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ORIGINAL ARTICLE

Relative age and tournament persistence in FIFA Men's World Cup squads, 2010–2026: No evidence that the underdog effect extends to senior international selection

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ABSTRACT

The relative age effect (RAE) is the overrepresentation of players born early in the selection year, a pattern well documented in youth football. Whether it is stable at senior international level, responds to competition-format change, and affects whether late-born players are retained across tournaments remains unclear. The 2026 FIFA Men's World Cup expansion from 32 to 48 teams offered a natural experiment, since additional nations qualified under widened confederation allocations while national selection processes remained unchanged. Squads for five FIFA Men's World Cups (2010 to 2026) were extracted from official FIFA documentation, yielding 4,287 player-tournament observations from 3,283 players. Birth-quartile distributions were tested against a uniform null by tournament, confederation, and playing position. Return to the subsequent tournament was modelled with logistic regression adjusted for age and edition, with clustered sensitivity models. RAE was significant in every tournament from 2014 onward (χ^2 range 14.86 to 25.84, all $p \leq .002$) and did not change in magnitude across the 16-year window (linear-by-linear $p = .584$). Players from the 20 nations that qualified only under the 48-team allocation ($n = 520$) did not differ from other 2026 players ($p = .703$). Goalkeepers showed the largest Q1 to Q4 differential (13.0 percentage points) and forwards the smallest (5.9 points). Q4-born players had lower odds of returning to the next tournament (OR = 0.69, 95% CI [0.54, 0.87], $p = .002$), an association that persisted after clustering on player and among players whose national team qualified again (OR = 0.74, 95% CI [0.57, 0.97]). RAE at senior World Cup level was small but stable across 16 years, with no detectable response to format expansion. The underdog advantage reported at academy transition may not extend into repeated senior international selection.

Keywords: performance analysis; relative age effect; football; birth quartile; selection bias; underdog hypothesis.

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INTRODUCTION

Elite football divides the calendar year into a single selection cohort, and that arbitrary boundary produces a durable inequality. The relative age effect describes the overrepresentation of players born early in the selection year and the loss of those born later, a skew that arises when transient differences in growth and experience are mistaken for talent (Bozděch et al., 2023; Roberts et al., 2020). A modest maturational head start is then amplified through better coaching and more competitive minutes, so that a small early advantage compounds into a durable selection bias documented across national football contexts including Portugal and China (Figueiredo et al., 2021; Li et al., 2020). At youth level the pattern is settled. Portuguese Football Association data covering 134,016 registered players returned selection odds favouring the earliest-born by more than nine to one at Under-16 and more than twelve to one at Under-17 (Figueiredo et al., 2021). A meta-analysis of 563 youth samples confirmed that the effect peaks in adolescence and strengthens with competitive level (Bozděch et al., 2023; Peña-González et al., 2020).

What survives to the senior pinnacle is contested by sample type. In European club football the bias persists into adulthood, with 30.9% of 18,429 senior professionals across 54 countries born in the first quarter against 19.6% in the last, a pattern replicated in the top ten UEFA leagues and across both Spanish divisions (Bezuglov et al., 2023; Işık et al., 2025; Yagüe et al., 2023). Market value, however, does not track birth date, and late born forwards command the highest mean valuation, indicating that club selection continues to favour early born players without any performance dividend (Bezuglov et al., 2023). International selection contradicts this pattern. Effects at European and Concacaf qualification appear only at under 17 and vanish by senior level, and the same senior disappearance is reported across women's World Cup age groups (Andrew et al., 2022, 2025; Ribeiro et al., 2023). Men's senior World Cup squads show the effect persisting and strengthening across four tournaments from 2006 to 2018, while the most decorated players of recent decades show resurgence rather than decline (Pedersen et al., 2022; Saavedra-García et al., 2024).

Two further dimensions have reframed the debate. The first is geography, since no overall effect was found at the 2023 Women's World Cup but a clear one was confined to European players, goalkeepers and defenders, and the strongest nations, offering a confederation-conditional reading that reconciles the earlier disagreement between persistence and disappearance (Pérez-González et al., 2025). A parallel analysis of both men's (1962 to 2022) and women's (1991 to 2023) FIFA World Cups documented significant RAE for the majority of tournament editions across the full historical record, and identified confederation-conditional variation in which UEFA showed no placement-based RAE while CONCACAF, AFC, and CAF each showed significant effects on specific placement outcomes (Martínez-Benítez et al., 2026). The second dimension is position, with goalkeepers showing the most reliable effect, defenders the next, and forwards the weakest, consistent with a selection premium on reach and physical duelling where maturity gaps are most visible (Bezuglov et al., 2023; Işık et al., 2025; Yagüe et al., 2023). However, no study has tested whether the effect responds to the 2026 format expansion, or whether birth quartile predicts retention across successive senior World Cups.

A further theoretical dimension concerns what happens to late-born players who overcome the initial selection filter. The underdog hypothesis proposes that Q4 survivors of youth selection benefit from repeatedly competing against older, larger peers, developing psychological, tactical, and technical resilience that yields superior long-term outcomes once the physical gap closes (Gibbs et al., 2012; McCarthy & Collins, 2014). Recent evidence supports this reversal at the youth-to-senior transition. Q4 survivors have been shown to transition to senior level at approximately twice the rate of Q1 counterparts (Brustio et al., 2024). Belgian data covering an eight-year cohort found Q4 players signing as senior professionals at higher rates than Q1

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counterparts (Bolckmans et al., 2023). German Bundesliga academy data revealed that once selected, Q4 survivors accumulated more professional career minutes than Q1 survivors (Biermann et al., 2024). In the Italian national team pathway, the Q1 to Q4 odds ratio fell from approximately 9 at Under-16 to approximately 1.7 at senior level (Boccia et al., 2023). Reversed effects appear in nearly half of long-term outcomes reviewed across team sports (de la Rubia et al., 2020). Yet the hypothesis has not been tested at the level of senior international tournament persistence, where selection operates through federation-level continuity rather than the transition-selection filter that governs academy-to-senior progression. Whether the underdog trajectory extends into repeated senior international selection therefore remains an open empirical question.

