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Article

The role of incentive mechanisms and intellectual property awareness in retaining R&D personnel in Chinese biopharmaceutical companies: the mediating role of perceived R&D staffing adequacy

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Abstract: Retaining research and development (R&D) personnel is a strategic challenge for Chinese biopharmaceutical companies because innovation depends on cumulative knowledge, long project cycles, and stable interdisciplinary teams. This study examines how career satisfaction, incentive mechanisms, intellectual property awareness, psychological contract fulfillment, and team collaboration influence R&D personnel retention, with perceived R&D staffing adequacy as a structural mediator. Data were obtained from 650 valid questionnaires collected from R&D employees in 27 biopharmaceutical companies; 900 questionnaires were distributed, yielding a 72.2% valid response rate. Regression, mediation, and firm-size subgroup analyses were conducted. The results show that all five antecedents are positively associated with retention. Career satisfaction has the strongest direct association, followed by psychological contract fulfillment, incentive mechanisms, intellectual property awareness, and team collaboration. Perceived staffing adequacy significantly transmits the associations of career satisfaction and incentive mechanisms with retention, while the continuing significance of the corresponding direct paths is consistent with partial mediation. Firm-size comparisons suggest that career satisfaction, incentives, and staffing adequacy are more salient in small and medium-sized enterprises, whereas intellectual property awareness is more salient in large enterprises. The findings extend strategic human resource management research by connecting motivational, relational, intellectual-property, and workforce-planning mechanisms in an innovation-intensive setting.

Keywords: R&D personnel retention, strategic human resource management, incentive mechanisms, intellectual property awareness, psychological contract, staffing adequacy

1. Introduction

Biopharmaceutical innovation relies on highly specialized employees whose tacit knowledge, scientific networks, and accumulated project experience are difficult to replace. Human capital and organizational learning perspectives therefore treat the retention of R&D personnel as a strategic capability rather than a routine staffing issue [1–4]. Recent research also emphasizes that turnover among STEM and R&D employees is shaped by career opportunities, work design, organizational attachment, and the management systems surrounding creative work [5–8].

R&D retention is analytically distinctive because the value of scientific employees is simultaneously individual and collective. Researchers carry portable expertise, credentials, and external professional networks, yet much of the knowledge required to advance a drug-development project is embedded in team

routines, accumulated experimental experience, and project-specific coordination. Turnover can therefore create a double loss: the organization loses a skilled employee and may also lose continuity in tacit knowledge, cross-functional relationships, and learning routines that are difficult to reconstruct quickly. This feature makes retention especially important in biopharmaceutical settings, where discovery, validation, clinical development, regulatory interaction, and commercialization are connected through long and uncertain sequences of work. Human-capital and organizational-learning perspectives imply that HRM systems should be evaluated not only by whether they motivate current performance, but also by whether they preserve the knowledge base needed for sustained innovation [1–4]. The recent turnover literature similarly emphasizes that career systems and the design of creative work shape whether highly skilled employees remain attached to their organizations [5–8].

In China's biopharmaceutical sector, retention decisions are unlikely to depend on compensation alone. R&D employees also evaluate whether the organization offers credible career progression, fair recognition of innovation outputs, dependable reciprocal obligations, and a collaborative research environment. Employer-sponsored career development is associated with lower turnover through organizational support and attachment [5], while job satisfaction and meaningful work remain important pathways linking employment quality to employees' intention to stay [6,7]. Intellectual property (IP) governance is especially relevant in research-intensive firms because patents, attribution, and benefit-sharing communicate whether employees' innovative contributions are recognized and protected.

These considerations reveal a gap between conventional retention explanations and the realities of innovation-intensive employment. Traditional retention models often treat compensation, satisfaction, or commitment as separate predictors. In R&D settings, however, employees evaluate a bundle of organizational signals at the same time: whether their career can progress, whether rewards recognize long-cycle and uncertain innovation, whether intellectual contributions are protected and attributed fairly, whether implicit promises are honored, and whether the team has enough capable people to complete demanding projects. The present framework therefore treats retention as the outcome of an HR architecture rather than a single policy. This system perspective is important for HRMS readership because it links staffing, performance management, career development, rewards, relational governance, and innovation-related recognition within one model of employee attachment.

This study develops an integrated strategic HRM framework in which career satisfaction, incentive mechanisms, IP awareness, psychological contract fulfillment, and R&D team collaboration predict retention directly and, for selected antecedents, through perceived R&D staffing adequacy. The mediator is interpreted as an employee-perceived workforce condition rather than an objective headcount measure. The study contributes in three ways. First, it brings together motivational, relational, and innovation-governance mechanisms that are usually examined in separate literatures. Second, it introduces perceived staffing adequacy as a structural mechanism linking HR practices to employees' judgments about whether demanding R&D work is operationally sustainable. Third, it compares the pattern of associations across firm-size groups to explore whether the same HR mechanisms are equally salient in organizations with different staffing buffers and governance complexity. In doing so, the study positions R&D retention as a strategic HRM problem involving the alignment of talent systems, innovation governance, and workforce planning rather than as a narrow compensation decision.

