI14. Degree of independence	3000	4.01	1.06
RI15. Work environment safety	2712	3.94	1.13
RI16. Workplace comfort	2484	3.48	1.19
RI17. Organizational diversity and inclusion	2389	3.28	1.21
RI18. Organizational environmental sustainability	2453	3.25	1.16
RI19. Relationship with colleagues	2699	3.63	1.17
RI20. Communication with supervisor	2529	3.50	1.29
Control variable			
Age	3184	4.62	1.28
Gender	3133	0.50	0.50
Residential area	3204	1.87	1.20
Work form	3172	2.29	1.00
Scientific research field	3210	2.06	1.16
Expectation fulfillment degree	3210	2.51	0.81
Career stage	3176	1.78	0.75

environment. This is consistent with the theoretical construction of research incentive, and the cumulative variance of interpretation reaches 72.84%. Confirmatory factor analysis and correlation analysis were performed on the above analysis results, with the test results of fitness of the measurement model shown in Table 2. The factor loading of each measurement item was above 0.5, the α

coefficients of all subscales were above 0.78, the construction reliability (CR) was above 0.7, the aggregation validity (AVE) was above 0.4. In terms of the overall fitness index, most values of absolute fitness index, value-added fitness index and simplified fitness index meet the standard [57], the measurement model in this study has good overall fitness. Moreover, the square root of AVE exceeds the

TABLE 2

Confirmatory factor analysis, reliability and validity index and correlation of variables

Measurement	MI	BWF	SM	OEI	MH	Factor loading	CR	α	Fitting degree
MI	0.74					0.535~0.788	0.825	0.788	CMIN = 687.975, GFI = 0.975, RMR = 0.050, RMSEA = 0.047; NFI = 0.970, RFI = 0.960, IFI = 0.974, TLI = 0.965, CFI = 0.974; CMIN/DF = 7.730
BWF	0.430**	0.750				0.619~0.881	0.830	0.888	
SM	0.377**	0.441**	0.833			0.677~0.911	0.900	0.886	
OEI	0.468**	0.471**	0.466**	0.654		0.560~0.716	0.747	0.825	
MH	0.348**	0.418**	0.536**	0.408**	0.661	0.534~0.732	0.874	0.885	
									CMIN = 105.959, GFI = 0.993, RMR = 0.020, RMSEA = 0.043; NFI = 0.992, RFI = 0.980, IFI = 0.993, TLI = 0.983, CFI = 0.993; CMIN/DF = 7.064

Notes: (1) As the factor loading was below 0.5, the small scale welfare test item was deleted. (2) Material incentive factors (MM) include RI1–RI4, work-family life balance factors (BWF) include RI7–RI10, Spiritual motivation(SM) includes RI11–RI14, Good organizational environment incentive (OEI) includes RI15–RI18, Mental health (MH) includes MH1–MH9. (3) ** indicates significant correlation at the 0.01 level (bilateral), and the diagonal is the square root of the convergent validity of the variable.

correlation coefficient among variables, indicating that the model has a good discriminative validity.

Regression results

Results of full sample regression

Based on the consideration of control variables, the estimation results of baseline regression and quantile regression are shown in Table 3. According to the baseline model, research incentives such as material incentive factors, work-family life balance factors, spiritual motivation and good organizational environment which is safe, comfort and inclusive can effectively promote researchers' mental health, in which, spiritual motivation exerts significantly higher effect than other factors. Hypothesis H5 is supported. According to the quantile regression results, for researchers with different mental health levels, all the four research incentive dimensions have significant positive effects on the

researchers' mental health, which indicates robustness of the baseline regression results, so hypotheses H1–H4 are supported.

Grouping regression results

In order to further verify the group heterogeneity behind the effect of research incentives on researchers' mental health, this study conducted grouping regression for the researcher groups in different research fields and career stages who "work overtime or not". The seemingly uncorrelated model was used to compare the differences in the effects of the mental health factors for different researcher groups.