The present study addressed these gaps through the FIFA Men's World Cup, which draws qualification pools from 211 member associations across six confederations and offers the first major format expansion since 1998 with the 2026 tournament moving from 32 to 48 teams (FIFA, 2017). Prior work has used policy-driven changes to age-grouping structures as natural experiments for testing RAE, through the comparison of Irish Under-21 footballers before and after a 1997 cutoff-date change (Butler & Butler, 2015). The 2026 expansion added sixteen berths under widened allocations, providing a natural experiment for testing whether the effect responds to structural change in the qualification pool. A flatter distribution among beneficiary squads would indicate narrow, intensive selection at the qualification threshold, whereas no attenuation would indicate that selection biases are entrenched within the domestic pipelines from which those nations draw (Delorme et al., 2024; Roberts et al., 2020). The study therefore aimed to chart the longitudinal trajectory of the effect across five tournaments, to disaggregate the effect by all six FIFA confederations and test whether the confederation-conditional pattern observed in women's international football also structures the men's senior game, and to examine position-specific effects across goalkeepers, defenders, midfielders, and forwards at senior international level. A final aim was to provide a senior-international test of the underdog hypothesis by modelling the odds of returning for the subsequent World Cup as a function of birth quartile.

METHODS

Study design

This study employed a retrospective longitudinal observational analysis of birth-date distributions in the final squads registered for five consecutive FIFA Men's World Cup tournaments: South Africa 2010, Brazil 2014, Russia 2018, Qatar 2022, and the 2026 tournament co-hosted by Canada, Mexico, and the United States. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007). The study used publicly available roster information for professional athletes and involved neither human contact nor primary data collection. The work nonetheless adhered to the ethical principles of the Declaration of Helsinki (World Medical Association, 2013) concerning research integrity and responsible data use.

Data sources

The unit of analysis was the player-tournament observation, defined as one player registered in one tournament's final squad. Squad lists, dates of birth, and playing positions were extracted from the official FIFA participating-teams document for each tournament. Tournament year, national team, player name, playing position, and date of birth were recorded for each observation, and age at tournament opening and birth quartile were derived from the date of birth. Players appearing in more than one tournament were linked through a persistent identifier, giving 4,287 observations from 3,283 unique players.

Squad size across editions

Squad-size regulations changed during the study window. FIFA set a fixed 23-man squad for 2010, 2014, and 2018, producing 32 × 23 = 736 registered players per tournament (FIFA, 2025). In 2022 the maximum

was expanded to 26, a temporary measure introduced in response to fixture congestion and the disruptive effects of the COVID-19 pandemic (FIFA, 2022). This yielded 31 teams of 26 plus Iran's 25-player registration, for a total of 831 players. FIFA retained the 26-player cap for 2026, and all 48 participating teams registered the maximum, producing 48 × 26 = 1,248 registered players. All quartile analyses were computed as within-tournament proportions rather than raw counts to preserve comparability across editions. The squad-size difference is reported as a structural feature of the data rather than statistically adjusted for.

Variables

The primary exposure variable was birth quartile, coded from month of birth according to the January to December age band cutoff applied by FIFA and its member federations, such that Quartile 1 comprised births from January to March, Quartile 2 from April to June, Quartile 3 from July to September, and Quartile 4 from October to December (Pedersen et al., 2022). Playing position was coded verbatim from the FIFA roster into four categories, namely goalkeeper, defender, midfielder, and forward. In cases where a player's registered position varied between tournaments, the position recorded in the FIFA squad list for each edition was retained, on the basis that this reflects the coaching staff's operational selection decision for that specific competition rather than the player's general tactical profile. Confederation was coded to the six FIFA confederations of UEFA, CONMEBOL, CONCACAF, CAF, AFC, and OFC. Australia was coded as AFC throughout the study window, consistent with its confederation reassignment from OFC to AFC in 2006. The player age at tournament was computed as the whole years elapsed between the player's date of birth and the opening match day of each tournament, these being 11 June 2010, 12 June 2014, 14 June 2018, 20 November 2022, and 11 June 2026.

In the present study, a persistent player identifier was constructed for each observation by concatenating the diacritic-stripped, lower-cased player name with the date of birth in ISO 8601 format. This identifier enabled linkage of individual players across successive tournaments and served as the basis for the multi-tournament persistence and return analyses. Two variables were subsequently derived from this identifier. The first was a persistence count representing the total number of tournaments in which each player appeared, ranging from one to five. The second was a binary return indicator coded one if the same player also appeared in the immediately subsequent tournament and zero otherwise. Observations from the 2026 tournament were set to missing on the return indicator because no subsequent tournament was available for observation.

Expansion beneficiary status was a binary variable defined only for the 2026 tournament. A nation was classified as an expansion beneficiary if it occupied a confederation qualification slot beyond the allocation set under the pre-expansion 32-team format (FIFA, 2017). Direct confederation allocations increased from 13 to 16 for UEFA, 5 to 9 for CAF, 4 to 8 for AFC, 4 to 6 for CONMEBOL, 3 to 6 for CONCACAF, and 0 to 1 for OFC, with two additional berths decided through the intercontinental play-off tournament (FIFA, 2026). The three host nations (Canada, Mexico, and the United States) were classified as non-beneficiaries because they qualified automatically rather than through the qualifying tournament. Twenty nations (520 players) met this definition. The count exceeds the sixteen added berths because all four UEFA play-off winners and all three non-host CONCACAF qualifiers were classified as beneficiaries. In CAF and AFC, direct qualifiers were ranked by the FIFA Men's Ranking and those beyond the former allocation were classified as beneficiaries.