2. Theoretical foundations and hypotheses

2.1. Strategic human capital and R&D retention

Human capital theory proposes that firm-specific knowledge and skills generate value that cannot be replaced without substantial cost [1]. In R&D settings, employee departures interrupt learning routines, weaken project continuity, and reduce the organization's ability to accumulate and recombine knowledge [2–4]. This logic is particularly strong in biopharmaceutical companies, where research cycles are long, failure risks are high, and regulatory knowledge is cumulative. Retention is therefore a strategic HRM outcome that protects both individual expertise and collective innovation capacity.

From a strategic human-capital perspective, the relevant question is not simply whether an employee is difficult to replace in the labor market, but whether the organization can reproduce the combination of firm-specific knowledge, project history, and relational connections that the employee contributes. In R&D teams, knowledge is often distributed across specialists and becomes valuable through repeated interaction. The departure of one scientist or technical manager can therefore impose coordination and learning costs on colleagues who remain. This argument also helps explain why retention is closely connected with workforce planning: replacing an individual after departure is not equivalent to maintaining adequate staffing before project continuity is disrupted. Accordingly, the present study views retention as a mechanism for protecting cumulative knowledge and maintaining the organizational capacity to recombine expertise over time [1–4].

2.2. Incentive, IP, and psychological-contract signals

Motivation theory explains how financial and non-financial rewards shape effort and behavioral intentions [9,10]. In R&D work, however, short-term rewards may be insufficient when employees also seek autonomy, recognition, career progress, and tolerance for experimentation. Strategic HR systems influence employee outcomes not only through the economic value of rewards but also through the signals those systems send about what the organization values and how it treats contributors [11]. Recent evidence focused specifically on creative R&D employees shows that performance-management design, including target difficulty and career-tournament arrangements, can shape turnover intentions [12]. This suggests that incentive mechanisms should be evaluated as part of a broader employment relationship: a bonus may motivate current effort, but its retention value depends on whether employees interpret the reward system as credible, fair, development-oriented, and compatible with the uncertain time horizon of research work.

IP awareness complements incentive mechanisms by shaping employees' perceptions of ownership, recognition, fairness, and career security. At the firm level, intellectual property rights are central to the appropriability problem because they influence whether innovators can capture returns from technological advances [13]. At the employee level, research on scientists and engineers shows that innovative output is related to a combination of pecuniary and non-pecuniary motives, including intellectual challenge, independence, and monetary rewards [14]. These findings do not imply that patents are merely personal rewards; rather, they indicate that the way an organization recognizes and governs innovation can become part of the employment relationship. Transparent attribution, inventor recognition, and understandable benefit-sharing arrangements can communicate respect for employees' contributions. Such signals are closely connected to the psychological contract: the implicit expectations of reciprocity, fairness, and long-term support that employees form from organizational practices [15–17]. When those expectations are fulfilled, employees have stronger reasons to view

the organization as a credible long-term partner; when they are violated, trust and attachment may deteriorate.

2.3. Career satisfaction, team collaboration, and staffing adequacy

Career satisfaction reflects employees' evaluation of their career progress, achievement, and future prospects [18]. It is especially important for R&D personnel, whose professional value accumulates through long-term projects, specialized expertise, and recognized scientific outputs. Collaborative teams add a relational resource to this career logic. Psychological safety supports learning behavior [19], while collective team identification can strengthen learning and performance in multidisciplinary settings [20]. Together, these mechanisms suggest that collaboration can make R&D work more sustainable by facilitating knowledge exchange, reducing coordination friction, and strengthening belonging. Staffing adequacy provides the structural condition that allows these relational processes to operate. When teams are persistently understaffed, even motivated employees may face excessive workload, insufficient backup expertise, delayed experiments, and fragile project continuity. The present study therefore conceptualizes the original 'number of R&D personnel' construct as perceived R&D staffing adequacy: employees' assessment of whether staffing levels, allocation, and team-size stability are sufficient for project execution.

2.4. Hypotheses

The hypotheses distinguish between two layers of the retention mechanism. H1–H5 capture direct associations between employees' evaluations of HRM and innovation-governance conditions and their intention to remain. H6, H8, and H10 capture whether career satisfaction, incentives, and collaboration are also associated with perceived staffing adequacy, while H11 links staffing adequacy to retention. H7 and H9 then test whether staffing adequacy transmits part of the career-satisfaction and incentive relationships with retention. The mediation hypotheses are restricted to career satisfaction and incentive mechanisms because these two antecedents are theorized to influence both individual attachment and the organization's capacity to attract and stabilize R&D labor. Team collaboration is modeled as an antecedent of staffing adequacy under H10, but a separate TC→NRD→RT mediation hypothesis was not pre-specified in the original model. Conceptual framework as shown in **Figure 1**.

H1: Career satisfaction has a positive effect on R&D personnel retention.

H2: Incentive mechanisms have a positive effect on R&D personnel retention.

H3: Intellectual property awareness has a positive effect on R&D personnel retention.

H4: Psychological contract fulfillment has a positive effect on R&D personnel retention.