(1) Grouping regression of scientific research field

The regression results regarding the influence of research incentives on mental health of groups in different research fields are shown in Table 4. For researchers in the field of humanities and social sciences, material incentive factors, as

TABLE 3

Full sample regression coefficient table

Variable	Baseline regression	Quantile regression				
		Q10	Q25	Q50	Q75	Q90
Material incentive factor	0.078*** (0.014)	0.087*** (0.026)	0.095*** (0.019)	0.094*** (0.016)	0.066*** (0.017)	0.051** (0.025)
Work-family life balance factor	0.113*** (0.014)	0.067*** (0.025)	0.096*** (0.019)	0.129*** (0.016)	0.145*** (0.017)	0.146*** (0.025)
Spiritual motivation	0.312*** (0.015)	0.343*** (0.028)	0.339*** (0.021)	0.362*** (0.018)	0.312*** (0.019)	0.259*** (0.028)
Good organizational environment	0.104*** (0.016)	0.130*** (0.029)	0.138*** (0.022)	0.088*** (0.019)	0.101*** (0.020)	0.061** (0.029)
Control variable	Control	Control	Control	Control	Control	Control
Intercept term	0.505*** (0.154)	-0.673** (0.287)	-0.336 (0.218)	0.472** (0.183)	1.097*** (0.196)	1.681*** (0.284)
N	2828	2828	2828	2828	2828	2828
R ²	0.40	0.24	0.25	0.26	0.24	0.20

Notes: The dependent variable is mental health, * means $p < 0.1$, ** means $p < 0.05$, *** means $p < 0.01$, with regression coefficient standard error in the parentheses.

TABLE 4
Grouping regression coefficient table of scientific research fields

Variable	Humanities and social sciences	Science and engineering
Material incentive factor	0.164*** (0.056)	0.071*** (0.015)
Work-family life balance factor	0.013 (0.055)	0.111*** (0.014)
Spiritual motivation	0.423*** (0.059)	0.302*** (0.016)
Good organizational environment	0.097 (0.061)	0.111*** (0.017)
Control variable	Control	Control
Intercept term	0.134 (0.563)	0.653*** (0.170)
N	198	2464
R ²	0.50	0.40
<i>p</i> value of inter-group difference		
Humanities and social sciences vs. science and engineering	Material incentive factor	0.087
	Work-family life balance factor	0.073
	Spiritual motivation	0.039
	Good organizational environment	0.791

Notes: * means $p < 0.1$, ** means $p < 0.05$, *** means $p < 0.01$, with regression coefficient standard error in the parentheses.

well as spiritual motivation can effectively promote their mental health, but work-family life balance factors and good organizational environment incentive have insignificant influence. In the group of science and engineering, all the four research incentive dimensions have a significant positive impact on researchers' mental health. Compared with researchers in the field of science and engineering, material incentive factors, as well as spiritual motivation play a more significant role in promoting the mental health of researchers in the field of humanities and social sciences,

but work-family life balance factors have a significantly lower effect. Hypothesis H6a is supported.

(2) Grouping regression of career stage

The regression results regarding the influence of research incentive on mental health in different career stage groups are shown in Table 5. For researchers in the early and middle career stages, different types of research incentives can effectively reduce mental health problems such as depression and anxiety brought by research work. For the late career stage group, material incentive factors could not

TABLE 5
Grouping regression coefficient table of career stage

	Early	Middle	Late	
Material incentive factor	0.100*** (0.021)	0.066*** (0.022)	0.050 (0.033)	
Work-family life balance factor	0.079*** (0.020)	0.153*** (0.022)	0.101*** (0.035)	
Spiritual motivation	0.324*** (0.023)	0.301*** (0.024)	0.284*** (0.037)	
Good organizational environment	0.104*** (0.023)	0.109*** (0.025)	0.108*** (0.038)	
Control variable	Control	Control	Control	
Intercept term	0.149 (0.328)	0.614** (0.243)	0.678* (0.372)	
N	1213	1096	519	
R ²	0.38	0.43	0.37	
<i>p</i> value of inter-group difference				
Early vs. middle	Material incentive factor	0.281	Spiritual motivation	0.483
	Work-family life balance factor	0.013	Good organizational environment	0.899
Early vs. late	Material incentive factor	0.199	Spiritual motivation	0.387
	Work-family life balance factor	0.595	Good organizational environment	0.948
Middle vs. late	Material incentive factor	0.678	Spiritual motivation	0.791
	Work-family life balance factor	0.192	Good organizational environment	0.977

Notes: * means $p < 0.1$, ** means $p < 0.05$, *** means $p < 0.01$, with regression coefficient standard error in the parentheses.

effectively improve the mental health level. By comparing the different effects on different groups, it was found that work-family life balance factors could more significantly promote mental health of researchers in the middle career stage than those in the early career stage. For researchers in the middle career stage, attention should be paid to the role of work-family life balance factors in promoting their mental health. Hypothesis H6b is supported.