Name standardisation

Diacritics were stripped from all player and team names to permit consistent string matching across editions (e.g., "Müller" → "Muller"; "Côte d'Ivoire" → "Cote d'Ivoire"). Brazilian and Portuguese mononyms were preserved as registered (e.g., Neymar, Casemiro, Fred). Country names were standardised so that "IR Iran" was coded as "Iran" and "Korea Republic" as "South Korea". Nineteen instances of romanisation drift in the

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2022 PDF relative to the 2018 PDF (e.g., Ruediger/Rudiger; Ziyech/Ziyach; Nkoulou/N'Koulou) were reconciled by matching each (team, date-of-birth) pair to the most recent prior tournament in which that individual appeared and canonicalizing to the earlier registered form, ensuring that the same player carried a stable identifier across editions.

Exclusions

Data cleaning was conducted to address discrepancies identified during consistency checks, including position validation, date-of-birth format consistency, and cross-tournament identifier matching. Five data-cleaning decisions were applied after cross-verification against contemporaneous secondary sources. Three corrections were made to the 2010 dataset. Vangelis Moras's date of birth was corrected from 1981-08-18 to 1981-08-26, Dimitris Salpigidis was corrected to Dimitris Salpingidis, and Egidio Arevalo Rios's date of birth was corrected from 1982-09-27 to 1982-01-01, shifting his birth-quartile classification from Q3 to Q1. In the 2018 dataset, two players listed on the FIFA participating-teams PDF were excluded because independent verification against contemporaneous match-preview and squad-announcement reporting confirmed they were not part of the final 23-man squad that participated in the tournament. These were Manuel Lanzini (Argentina), who sustained an anterior cruciate ligament rupture on 5 June 2018 and was officially replaced by Enzo Perez. Krzysztof Maczynski (Poland) was cut from the final squad in favour of Jan Bednarek (FIFA, 2018). These exclusions reduced the 2018 dataset from 738 to 736 registered players, restoring the expected 32 × 23 structure. No exclusions were applied to the 2022 or 2026 datasets. The FIFA participating-teams PDFs for both tournaments were internally consistent, with no duplicate shirt numbers or preliminary-squad artefacts identified during verification.

Verification

After extraction, each tournament dataset was subjected to three consistency checks. First, team-size was validated against the FIFA squad limit in force for that edition. Second, within-tournament duplicates were flagged using the composite player identifier. Third, cross-tournament persistence checks were run to detect romanisation drift for the same individual across editions, which was reconciled as described above. The final analytic dataset comprised 4,287 player-tournament observations, distributed as 736 in 2010, 736 in 2014, 736 in 2018, 831 in 2022, and 1,248 in 2026.

Statistical analysis

All analyses were conducted in IBM SPSS Statistics version 29 (IBM Corp., Armonk, NY). Statistical significance was set at $\alpha = .05$ (two-tailed) unless otherwise stated. Under the null hypothesis of no relative age effect, the expected birth-quartile distribution was uniform at 25.0% per quartile. The uniform expectation was retained as the conventional reference in RAE research. It is an approximation, since national birth distributions vary by season, country, and birth cohort (Delorme et al., 2010). Cramér's V was reported as the effect size for goodness-of-fit and independence tests, and any subgroup with a minimum expected cell frequency below five was reported descriptively rather than inferentially (McHugh, 2013). Birth-quartile distributions were tested against the uniform expectation using chi-square goodness-of-fit tests within each tournament, confederation, and playing position. Chi-square tests of independence and linear-by-linear association tests examined change across tournament year and across multi-tournament persistence level. Bonferroni correction was applied across confederation ($\alpha = .0083$) and position ($\alpha = .0125$) comparisons.

Two comparisons were conducted for the 2026 expansion analysis. The first tested beneficiary against non-beneficiary players within 2026. The second tested beneficiary players against the pooled 2010 to 2022 cohort. Return to the subsequent tournament was modelled at the player-tournament level using binary logistic regression, with 2026 observations excluded because no future tournament was observed.

Unadjusted and age- and year-adjusted models were fit, with Q1 and 2010 as reference categories. Odds ratios were reported with 95% confidence intervals, model fit was assessed with the Nagelkerke pseudo-R^2 and Hosmer and Lemeshow test, and confederation-stratified and returnees-only sensitivity analyses were conducted. Sensitivity analyses addressed repeat appearances by the same player. Pooled goodness-of-fit and independence tests were repeated on a unique-player dataset retaining each player's first appearance. The return model was refitted using generalised estimating equations with player as the clustering unit, an independence working correlation, and robust standard errors, adding playing position and confederation as covariates (Liang & Zeger, 1986; Pepe & Anderson, 1994). The model was also refitted among observations whose national team qualified for the subsequent tournament. OFC was excluded from these models because none of its 23 eligible observations returned.

RESULTS

Demographic characteristics

Table 1. Sample characteristics by tournament, confederation, and position.

Characteristic	n	% of Sample	Mean age (SD)
Tournament			
2010	736	17.2	26.89 (3.78)
2014	736	17.2	26.82 (3.81)
2018	736	17.2	27.41 (3.95)
2022	831	19.4	26.93 (4.28)
2026	1,248	29.1	27.45 (4.27)
Confederation			
UEFA	1,674	39.0	26.99 (4.00)
CAF	758	17.7	26.44 (4.06)
AFC	688	16.1	27.46 (3.91)
CONMEBOL	628	14.6	27.72 (4.04)
CONCACAF	490	11.4	27.50 (4.32)
OFC	49	1.1	27.59 (4.55)
Playing position			
Defenders	1,415	33.0	27.26 (3.87)
Midfielders	1,369	31.9	26.62 (3.86)
Forwards	972	22.7	26.59 (4.01)
Goalkeepers	531	12.4	29.17 (4.51)
Total observations	4,287	100.0	27.14 (4.07)

Note. Sample percentage was calculated relative to the full analytic dataset (N = 4,287 player-tournament observations). Age at tournament is reported as the number of years elapsed between the player's date of birth and the opening match day of each tournament. SD = standard deviation.