H5: R&D team collaboration has a positive effect on R&D personnel retention.

H6: Career satisfaction has a positive effect on perceived R&D staffing adequacy.

H7: Perceived R&D staffing adequacy mediates the relationship between career satisfaction and retention.

H8: Incentive mechanisms have a positive effect on perceived R&D staffing adequacy.

H9: Perceived R&D staffing adequacy mediates the relationship between incentive mechanisms and retention.

H10: R&D team collaboration has a positive effect on perceived R&D staffing adequacy.

H11: Perceived R&D staffing adequacy has a positive effect on R&D personnel retention.

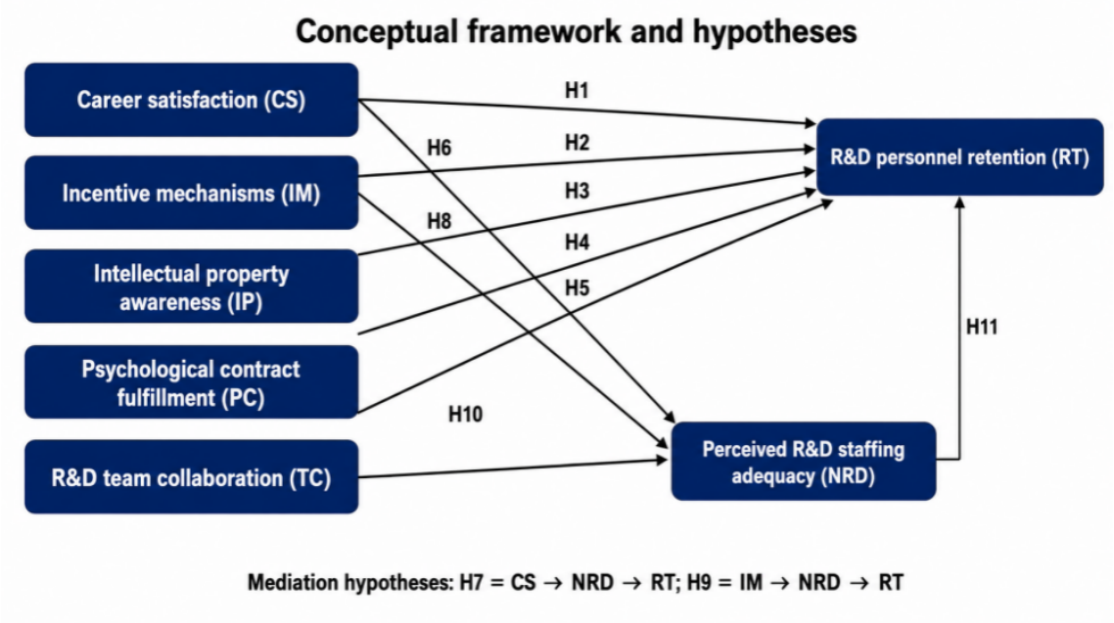


Figure 1. Conceptual framework.

3. Materials and methods

3.1. Research design and sampling

The study used a quantitative, cross-sectional questionnaire design. A multi-stage stratified purposive sampling approach was used to obtain coverage across eastern, central, and western China rather than to construct a national probability sample. At the first stage, the study sought representation from the three macro-regions. At the second stage, biopharmaceutical companies were selected to cover different ownership forms and organizational sizes, including state-owned, private, and foreign-invested or joint-venture firms. At the third stage, eligible employees were approached through enterprise R&D and HR contacts and professional networks. The sampling frame included laboratory researchers, pharmaceutical engineers, R&D project managers, IP management personnel, and R&D administrators with practical experience of biopharmaceutical R&D activities. This design increased diversity in the realized sample, but because firm and respondent recruitment included purposive elements, the sample should not be interpreted as a probability-representative estimate of the entire Chinese biopharmaceutical workforce.

Questionnaires were distributed through enterprise R&D and HR departments, professional networks, and industry contacts using standardized survey invitations. Both organizationally coordinated distribution and anonymous survey links were used in the broader data-collection process. A total of 900 questionnaires were distributed to employees in 27 participating companies. Screening removed incomplete responses, cases with excessive missing values, and questionnaires showing abnormal or internally inconsistent response patterns. The final analytical sample contained 650 valid questionnaires, corresponding to a valid response rate of 72.2%. Participation was voluntary and anonymous, respondents were informed that the survey was for academic research, and no personally identifying information was collected. The 27-firm coverage improves contextual breadth, but firm-level clustering and the non-probability component of recruitment remain important considerations when interpreting generalizability.

Ethical considerations. The study was designed as a minimal-risk,

anonymous, non-interventional organizational survey. No personally identifiable information, clinical information, biological specimens, or patient data were collected, and no experimental manipulation or clinical intervention was involved. Under the University of Cyberjaya institutional requirements applicable to this type of social and organizational survey research, formal ethics committee review was not required. Participation was voluntary, and informed consent was obtained before questionnaire completion.

3.2. Respondent distribution

Table 1 reports the demographic profile of the final sample. The respondents were relatively balanced by gender and were predominantly early- and mid-career professionals. The largest age group was 25–34 years, 60.8% held postgraduate degrees, and most respondents had between three and ten years of work experience.