(3) Grouping regression of overtime

The regression results regarding the influence of research incentive on mental health of groups “who work overtime or not” are shown in Table 6. In the group that does not work overtime, except that work-family life balance factors could not bring significant positive impact on mental health, all the other incentives could effectively improve researchers’ mental health. For the overtime group, the four research incentives could significantly promote their mental health. By comparing the different effects on different groups, it was found that work-family life balance factors had a greater positive promoting effect on the mental health of researchers who work overtime than those who do not. Hypothesis H6c is supported.

Conclusion and Discussion

This study aims to explore the dimensions of research incentives and their promoting effects on researchers’ mental health, and to identify which incentive factors are more effective for different researcher groups. Based on the salary and satisfaction survey data of Nature global academia in 2021, factor analysis, OLS regression and seemingly uncorrelated regression were used. The expected research objectives are attained, with the main conclusions and discussions shown as follows:

First, research incentives can promote researchers’ mental health, and these incentives are multi-level, including material incentive factors, work-family life balance factors,

good organizational environment which is comfort, safe and inclusive and spiritual motivation. Multi-dimensional incentives can accurately target the researchers’ needs at different levels, strengthen their material life and work security, enhance their sense of control over the balance between family life and work, increase their job embedding satisfaction and strengthen their self-identification, effectively improve their sense of research efficacy and motivation for innovation, reduce research pressure and “concerns”, so that researchers devote themselves to research, which significantly reduces the likelihood of mental health problems such as anxiety or depression. In fact, the four types of research incentives belong to the same incentive system and display a certain hierarchical structure, but the different types of incentives do not show a “rigid ladder rise pattern”, but have complex correlations and jointly impact researchers’ mental health. If the intensity of incentive is reduced in one aspect, it may affect the incentive of other dimensions, thus weakening the overall positive impact of research incentive on researchers’ mental health. For example, when researchers face the pressure from salary and research funds, they may reduce the amount of research work they are interested in or recognize, turn to research projects not in line with their own research interests, expertise and value recognition, but are easier to access funding. In this way, they feel greatly reduced sense of meaning and achievement in the completion of such research, with emotional labor greatly increased. In the long run, researchers will have a sense of job burnout and powerlessness, finding it difficult to maintain mental health. In view of this, it is recommended to adopt the perspective of overall quality management and plan the four incentive measures for scientific researchers as a whole, focus on the national major strategic needs and the basic science frontiers, so as to encourage scientific researchers in a long-term and stable way. For instance, we should provide adequate research funds and competitive work income for

TABLE 6

Grouping regression coefficient table of overtime

Variable	Non-overtime	Overtime
Material incentive factor	0.087*** (0.023)	0.069*** (0.017)
Work-family life balance factor	0.038 (0.027)	0.126*** (0.017)
Spiritual motivation	0.351*** (0.026)	0.301*** (0.019)
Good organizational environment	0.107*** (0.027)	0.105*** (0.019)
Control variable	Control	Control
Intercept term	0.832*** (0.251)	0.320 (0.195)
N	1051	1777
R ²	0.38	0.41
<i>p</i> value of inter-group difference		
None-overtime vs. overtime	Material incentive factor	0.516
	Work-family life balance factor	0.004
	Spiritual motivation	0.138
	Good organizational environment	0.942

Notes: * means $p < 0.1$, ** means $p < 0.05$, *** means $p < 0.01$, with regression coefficient standard error in the parentheses.

researchers, establish and improve the welfare and vacation system for researchers, create an atmosphere for independent innovation and research, build a free and inclusive academic environment, deepen research evaluation methods, and improve their research efficacy, job satisfaction and happiness index.