The pooled dataset contained 4,287 player–tournament observations across five FIFA Men's World Cup tournaments (2010, 2014, 2018, 2022, 2026), drawn from 3,283 unique players. The 2010, 2014, and 2018 tournaments contributed identical squad counts (n = 736 each, reflecting the 32-team era with 23-man rosters). The 2022 tournament contributed 831 observations following FIFA's mid-cycle roster expansion to 26 players per squad, and the 2026 expansion tournament contributed 1,248 observations from 48 teams with 26-player squads. Confederation representation reflected long-standing slot allocations, with UEFA accounting for 39.0% of all observations, followed by CAF (17.7%), AFC (16.1%), CONMEBOL (14.6%), CONCACAF (11.4%), and OFC (1.1%, n = 49). Players were classified by FIFA squad-list positions into

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defenders (33.0%), midfielders (31.9%), forwards (22.7%), and goalkeepers (12.4%). Six players appeared in all five tournaments examined. Player ages at tournament ranged from 17 to 45 years (M = 27.14, SD = 4.07), with goalkeepers older on average (M = 29.17, SD = 4.51) than outfield players and modest age variation across tournaments and confederations (Table 1).

Tournament birth quartile distributions

Table 2. Birth quartile distribution and Chi-Square goodness-of-fit tests per tournament.

Tournament	n	Q1 %	Q2 %	Q3 %	Q4 %	$\chi^2(3)$	*p*
2010	736	28.3	26.4	22.4	23.0	6.86	.077
2014	736	29.8	26.0	24.5	19.8	14.86	.002
2018	736	31.4	25.8	24.6	18.2	25.84	< .001
2022	831	32.1	24.5	22.7	20.6	25.16	< .001
2026	1,248	28.5	26.8	24.5	20.2	19.41	< .001
Pooled	4,287	29.9	26.0	23.8	20.3	—	—

Note. Q1–Q4 = birth quartiles based on January–December calendar year. Expected distribution under the null hypothesis is 25.0% per quartile. Pooled row shows aggregate distribution across all five tournaments.

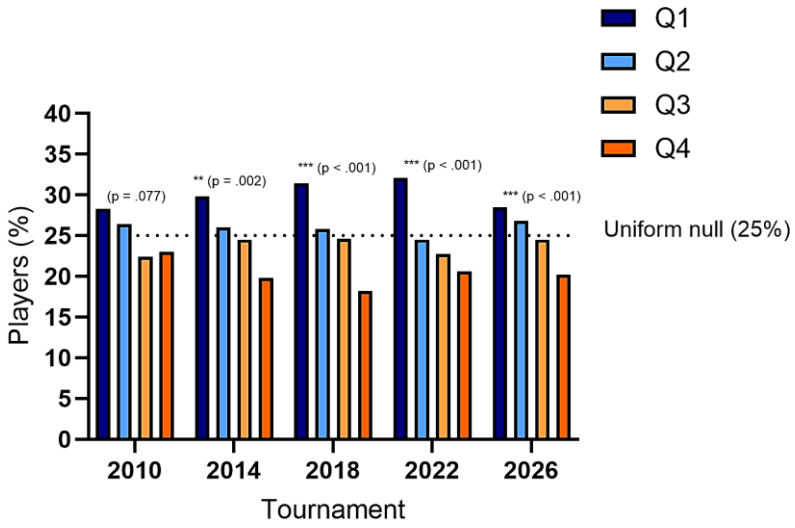

Figure 1. Birth-quartile distribution across five FIFA Men's World Cup tournaments (2010–2026).

Chi-square goodness-of-fit tests indicated significant departures from a uniform birth quartile distribution in four of the five tournaments examined (Table 2, Figure 1). The 2010 tournament alone failed to reach significance, $\chi^2(3, N = 736) = 6.86$, $p = .077$, with Q1 (28.3%) and Q4 (23.0%) substantially closer than in subsequent tournaments. From 2014 onward, RAE was detected in every tournament. Chi-square values were 14.86 for 2014 ($p = .002$), 25.84 for 2018 ($p < .001$), 25.16 for 2022 ($p < .001$), and 19.41 for 2026 ($p < .001$).

The independence test for birth quartile × tournament year was non-significant, $\chi^2(12, N = 4,287) = 10.22$, $p = .597$, with a trivial effect size (Cramér's V = .028). The linear-by-linear trend component was likewise non-significant, $\chi^2(1) = 0.30$, $p = .584$, indicating no change in magnitude across the 16-year window. Within the 2026 tournament, the birth quartile distribution of expansion-beneficiary players (n = 520) did not differ significantly from that of non-beneficiary players (n = 728), with Q1 at 28.8% versus 28.3% and Q4 at 19.2%

versus 20.9%, $\chi^2(3, N = 1,248) = 1.41$, $p = .703$, $V = .034$. A secondary comparison against the pooled 2010–2022 dataset (n = 3,039) was likewise null, with Q1 at 28.8% among beneficiaries versus 30.4% in the pre-expansion era, $\chi^2(3, N = 3,559) = 1.79$, $p = .616$, $V = .022$. The roster expansion from 32 to 48 teams therefore produced no detectable shift in the birth quartile profile of newly qualified players.

Confederation-level analysis

Table 3. Birth quartile distribution by FIFA confederation, pooled across tournaments (2010–2026).