Table 1. Demographic characteristics of respondents (N = 650).

Variable	Category	Frequency	Percentage (%)
Gender	Male	371	57.1
	Female	279	42.9
Age	Under 25	67	10.3
	25–34	309	47.5
	35–44	190	29.2
	45 and above	84	12.9
Education	Bachelor's degree	255	39.2
	Master's degree	302	46.5
	Doctoral degree	93	14.3
Work experience	Less than 3 years	126	19.4
	3–5 years	206	31.7
	6–10 years	196	30.2
	More than 10 years	122	18.8

3.3. Questionnaire development and measures

Questionnaire development followed four stages: literature review and construct definition, expert review, pilot testing, and formal administration. Expert review assessed wording, logical flow, cultural relevance, and the fit between the items and the biopharmaceutical context. Pilot testing examined completion time and preliminary internal consistency; ambiguous or overlapping items were revised before the formal survey. All substantive items used a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The measurement strategy was designed to keep the level of analysis consistent with the survey design. Career satisfaction, incentives, IP awareness, psychological-contract fulfillment, collaboration, staffing adequacy, and retention were all treated as employee perceptions or behavioral intentions. The scale domains were anchored in the literatures used to build the theoretical framework: career outcomes [18], motivation and HR systems [9–11], appropriability and R&D motives [13,14], psychological contracts [15–17], team learning and identification [19,20], and contemporary turnover research [5–8]. The formal survey used multi-item measurement so that each construct represented a domain rather than a single question. The constructs, codes, number of items, and corresponding measurement domains are summarized in **Table 2**. This is particularly important for the mediator, because 'staffing adequacy' is conceptually broader than a raw headcount and includes sufficiency, allocation,

stability, and the ability of staffing levels to support project work.

Table 2. Measurement structure.

Construct	Code	Items	Measurement focus
Career satisfaction	CS	5	Career progress, achievement, development opportunities
Incentive mechanism	IM	6	Financial rewards, recognition, long-term incentives
Intellectual property awareness	IP	5	Protection, attribution, recognition, benefit-sharing
Psychological contract	PC	5	Fulfillment of support, respect, and development promises
Team collaboration	TC	5	Communication, knowledge sharing, trust, shared goals
Perceived R&D staffing adequacy	NRD	4	Staffing sufficiency, allocation, team-size stability, project support
R&D personnel retention	RT	5	Intention to remain and continue long-term contribution

The mediator was relabeled as perceived R&D staffing adequacy to avoid implying that respondents reported an objective headcount. The four items assessed whether: (1) the current number of R&D personnel was sufficient for project requirements; (2) personnel were allocated appropriately across tasks and projects; (3) changes in team size did not disrupt project execution; and (4) staffing levels supported knowledge sharing and innovation activities. This perceptual operationalization is appropriate because employees directly experience workload and staffing sufficiency, even when they do not have access to company-wide headcount records. Nevertheless, it should not be interpreted as a substitute for audited staffing data.

3.4. Data quality and common method bias

Procedural remedies included anonymous participation, standardized instructions, concise item wording, and separation of construct blocks within the questionnaire. As a descriptive diagnostic, Harman's single-factor procedure showed that the first unrotated factor accounted for 28.43% of the variance. This result indicates that the items did not collapse into one dominant general factor, but it should not be interpreted as proof that common method bias is absent. Podsakoff et al. [21] emphasize that common method variance can arise from multiple sources and that procedural design is more informative than reliance on a single post-hoc diagnostic. Because all focal constructs were reported by the same respondents at one point in time, residual common method variance remains possible and is treated as a limitation rather than ruled out statistically.

3.5. Analytical procedure

The analysis proceeded through descriptive statistics, correlation analysis, multicollinearity diagnostics, reliability and convergent-validity assessment, discriminant-validity assessment using the Fornell-Larcker criterion [25], benchmark regression, mediation analysis, and firm-size subgroup comparisons. The benchmark model included the available individual and organizational controls collected in the questionnaire, including demographic characteristics and firm attributes. Mediation was evaluated from the reported antecedent-to-mediator path, mediator-to-outcome path, indirect-effect estimate, and the continuing significance of the corresponding direct path. Significant indirect and direct paths were interpreted as partial mediation [22]. Because the design is cross-sectional, the analysis is interpreted as evidence of patterned associations consistent with the hypothesized mechanism rather than as definitive temporal causality. No lagged-variable robustness test was conducted because the survey does not contain temporally ordered observations.

4. Results

4.1. Descriptive statistics and correlations

Table 3. Descriptive statistics of key variables.