In addition, the study found that spiritual motivation was particularly effective in improving researchers' mental health. Researchers' unique spiritual needs are satisfied, and achievement of a sense of accomplishment and self-worth will significantly reduce the probability of anxiety and depression. In view of this, it is suggested that national research fund projects should cover more subjects that meet national needs, bridge regional development and boost economic and social changes to better let scientific research serve the economy and society. It is recommended to create a research atmosphere in universities and other institutions that advocates free exploration among researchers, encourage researchers to conduct research based on their interests, and strengthen spiritual motivations by praising advanced research and popularizing typical examples.

Second, material incentive factors, work-family life balance factors, good organizational environment and spiritual motivation exert varying effects on different groups of researchers. Firstly, by comparing the effects of research incentives in different research fields, it was found that mental health of researchers in humanities and social sciences was more dependent on material incentive factors and spiritual motivation than science and engineering groups. However, work-family life balance factors did not show such an effect. Researchers in the humanities and social sciences have less overtime work and smaller workload on average, and accordingly less material incentives from salary, funds and transformation of scientific research results. According to the viewpoint in economics that "scarcity determines value", the lack of material capital among researchers in the humanities and social sciences naturally becomes an important demand orientation. Gaining it is of great value in promoting mental health. In view of this, it is suggested that targeted measures should be taken for researchers in different disciplines. On the one hand, salaries, research funds and spiritual rewards for researchers in humanities and social sciences should be increased to stimulate their creativity and motivation for research. On the other hand, the welfare, vacation system security for researchers in the field of science and engineering should be improved to let them better balance work and life.

In addition, the grouping regression on researchers at different career stages who work overtime or not verified the group heterogeneity behind the influence of work-family life balance factors on mental health: researchers in the "middle career stage" and those who "work overtime" were more dependent on work-family life balance factors than those in the "early career stage" and those who do not "work overtime". In general, maintaining a balance between professional work, family life and self-development is particularly important for mid-career scientists. Nevertheless, the pressure of performance appraisal and the need for career promotion force researchers to over-spend

time and energy on work, making them physically and mentally exhausted, so that they feel powerless in family life and self-development. Hence, for these researchers who are overworked or in the middle career stage, in addition to spiritual motivation, more attention should be paid to the promoting effect of work-family life balance factors on mental health. This suggests that we should improve the human resource management system of scientific research personnel, and let them get rid of the tournament mechanism of employment, assessment, promotion. In addition, the vacation and welfare system should be improved to give researchers, especially those who are overworked and those in the middle career stage, more time and energy to return to family life, so that they find a stable balance between work, life and self-development after work.

On the whole, compared with the existing literatures on the same topic, this study has the following marginal contributions: First, the global large-scale survey data verified that spiritual incentive factors can better promote researchers' mental health than material incentive factors; Second, it is proposed that targeted measures should be taken to improve the mental health level of researchers in different career stages. For mid-career researchers, the incentive effect of work-family life balance factors should be particularly emphasized. For researchers in later careers, material incentives could not effectively promote mental health. Third, it is necessary to determine effective factors in improving the mental health of researchers in different disciplines via a targeted manner. For researchers of humanities and social sciences, material incentive and spiritual motivation are important factors in promoting mental health. By contrast, science and engineering researchers can effectively improve their mental health through the four dimensions of research incentives, and work-family life balance factors create significantly greater effect on science and engineering researchers than on humanities and social sciences researchers.

Research limitations and prospects

Limited by the research topic and data, this study has some limitations, which requires further exploration. First, the difference comparison of the effects of research incentives on mental health promotion of different groups lacks the comparison of different countries. Due to the differences in economic, social, scientific and technological development stages, cultural differences, different scientific research levels and other realistic environments in different countries, researchers present different demand tendencies. In view of this, future research should explore which incentive factors are more effective in promoting the mental health of researchers in different countries, such as developed and developing countries. Second, there is a lack of diachronic monitoring of researchers' mental health level and the factors affecting the changes are not analyzed. In the future, we will collect and sort out the data of Nature's global academic salary and satisfaction survey over the years and construct panel data sets for analysis to make up for the shortcomings of this study.

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