Confederation	n	Q1 %	Q2 %	Q3 %	Q4 %	$\chi^2(3)$	*p*	*V*
UEFA	1,674	31.2	25.8	23.5	19.5	48.53	< .001	.098
CAF	758	28.5	27.0	19.1	25.3	15.46	.001	.082
AFC	688	28.1	23.0	31.5	17.4	31.20	< .001	.123
CONMEBOL	628	29.5	28.5	23.2	18.8	18.54	< .001	.099
CONCACAF	490	30.0	26.5	21.8	21.6	9.54	.023	.081
OFC	49	34.7	18.4	26.5	20.4	3.16	.367	.147
Overall (independence test)	4,287	29.9	26.0	23.8	20.3	47.40[a]	< .001	.061

Note. V for goodness-of-fit tests = $\sqrt{[\chi^2/(N \times 3)]}$. OFC is interpreted descriptively owing to low power (n = 49), although the minimum expected frequency (12.3) satisfied the chi-square assumption. The overall independence test was for birth quartile × confederation; df = 15.

Five of the six confederations exhibited significant RAE pooled across tournaments (Table 3). With Bonferroni correction across the six confederation-level goodness-of-fit tests ($\alpha = .0083$), four confederations retained significance. These were UEFA, $\chi^2(3, N = 1,674) = 48.53$, $p < .001$; AFC, $\chi^2(3, N = 688) = 31.20$, $p < .001$; CONMEBOL, $\chi^2(3, N = 628) = 18.54$, $p < .001$; and CAF, $\chi^2(3, N = 758) = 15.46$, $p = .001$. CONCACAF reached uncorrected significance ($p = .023$) but did not survive Bonferroni correction. OFC was reported descriptively only owing to low power.

Two confederations showed quartile profiles inconsistent with the canonical Q1 > Q2 > Q3 > Q4 monotonic decline. The AFC distribution showed Q3 (31.5%) exceeding Q1 (28.1%), with Q4 the smallest (17.4%). The CAF distribution showed Q4 (25.3%) approaching Q1 (28.5%) and exceeding Q3 (19.1%). The conventional declining gradient was therefore inverted at the lower end. UEFA, CONMEBOL, and CONCACAF showed the canonical monotonic pattern. OFC's nominal Q1 dominance (34.7%) carried wide imprecision given the small sample. When stratified by tournament year (five confederation-specific 4 × 5 tables, OFC not tested), no confederation × tournament interaction reached significance (AFC, $\chi^2(12) = 11.30$, $p = .503$; CAF, $\chi^2(12) = 15.61$, $p = .210$; CONCACAF, $\chi^2(12) = 8.99$, $p = .703$; CONMEBOL, $\chi^2(12) = 8.30$, $p = .761$; UEFA, $\chi^2(12) = 5.78$, $p = .927$). Confederation-specific quartile profiles were therefore stable across the 16-year window.

Position stratification

Birth quartile distributions differed significantly from uniform within each of the four position groups (Table 4). After Bonferroni correction ($\alpha = .0125$), three positions retained significance: defenders, $\chi^2(3, N = 1,415) = 31.13$, $p < .001$; goalkeepers, $\chi^2(3, N = 531) = 25.54$, $p < .001$; and midfielders, $\chi^2(3, N = 1,369) = 32.24$, $p < .001$. Forwards reached uncorrected significance only, $\chi^2(3, N = 972) = 10.11$, $p = .018$.

Goalkeepers produced the largest Q1–Q4 differential (13.0 percentage points), with Q4 representation falling to 17.1%, the lowest value of any position-by-quartile cell in the dataset. Defenders and midfielders showed near-identical differentials (10.3 and 10.0 percentage points, respectively). Forwards displayed the flattest profile, with the Q1–Q4 differential decreasing to 5.9 percentage points and Q4 representation (23.4%) nearly matching the uniform expected value. Position × tournament year interactions were non-significant within

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each position group (all *p* values > .80), indicating that position-specific RAE patterns did not shift across the 2010–2026 window.

Table 4. Birth quartile distribution by playing position, pooled across tournaments.

Position	n	Q1 %	Q2 %	Q3 %	Q4 %	$\chi^2(3)$	*p*	Q1–Q4 Δ
Goalkeepers	531	30.1	30.1	22.6	17.1	25.54	< .001	13.0
Defenders	1,415	30.7	23.9	25.1	20.4	31.13	< .001	10.3
Midfielders	1,369	29.4	27.6	23.6	19.4	32.24	< .001	10.0
Forwards	972	29.3	24.4	22.9	23.4	10.11	.018	5.9
Position × Quartile (independence test)	4,287					18.01[a]	.035	—

Note. Q1–Q4 Δ = absolute difference in percentage points between Q1 and Q4 proportions. Larger Δ values indicate stronger position-specific RAE. [a] *The position × quartile independence test had df = 9; Cramér's V = .037.*

Multi-tournament player persistence

Table 5. Birth quartile distribution across multi-tournament persistence levels.

Persistence level	n	% of players	Q1 %	Q2 %	Q3 %	Q4 %
1 tournament	2,504	76.3	28.8	25.9	23.1	22.2
2 tournaments	600	18.3	30.3	25.2	24.0	20.5
3 tournaments	139	4.2	30.9	28.8	25.2	15.1
4 tournaments	34	1.0	41.2	23.5	29.4	5.9
5 tournaments	6	0.2	33.3	33.3	33.3	0.0
Multi-tournament players (≥ 3 tournaments)	179	5.4	33.0	27.9	26.3	12.8

Note. Persistence level = number of distinct FIFA Men's World Cup tournaments in which a player appeared (2010, 2014, 2018, 2022, 2026). % of players is calculated against the unique player base (n = 3,283).