Variable	Mean	Standard Deviation	Minimum	Maximum
Career Satisfaction (CS)	3.72	0.64	1.45	4.96
Incentive Mechanisms (IM)	3.60	0.62	1.50	4.88
Intellectual Property Awareness (IP)	3.85	0.58	1.67	5.00
Psychological Contract Fulfillment (PC)	3.70	0.63	1.58	4.92
Team Collaboration (TC)	3.78	0.56	1.83	4.94
Perceived R&D Staffing Adequacy (NRD)	3.63	0.60	1.71	4.89
Retention of R&D Personnel (RT)	3.75	0.65	1.46	4.98

As shown in **Table 3**, the construct means ranged from 3.60 to 3.85, indicating moderately favorable evaluations of the organizational and innovation environment. Standard deviations ranged from 0.56 to 0.65, and the observed values were not concentrated at the scale boundaries.

The correlation matrix also helps clarify the empirical structure of the model. Retention showed its strongest bivariate association with career satisfaction ($r = 0.63$) and psychological contract fulfillment ($r = 0.61$), while perceived staffing adequacy was most strongly correlated with team collaboration ($r = 0.51$). These patterns are consistent with the proposed distinction between attitudinal attachment and workforce structure: career and relational evaluations are closely connected to employees' willingness to remain, whereas collaboration is especially relevant to whether the R&D team is experienced as sufficiently staffed and workable. Because all correlations are based on the same cross-sectional survey, however, they are descriptive associations and should not be interpreted as evidence of directionality.

Table 4. Correlation analysis of major variables.

Variable	CS	IM	IP	PC	TC	NRD	RT
CS	1						
IM	0.54***	1					
IP	0.47***	0.51***	1				
PC	0.59***	0.56***	0.49***	1			
TC	0.45***	0.48***	0.42***	0.53***	1		
NRD	0.41***	0.44***	0.39***	0.46***	0.51***	1	
RT	0.63***	0.58***	0.55***	0.61***	0.52***	0.57***	1

All major constructs were positively correlated with R&D personnel retention. As shown in **Table 4**, the correlations among predictors remained below levels typically associated with severe multicollinearity, providing a basis for multivariate analysis.

4.2. Reliability, validity, and multicollinearity

Table 5. Multicollinearity test.

Variable	VIF
Career Satisfaction (CS)	2.10
Incentive Mechanisms (IM)	2.23
Intellectual Property Awareness (IP)	1.97
Psychological Contract Fulfillment (PC)	2.35
Team Collaboration (TC)	2.04
Perceived R&D Staffing Adequacy (NRD)	1.88

Table 6. Reliability and convergent-validity results.

Construct	Cronbach's α	Composite Reliability (CR)	Average Variance Extracted (AVE)
Career Satisfaction (CS)	0.91	0.92	0.58
Incentive Mechanisms (IM)	0.93	0.94	0.56
Intellectual Property Awareness (IP)	0.92	0.93	0.57
Psychological Contract Fulfillment (PC)	0.94	0.95	0.60
Team Collaboration (TC)	0.90	0.91	0.55
Perceived R&D Staffing Adequacy (NRD)	0.89	0.90	0.54
Retention of R&D Personnel (RT)	0.93	0.94	0.59

As shown in **Tables 5 and 6**, VIF values ranged from 1.88 to 2.35. Cronbach's alpha values ranged from 0.89 to 0.94, composite reliability from 0.90 to 0.95, and AVE from 0.54 to 0.60. These results indicate acceptable internal consistency and convergent validity, while multicollinearity remained limited.

The measurement results provide support for using composite construct scores in the subsequent models. All reported AVE values exceed 0.50, indicating that the constructs capture more variance in their indicators than measurement error on average, while the CR and alpha values are well above conventional reliability thresholds. Discriminant validity was further assessed using the Fornell-Larcker criterion [25]. As shown in **Table 7**, the square root of AVE for every construct exceeded its correlations with all other constructs. This criterion was also satisfied for the conceptually closest constructs: career satisfaction ($\sqrt{\text{AVE}} = 0.762$), psychological contract fulfillment ($\sqrt{\text{AVE}} = 0.775$), and retention ($\sqrt{\text{AVE}} = 0.768$) all exceeded their mutual correlations ($r = 0.59$–0.63). These results support discriminant validity while recognizing that the constructs remain substantively related.

Table 7. Fornell-Larcker discriminant-validity assessment.

Variable	CS	IM	IP	PC	TC	NRD	RT
CS	0.762						
IM	0.54	0.748					
IP	0.47	0.51	0.755				
PC	0.59	0.56	0.49	0.775			
TC	0.45	0.48	0.42	0.53	0.742		
NRD	0.41	0.44	0.39	0.46	0.51	0.735	
RT	0.63	0.58	0.55	0.61	0.52	0.57	0.768

4.3. Direct effects

Table 8. Benchmark regression results (dependent variable: R&D personnel retention).

Variable	Coefficient (SE)
Career Satisfaction (CS)	0.33***(0.04)
Incentive Mechanisms (IM)	0.27***(0.05)
Intellectual Property Awareness (IP)	0.22***(0.04)
Psychological Contract Fulfillment (PCF)	0.30***(0.05)
Team Collaboration (TC)	0.19***(0.04)
Control Variables	Yes
R^2	0.53
F Value	49.12***

*Note: Standard errors are reported in parentheses. *** $p < 0.01$.*

As shown in **Table 8**, after controlling for the available individual and enterprise characteristics, career satisfaction, incentive mechanisms, IP awareness, psychological contract fulfillment, and team collaboration were all positively associated with retention. Career satisfaction had the largest reported coefficient (0.33), followed by psychological contract fulfillment (0.30), incentive mechanisms (0.27), IP awareness (0.22), and team collaboration (0.19). The model explained 53% of the observed variance in retention ($R^2 = 0.53$). Substantively, the ordering suggests that R&D employees' long-term career evaluation and trust in organizational commitments are at least as salient as immediate reward arrangements. The positive IP coefficient also indicates that innovation governance belongs within the HRM conversation: employees' perceptions of how inventive contributions are protected and recognized are associated with whether they intend to remain. Because the model is based on cross-sectional self-report data, these coefficients are best described as conditional associations rather than causal effect estimates.

4.4. Mediation analysis

Table 9. Mediation results: perceived R&D staffing adequacy as mediator.

Path	Coefficient / indirect effect	Interpretation	Mediation type
CS → NRD	0.29***	Positive antecedent path	—
IM → NRD	0.32***	Positive antecedent path	—
TC → NRD	0.35***	Positive antecedent path	—
NRD → RT	0.28***	Positive mediator–outcome path	—
CS → NRD → RT	0.081***	Significant indirect effect	Partial mediation
IM → NRD → RT	0.090***	Significant indirect effect	Partial mediation

*Note: *** $p < 0.01$.*

As shown in **Table 9**, career satisfaction, incentive mechanisms, and team collaboration significantly predicted perceived staffing adequacy, and staffing adequacy significantly predicted retention. The indirect-effect estimates for career satisfaction (0.081) and incentive mechanisms (0.090) are consistent with the products of their component paths to rounding. Because the corresponding direct associations with retention remained significant, the reported pattern is consistent with partial rather than full mediation. This distinction is theoretically important. Career satisfaction and incentives appear to operate through two channels: an individual channel in which employees directly evaluate the value of remaining,

and a structural channel in which favorable career and reward systems are associated with a more sustainable staffing environment. The mediation results should nevertheless be interpreted cautiously because the cross-sectional design does not establish temporal ordering among antecedent, mediator, and outcome.

4.5. Firm-size subgroup comparison

Table 10. Heterogeneous regression results by enterprise size.

Variable	Large Enterprises	Small and Medium-sized Enterprises
Career Satisfaction → Retention	0.28***	0.38***
Incentive Mechanisms → Retention	0.22***	0.34***
Intellectual Property Awareness → Retention	0.27***	0.18***
Perceived R&D Staffing Adequacy → Retention	0.25***	0.32***

*Note: *** $p < 0.01$. The subgroup coefficients are descriptive comparisons; a formal coefficient-difference test is not reported.*

As shown in **Table 10**, the firm-size subgroup comparison suggests a potentially meaningful contingency pattern. Career satisfaction (0.38 versus 0.28), incentive mechanisms (0.34 versus 0.22), and perceived staffing adequacy (0.32 versus 0.25) show larger coefficients in small and medium-sized enterprises (SMEs) than in large enterprises. One plausible interpretation is that SMEs have narrower internal labor markets and fewer staffing buffers, so employees may be more sensitive to development opportunities, reward credibility, and workload sustainability. By contrast, IP awareness shows a larger coefficient in large enterprises (0.27 versus 0.18), where patent processes, inventor attribution, and benefit-sharing arrangements may be more formalized and organizationally complex. These comparisons should be treated as suggestive rather than as formal evidence that coefficients differ statistically across groups, because the subgroup analysis does not report subgroup sample sizes, standard errors for the difference, or a cross-group equality test. The pattern is therefore most useful for theory development and managerial interpretation, not for a definitive claim of moderated effects.

5. Discussion

5.1. Integrated HRM and innovation-governance mechanisms

The findings show that R&D retention is produced by an integrated system rather than a single HR practice. Career satisfaction and psychological contract fulfillment were the strongest direct predictors, indicating that R&D employees attach considerable importance to long-term development and the credibility of organizational commitments. Incentives also matter, but their association with retention is embedded in a broader employment relationship that includes recognition, professional growth, trust, and the practical conditions under which research is performed. This interpretation is consistent with evidence that employer-sponsored career development can strengthen organizational attachment and reduce turnover [5] and with the broader literature linking psychological-contract breach to adverse work-related outcomes [17]. Recent work further shows that psychological contract violations can suppress employees' willingness to champion innovative ideas when they are accompanied by inadequate career support [23]. Taken together, these findings suggest that retention policies in innovation-intensive organizations should be designed as mutually reinforcing HR practices rather than as isolated compensation instruments.

The relative size of the coefficients also has a practical implication for the sequencing of HR interventions. Increasing pay or bonuses may be visible

and administratively straightforward, but the results imply that employees also evaluate whether the organization offers a credible future and follows through on implicit commitments. Career architecture, mentoring, internal mobility, research autonomy, and supervisor support can therefore determine how employees interpret the value of incentives. A reward system that is generous but unpredictable may not create the same attachment as a system that is transparent, development-oriented, and aligned with long-cycle innovation. The study thus supports a strategic HRM view in which compensation, career development, and relational credibility work as a bundle.