Of the 3,283 unique players in the dataset, 76.3% appeared in only one tournament, 18.3% in two, 4.2% in three, 1.0% in four, and 0.2% (n = 6) in all five tournaments examined. The birth quartile × persistence-level independence test was non-significant overall, $\chi^2(12, N = 3,283) = 12.74$, $p = .388$, $V = .036$, with four cells violating the minimum expected-frequency assumption. The linear-by-linear trend component, which is appropriate when both variables can be treated as ordered, reached significance, $\chi^2(1) = 5.60$, $p = .018$, indicating a monotonic relationship between birth quartile and persistence. Within the multi-tournament subset of players (≥ 3 tournament appearances; n = 179), the quartile distribution departed significantly from uniform, $\chi^2(3, N = 179) = 15.84$, $p = .001$. The Q1–Q4 differential widened to 20.1 percentage points (Q1 33.0% vs. Q4 12.8%), more than double the differential observed in the full dataset. Among the six 5-tournament players, Q1 contained two players, Q2 two, Q3 two, and Q4 zero.

Senior-international tournament return rate (underdog hypothesis test)

The unadjusted return rate by birth quartile differed significantly across the 3,039 player-tournament observations eligible for return analysis, $\chi^2(3, N = 3,039) = 10.66$, $p = .014$, $V = .059$. Players born in Q4 returned for the next tournament at a rate of 25.6%, compared with 31.4% for Q1, 32.0% for Q2, and 33.4% for Q3. The pattern expected under the underdog hypothesis, in which Q4 players would return at higher rates than Q1 players, was therefore not observed. When stratified by source tournament, only the 2010–2014 transition reached significance, $\chi^2(3) = 10.30$, $p = .016$. The 2014–2018, 2018–2022, and 2022–2026 transitions were all non-significant (all *p* values > .30). After adjustment for age at tournament as a continuous variable and tournament year as a categorical variable with 2010 as the reference, the birth quartile effect remained significant overall, Wald $\chi^2(3) = 17.34$, $p = .001$. The full adjusted model is presented in Table 6.

Players born in Q4 had lower odds of returning than Q1 players, OR = 0.69, 95% CI [0.54, 0.87], p = .002. Q2 and Q3 did not differ significantly from Q1 (ORs = 1.05 and 1.13, respectively; both p values > .28). Age was the strongest single predictor, with each additional year reducing the odds of return by 13%, OR = 0.87, 95% CI [0.85, 0.89], p < .001. The model explained 9.8% of the variance (Nagelkerke R^2 = .098) and showed acceptable calibration, Hosmer–Lemeshow $\chi^2(8) = 9.27$, p = .320.

Table 6. Adjusted logistic regression predicting return to the next FIFA Men's World Cup.

Predictor	B	SE	Wald χ^2	OR [95% CI]	df	*p*
Birth quartile (Q1 reference)			17.34		3	.001
Q2 vs Q1	0.05	0.11	0.22	1.05 [0.85, 1.30]	1	.637
Q3 vs Q1	0.12	0.11	1.15	1.13 [0.91, 1.40]	1	.283
Q4 vs Q1	−0.37	0.12	9.60	0.69 [0.54, 0.87]	1	.002
Age at tournament (years)	−0.14	0.01	155.33	0.87 [0.85, 0.89]	1	< .001
Tournament year (2010 reference)			42.08		3	< .001
2014	−0.08	0.12	0.43	0.92 [0.73, 1.17]	1	.514
2018	0.34	0.12	8.35	1.41 [1.12, 1.78]	1	.004
2022	0.57	0.11	24.86	1.76 [1.41, 2.20]	1	< .001
Constant	2.66	0.31	74.57	14.22	1	< .001

Note. The dependent variable was return to the next tournament (1 = yes, 0 = no). Reference categories were Q1 for birth quartile and 2010 for tournament year. Observations from the 2026 tournament were excluded because no subsequent tournament was available. N = 3,039. B = unstandardised regression coefficient; CI = confidence interval; OR = odds ratio; SE = standard error. Model $\chi^2(7) = 219.73$, p < .001; Nagelkerke R^2 = .098; Hosmer–Lemeshow $\chi^2(8) = 9.27$, p = .320.

When the quartile × return-status crosstabulation was stratified by confederation, only AFC approached the uncorrected threshold, $\chi^2(3, N = 454) = 7.82$, p = .050, V = .131. CAF was marginal, $\chi^2(3, N = 498) = 7.27$, p = .064. CONCACAF, CONMEBOL, and UEFA were non-significant (all p values > .28). OFC could not be analysed because none of the 23 eligible observations returned. The adjusted Q4 disadvantage observed in the pooled model was not consistently replicated within individual confederations, although the within-confederation tests had limited power. Restricting the analysis to the 937 player-tournament observations that resulted in a return to the subsequent tournament, the birth quartile distribution remained significantly skewed (Q1 = 31.0%, Q2 = 26.6%, Q3 = 25.5%, Q4 = 17.0%), $\chi^2(3, N = 937) = 38.47$, p < .001. The Q1–Q4 differential among returnees (14.0 percentage points) was larger than that in the parent pool (10.0 percentage points), consistent with the regression finding for the full sample.

Sensitivity analyses addressed the 1,004 repeat appearances. When each player was counted once at his first appearance (n = 3,283), the pooled distribution remained skewed (Q1 = 29.3%, Q4 = 21.4%), $\chi^2(3) = 46.43$, p < .001, and did not vary by debut edition, $\chi^2(12) = 11.28$, p = .505. UEFA, AFC, and CAF retained significance after Bonferroni correction (all p values ≤ .007), whereas CONMEBOL (p = .021) and CONCACAF (p = .030) did not. Goalkeepers, defenders, and midfielders retained significance (all p values ≤ .005), with goalkeepers again showing the largest differential (Q1 = 30.9%, Q4 = 17.0%), whereas forwards did not (p = .081). The position × quartile test was not significant among unique players, $\chi^2(9) = 14.16$, p = .117. In the clustered return model adjusted for age, edition, position, and confederation, Q4-born players had lower odds of returning, OR = 0.71, 95% CI [0.56, 0.91], p = .006, n = 3,016. Among players whose national team qualified for the next edition, the estimate was *OR* = 0.74, 95% CI [0.57, 0.97], p = .029, n = 2,239.