IP awareness adds an innovation-governance dimension to strategic HRM. At the firm level, appropriability mechanisms determine how organizations capture value from innovation [13]. At the employee level, R&D motivation depends on a mixture of pecuniary and non-pecuniary motives [14]. In biopharmaceutical R&D, patent attribution, inventor recognition, and benefit-sharing therefore matter not only as legal or commercial arrangements but also as management practices through which employees interpret whether their contributions are visible and fairly treated. The positive IP–retention association extends conventional retention models by showing that innovation governance can function as an employee-management signal. Importantly, this interpretation is narrower than claiming that patents automatically create retention; the data capture employees' awareness and evaluations of IP-related practices, not the objective strength of a company's patent portfolio.

5.2. Structural meaning of perceived staffing adequacy

The partial mediation results explain why favorable attitudes do not automatically translate into retention. Employees may value their careers and rewards but still consider leaving when persistent understaffing generates excessive workload, weakens knowledge sharing, or threatens project continuity. Perceived staffing adequacy therefore operates as a structural transmission mechanism: it converts HR practices and team conditions into a daily judgment about whether sustained R&D work is feasible. This mechanism is especially plausible in research environments because work is interdependent. A vacancy in one specialized role can increase workload for others, delay experiments, reduce opportunities for peer review, and make project progress more fragile. Relabeling the mediator clarifies that the study measures experienced workforce sufficiency rather than objective company headcount. That distinction also places the mediator at the same individual perceptual level as the other survey constructs, which improves conceptual coherence but limits claims about actual staffing levels.

The mediation pattern also helps distinguish retention intention from workforce capacity. An employee can report high career satisfaction while working in a team that is objectively or subjectively understaffed; conversely, a well-staffed team does not guarantee that employees feel rewarded or supported. The model therefore does not treat staffing adequacy as a substitute for motivational and relational HR practices. Instead, it suggests complementarity: career and incentive systems may strengthen attachment directly, while the perceived sustainability of the staffing environment can reinforce or weaken that attachment. For HR managers, this means that retention dashboards should connect attitudinal indicators with workload and staffing information rather than monitor turnover intention in isolation.

5.3. Theoretical and practical implications of heterogeneity

The subgroup results support a cautious contingency interpretation of retention. In SMEs, limited replacement capacity and narrower internal labor markets may make career development, incentives, and staffing sufficiency

more salient because the loss of one specialist can immediately alter workloads and promotion opportunities. In large enterprises, more formalized governance structures can make IP attribution and inventor-recognition procedures more visible and consequential. These interpretations are compatible with broader evidence that the tenure of R&D employees depends on organizational and institutional context rather than on a universal set of retention levers [24]. However, the subgroup coefficients should not be described as statistically different unless a formal cross-group equality test confirms the differences.

Across firm sizes, managers should integrate workforce planning with talent management. Recruitment targets should be linked to project pipelines; team leaders should monitor staffing sufficiency during critical research stages; and retention metrics should be reviewed alongside workload, project delay, vacancy duration, and knowledge-continuity indicators. Career systems should provide transparent technical and managerial pathways, while incentive systems should recognize both near-term output and long-horizon scientific contribution. IP procedures should clearly explain attribution, inventor recognition, and benefit-sharing rules. Finally, managers should treat collaboration as an HR capability that can be supported through team design, cross-training, mentoring, and mechanisms for knowledge transfer. This moves retention management from isolated compensation decisions toward a coordinated architecture of career, reward, IP, relational, and staffing practices.

6. Limitations and future research

Several limitations define the boundary of the conclusions. First, all focal variables were obtained from the same respondents at one point in time. Although anonymous administration, standardized instructions, and the single-factor diagnostic reduce some immediate concerns, single-source cross-sectional data remain vulnerable to common method variance and cannot establish temporal causality [21]. Future studies should use time-separated measurements, supervisor or team-leader reports, HR records, and longitudinal designs. Second, the sampling approach deliberately sought diversity across regions, ownership forms, job roles, and firm sizes, but it included purposive recruitment through 27 companies and therefore is not a probability sample of the national biopharmaceutical workforce. Replication with a larger firm sample and transparent firm-level response rates would improve external validity. Third, perceived R&D staffing adequacy captures experienced workload and workforce sufficiency but is not an audited headcount measure. Future research should compare perceptions with objective staffing levels, vacancy rates, and turnover records, project staffing ratios, and workload indicators. Fourth, the firm-size analysis is based on subgroup coefficients and does not report formal cross-group equality tests; its implications should therefore be treated as exploratory. Fifth, mediation was estimated from cross-sectional data and therefore cannot establish temporal ordering; future research should test the indirect pathways with longitudinal or time-separated mediation designs. Finally, the current study focuses on China's biopharmaceutical sector. Firm ownership, regional labor markets, R&D project stage, employee career stage, and national institutional context may all alter the proposed relationships.