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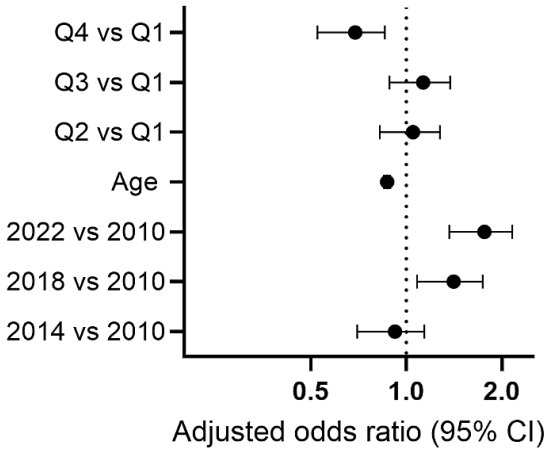

Note. The dashed vertical line at OR = 1.0 represents the null hypothesis of no association.

Figure 2. Adjusted odds of returning to the subsequent FIFA Men's World Cup by birth quartile, age, and tournament year.

DISCUSSION

The present study characterised the birth-quartile distribution of registered squads across five consecutive FIFA Men's World Cup tournaments from 2010 to 2026, examining whether the relative age effect (RAE) changed across the sixteen-year window, whether the 32-to-48-team expansion altered the birth profile of newly qualified nations, whether the effect varied by position and confederation, and whether late-born players showed the elevated return trajectory reported at academy level. An RAE was present in every tournament from 2014 onward without change in magnitude across the window, expansion-beneficiary nations were indistinguishable from non-beneficiaries, the effect was largest in goalkeepers and weakest in forwards, and late-born players had reduced rather than elevated odds of returning to the subsequent edition.

The effect was small in absolute terms, with a pooled Q1/Q4 ratio of 1.47. Its practical weight lies in its recurrence. Relative to a uniform expectation, the pooled distribution corresponds to roughly one fewer Q4-born player in every 26-player squad, a shortfall repeated in every edition from 2014 onward. The longitudinal stability from 2014 to 2026 aligns with cohort-comparison work showing that three decades of published awareness have not attenuated the RAE and with meta-analytic evidence that the effect strengthens as competitive level rises (Bozděch et al., 2023; Craig et al., 2025; Ruscello et al., 2022). The finding also aligns with the strengthening pattern reported in earlier World Cup data covering 2006 to 2018, although the present analysis identifies no monotonic trend across the extended window and instead a plateau after 2014, with the 2010 tournament alone failing to reach significance (Pedersen et al., 2022). This may reflect residual variation in a single 736-player sample or a genuine shift in the selection environment during the intervening period. The latter possibility aligns with historical work showing a resurgence of Q1 dominance in the recent decades of the Ballon d'Or nomination pool after middle decades of no discernible effect (Saavedra-García et al., 2024). The expansion natural experiment returned a null result. The twenty nations that qualified only under the widened allocation, drawn from all six confederations, showed no measurable shift in birth-quartile profile, although the comparison could not exclude small differences. Research consistent with the present finding has argued that the RAE arises from institutional selection structures rather than from the geography or scale of the qualification pool (Delorme et al., 2024). The absence of change is consistent with the effect originating in domestic development pipelines, although those pipelines were not observed here.

The most theoretically consequential finding of the present study is that late-born players who reached the World Cup had reduced adjusted odds of returning to the subsequent tournament compared with those born in the first quartile (OR = 0.69, 95% CI [0.54, 0.87], p = .002). This pattern is directionally opposite to the underdog trajectory documented at academy-to-senior transitions (Biermann et al., 2024; Boccia et al., 2023; Bolckmans et al., 2023; Brustio et al., 2024; de la Rubia et al., 2020) and requires interpretation. The association held after clustering on player and adjustment for position and confederation, and among players whose national team qualified for the next edition. It is not a refutation of the underdog hypothesis, since the present outcome sits at a later stage of the pathway and measures a different transition. The reconciliation proposed here rests on a distinction between two structurally different transitions. Academy-to-senior transition operates through selection filters that progressively remove players over multiple years, so that Q4-born players who reach senior level have already passed a stringent screen (Brustio et al., 2024). Tournament-to-tournament transition at senior international level operates through federation-level squad continuity, in which national team selection is influenced by prior tournament performance, coaching-staff preferences, and player availability across a four-year cycle. Such continuity may disadvantage late-born players even after the initial selection filter, although this mechanism was not observed directly. Two features of the present data are consistent with this interpretation. First, the multi-tournament player subset showed a Q1 to Q4 differential more than double that of the full sample. Second, the adjustment for chronological age did not remove the Q4 disadvantage, which argues against age-related retirement as the sole explanation. The pattern is more consistent with cumulative-advantage accounts, in which initial selection brings resources and expectations that favour the next selection (Hancock et al., 2013).

The position-stratified analysis identified goalkeepers as the most RAE-affected group, with the smallest Q4 representation of any position-by-quartile cell in the dataset. Research has consistently identified goalkeepers as the position most sensitive to relative age across national and international samples (Işık et al., 2025; Li et al., 2020; Yagüe et al., 2023). The mechanism is likely rooted in the developmental importance of stature and reach for this position, both of which favour biologically more mature and relatively older youth players (Curnyn et al., 2025). The age distribution of the present sample is consistent with this mechanism operating at senior level, with goalkeepers older on average (M = 29.17, SD = 4.51) than defenders (M = 27.26, SD = 3.87), midfielders (M = 26.62, SD = 3.86), and forwards (M = 26.59, SD = 4.01). Forwards showed the flattest quartile profile with a Q1 to Q4 differential of under six percentage points, aligning with work reporting the highest market value in late-born forwards and the smallest Q1 to Q4 gap for this position across European top-tier leagues (Bezuglov et al., 2023; Yagüe et al., 2023). The difference between positions was small and was not significant when each player was counted once, so the ordering of positions should be read descriptively.