7. Conclusion

This study demonstrates that retaining R&D personnel in Chinese biopharmaceutical companies requires alignment among career development, incentive design, IP governance, psychological-contract fulfillment, team collaboration, and workforce planning. Career satisfaction was the strongest direct predictor of retention, while perceived R&D staffing adequacy partially transmitted the relationships of career satisfaction and incentive mechanisms

with retention. The firm-size subgroup patterns further suggest that the salience of retention mechanisms varies with organizational context. The theoretical contribution is therefore not the identification of a single dominant HR practice, but the articulation of a multi-layered retention architecture in which motivational and relational signals operate alongside the structural feasibility of R&D work. For practice, the central implication is that organizations retain scientific talent not only by increasing rewards but by creating credible career and recognition systems, honoring organizational commitments, supporting collaborative work, and ensuring that teams are sufficiently staffed to sustain demanding innovation projects. These conclusions should be interpreted as associational evidence from a cross-sectional survey and provide a basis for more rigorous longitudinal and multi-source tests of the proposed mechanism.

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Data availability statement: The data supporting the findings are available from the corresponding author upon reasonable request, subject to confidentiality restrictions.

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References

[1] Argote L. Organizational Learning: Creating, Retaining and Transferring Knowledge. Kluwer Academic Publishers; 1999.
[2] Becker GS. Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education. University of Chicago Press; 1964.
[3] Borah D, Massini S, Piscitello L. R&D employee tenure in MNC subsidiaries: The role of institutional distance and experience. R&D Management. 2023;53(1):71–96. https://doi.org/10.1111/radm.12546.
[4] De Clercq D, Pereira R. Violated contracts, inadequate career support, but still forgiveness: Key organizational factors that determine championing behaviors. European Management Review. 2024;21(1):118–133. https://doi.org/10.1111/emre.12560.
[5] Edmondson A. Psychological safety and learning behavior in work teams. Administrative Science Quarterly. 1999;44(2):350–383.
[6] Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research. 1981;18(1):39–50. https://doi.org/10.1177/002224378101800104.
[7] Grabner I, et al. The role of target difficulty and career tournaments in retaining creative R&D employees. Contemporary Accounting Research. 2024. https://doi.org/10.1111/1911-3846.12931.
[8] Greenhaus JH, Parasuraman S, Wormley WM. Effects of race on organizational experiences, job performance evaluations, and career outcomes. Academy of Management Journal. 1990;33(1):64–86. https://doi.org/10.5465/256352.
[9] Hayes AF. Introduction to Mediation, Moderation, and Conditional Process Analysis. 2nd ed. Guilford Press; 2018.
[10] Herzberg F, Mausner B, Snyderman BB. The Motivation to Work. 2nd ed. Wiley; 1959.
[11] Jiang K, Lepak DP, Hu J, Baer JC. How does human resource management influence organizational outcomes? A meta-analytic investigation of mediating mechanisms. Academy of Management Journal. 2012;55(6):1264–1294.

[12] Kiazad K, et al. STEMming the tide: New perspectives on careers and turnover. Journal of Organizational Behavior. 2024;45(3):335–343. https://doi.org/10.1002/job.2780.
[13] Nelson RR, Winter SG. An Evolutionary Theory of Economic Change. Harvard University Press; 1982.
[14] Ng TWH, Yim FHK, Chen H, Zou Y. Employer-sponsored career development practices and employee performance and turnover: A meta-analysis. Journal of Management. 2024. https://doi.org/10.1177/01492063221125143.
[15] Oprea B, Păduraru L, Iliescu D. Job crafting and intent to leave: The mediating role of meaningful work and engagement. Journal of Career Development. 2022. https://doi.org/10.1177/0894845320918666.
[16] Pisano GP. Science Business: The Promise, the Reality, and the Future of Biotech. Harvard Business School Press; 2006.
[17] Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology. 2003;88(5):879–903. https://doi.org/10.1037/0021-9010.88.5.879.
[18] Robinson SL, Rousseau DM. Violating the psychological contract: Not the exception but the norm. Journal of Organizational Behavior. 1994;15(3):245–259.
[19] Rousseau DM. Psychological Contracts in Organizations: Understanding Written and Unwritten Agreements. Sage; 1995.
[20] Sauermann H, Cohen WM. What makes them tick? Employee motives and firm innovation. Management Science. 2010;56(12):2134–2153. https://doi.org/10.1287/mnsc.1100.1241.
[21] Teece DJ. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy. 1986;15(6):285–305. https://doi.org/10.1016/0048-7333(86)90027-2.
[22] Van der Vegt GS, Bunderson JS. Learning and performance in multidisciplinary teams: The importance of collective team identification. Academy of Management Journal. 2005;48(3):532–547.
[23] Vroom VH. Work and Motivation. Wiley; 1964.
[24] Wan W, Duffy RD. Decent work and turnover intention among new generation employees: The mediating role of job satisfaction and the moderating role of job autonomy. SAGE Open. 2022;12. https://doi.org/10.1177/21582440221094591.
[25] Zhao H, Wayne SJ, Glibkowski BC, Bravo J. The impact of psychological contract breach on work-related outcomes: A meta-analysis. Personnel Psychology. 2007;60(3):647–680.