The confederation analysis identified significant RAE in UEFA, CONMEBOL, CAF, and AFC after correction, although CONMEBOL did not retain significance when each player was counted once. The AFC distribution showed the third quartile exceeding the first, and the CAF distribution showed the fourth quartile approaching the first. Both patterns are difficult to attribute definitively from the present data. Smaller AFC and CAF sample sizes generate greater variability around the canonical gradient. Confederation-specific cutoff dates have sometimes been proposed as an alternative explanation for regional variation, but no such variation is documented in FIFA regulations. No measures of development systems, competition structures, or age-group policy were collected, so these patterns are reported as descriptive findings rather than evidence of confederation-specific selection cultures. The heterogeneity is nonetheless consistent with a growing view that the RAE is context dependent rather than uniform (Andrew et al., 2025; Martínez-Benítez et al., 2026; Pérez-González et al., 2025).

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The primary strengths of the present analysis are its longitudinal scope across sixteen years of senior World Cup competition, its inclusion of all six FIFA confederations, and its use of the 2026 tournament expansion as a natural experiment that no prior study has been positioned to test. However, there are several limitations that should be acknowledged. The dataset contains only date of birth, and like the majority of large-sample RAE research it cannot separate calendar-age effects from biological maturity, which recent smaller-sample work has demonstrated to be a statistically distinct construct with typically larger magnitude in youth populations (Curnyn et al., 2025; Sweeney & Lundberg, 2024). The classification of expansion beneficiaries relies on confederation slot ranking under the pre-expansion allocation, and the counterfactual of which teams would have qualified under a 32-team format cannot be observed directly, likely biasing the beneficiary comparison toward the null. The return analysis operationalises persistence at the player-tournament level and cannot distinguish deselection from retirement, injury, or federation-level squad turnover, meaning that the reduced Q4 return odds may reflect an aggregate of several distinct mechanisms.

The uniform expectation overstates the RAE where national births concentrate early in the year and understates it where births peak later (Delorme et al., 2010). Playing position was taken from FIFA roster designations, which do not distinguish sub-roles and may be applied inconsistently across federations and editions, a misclassification that would bias between-position differences toward the null. The return model explained a small share of variance (Nagelkerke R^2 = .098). This is expected, since return depends on injury, form, and coaching decisions that squad lists do not record, and the model was specified to estimate the quartile association rather than to predict return. Team strength was not modelled directly and could confound the quartile estimate in either direction. Finally, the analysis draws exclusively on registered squads and cannot speak to the birth distribution of players in the qualification tournaments or the wider development pipelines from which those squads were drawn.

The finding that RAE persists at senior World Cup level and has not attenuated across sixteen years indicates that the awareness accumulated across three decades of published research has not been accompanied by a measurable reduction of the effect at the highest level. This aligns with critical commentary calling for a shift away from further chi-square replication studies in new contexts and towards mechanism-focused and intervention-focused research (Roberts et al., 2020). Interventions that address relative age at its source already exist, including maturity-based grouping and age-ordered shirt numbering during talent evaluation (Cumming et al., 2017; Mann & van Ginneken, 2017). Neither was evaluated here, and their effect on senior international squads is untested. If late-born players are under selected without a corresponding performance deficit, federations also draw on a narrower effective talent pool than their registration base allows (Bezuglov et al., 2023; Craig et al., 2025). For federations, the position-specific finding on goalkeepers has an immediate practical implication because it is the position where relative age has the largest apparent influence, and any age-corrected or maturity-corrected assessment protocol at this position is likely to yield the largest change to selected pools. The reduced return odds for late-born players suggest that federation-level career continuity mechanisms may systematically disadvantage the players who most successfully overcame the initial youth selection filter, a possibility that federation talent identification units could examine using their own retention data. Three future directions are indicated. First, an equivalent transition-rate model applied to the World Cup pool along the lines of established academy-to-senior analyses would help reconcile the underdog contradiction identified here (Brustio et al., 2024). Second, retrospective maturity estimates from youth-national-team records, where federations hold them, would allow calendar age and biological maturity to be separated in senior international samples (Curnyn et al., 2025; Sweeney & Lundberg, 2024). Third, confederation-specific analyses of the AFC third-quartile pattern and the CAF fourth-quartile approach to Q1 may help determine whether these non-canonical distributions reflect genuine confederation-specific selection structures or artefacts of the pooled sample.

CONCLUSION

The relative age effect was present in every FIFA Men's World Cup from 2014 to 2026, did not attenuate across the sixteen-year window, and showed no detectable response to the 32-to-48-team expansion. The effect was largest in goalkeepers and smallest in forwards.

Late-born players who reached the tournament had lower adjusted odds of returning to the subsequent edition (OR = 0.69), so the underdog advantage reported at academy transition may not extend into repeated senior international selection. Federations can examine squad retention by birth quartile using records they already hold. Prospective work is needed to separate deselection, retirement, injury, and cumulative selection advantage as explanations.

AUTHOR CONTRIBUTIONS

All authors meet the established criteria for authorship. Contributions are reported according to the CRediT taxonomy as follows:

Conceptualisation: H. M. Methodology: H. M., J. L. F. L., R. I. D. Formal analysis: H. M. Investigation: H. M., H. H., A. M. N. A. Data curation: H. M., H. H., A. T. L. S., A. M. N. A. Writing – original draft: H. M. Writing – review & editing: H. M., J. L. F. L., H. H., R. I. D., A. T. L. S., A. M. N. A. Supervision: J. L. F. L., R. I. D.

All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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