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WORKFORCE SHORTAGES, RETENTION, AND CAREER PROGRESSION AMONG LABORATORY TECHNICIANS: A SYSTEMATIC REVIEW

Review question: What factors influence recruitment, retention, and career development in the laboratory technician workforce?

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Abstract

Background. Shortages of laboratory technicians threaten diagnostic capacity, yet evidence on what drives recruitment, retention, and career progression is scattered and rarely compares Saudi Arabia with global patterns. **Objective.** To synthesise factors that influence recruitment, retention, and career development in the laboratory technician workforce. **Methods.** Systematic review reported against PRISMA 2020. PubMed and Consensus were searched on 22 November 2026. One reviewer screened records at title and abstract level and extracted data from abstracts; no protocol was registered. Findings were synthesised narratively into eight coded domains. **Results.** Of 258 records identified, 27 studies were included (Saudi Arabia 3, other GCC/MENA 3, international 21); 18 were cross-sectional surveys. The most frequently reported domains were career development, promotion, and education (12 studies), stress and burnout (10), the recruitment pipeline (9), workload and staffing (8), compensation (7), recognition and visibility (7), leadership and culture (6), and ageing and retirement (6). Saudi and GCC studies stressed career development (5 of 6) and leadership or appraisal (3 of 6) and reported no data on retirement. **Conclusions.** Evidence is consistent in direction but low in certainty. Transparent promotion routes, funded professional development, equitable pay, manageable workloads, supportive supervision, and visible entry pathways are the most supported levers. Multi-centre Saudi studies with validated instruments are needed.

Keywords: laboratory technicians; medical laboratory workforce; staff retention; recruitment; career development; Saudi Arabia; systematic review

1. Introduction

Laboratory technicians, technologists, and scientists generate the test results that guide diagnosis and treatment. Vacancy surveys of United States laboratories show that shortages deepened during the pandemic and remain above pre-pandemic levels, with retirements still rising (Garcia et al.,

2024; Garcia et al., 2025). Microbiology laboratories report vacancies in about 80% of surveyed sites (Leber et al., 2022). Retention matters as much as recruitment: the 2022 US vacancy survey concluded that both need attention (Garcia et al., 2024), and a 2026 US survey found that tenured staff had stayed a median of 20.5 years at their workplace against 3.0 years for younger colleagues (Chiou & Mulder, 2026). Similar pressure is described in Canada (Dignos et al., 2023) and in Uganda, where only half of technologist posts were filled at general hospitals (Kiwanuka et al., 2020).

Saudi and Gulf evidence is thinner. Reviews of healthcare staff in Saudi Arabia and the Gulf Cooperation Council (GCC) identify pay, promotion, supervision, workload, and stress as determinants of satisfaction and turnover intention, but they pool many professions and rest largely on cross-sectional surveys (Alkhurayji et al., 2024; Al-Khateeb et al., 2025). Studies focused on laboratory staff are few, small, and mostly single-site. No synthesis has set the laboratory-specific Saudi and regional findings against the wider international evidence. This review fills that gap for the laboratory technician workforce and asks what factors influence recruitment, retention, and career development.

2. Methods

2.1 Design, protocol, and question

We followed PRISMA 2020 reporting. No protocol was registered. The question was framed in PECO form: **Population**, laboratory technicians, technologists, scientists, and assistants in clinical or public-health laboratories; **Exposure**, workforce, organisational, educational, and individual factors; **Comparator**, none required; **Outcomes**, recruitment (entry, vacancies), retention (turnover, intention to leave, satisfaction), and career development (promotion, education, mobility).

2.2 Eligibility

We included peer-reviewed primary studies (surveys, qualitative, mixed methods, facility assessments) and reviews that reported explicit workforce-factor findings for laboratory staff, published 2000–2026 in English. We excluded commentaries without data, theses, studies of mixed health professions in which laboratory staff could not be separated, studies of pathologists or other non-laboratory cadres, and earlier editions of a survey series superseded by later ones.

2.3 Search, selection, and extraction

PubMed and Consensus were searched on 22 November 2026 (Table 1). PubMed date filters were 2010 onward for searches S1–S8 and 2012 onward for S9–S11; PubMed returned two older eligible records (2001, 2005), which were kept. Consensus was searched without date limits, restricted to peer-reviewed records. Searches targeted both Saudi/regional and international evidence.

Table 1. Search strategy (all searches run 22 November 2026)

ID	Database	Query	Records found	Retrieved
S1	PubMed	(laboratory OR "medical technologist" OR "laboratory technician") AND (workforce OR shortage OR retention OR turnover) AND Saudi Arabia	820	20
S2	PubMed	medical laboratory workforce shortage retention career	8	8
S3	PubMed	laboratory professionals job satisfaction turnover intention	28	20

ID	Database	Query	Records found	Retrieved
S4	PubMed	laboratory workforce Gulf OR GCC OR "Middle East" OR Africa recruitment retention	45,640	20
S5	PubMed	medical laboratory professionals job satisfaction	227	25
S6	PubMed	medical laboratory Saudi Arabia burnout OR satisfaction OR retention OR Saudization	613,032	25
S7	PubMed	clinical laboratory scientists burnout OR "intent to leave" OR "career advancement"	2,700	25
S8	PubMed	laboratory workforce vacancy rate OR staffing clinical laboratory shortage	100	25
S9	PubMed	laboratory technologists Saudi Arabia	25	20
S10	PubMed	Saudi Arabia healthcare workforce turnover intention allied health	0	0
S11	PubMed	Saudi laboratory medical technologists job satisfaction OR burnout OR stress	1,638,661	20
C1	Consensus	medical laboratory technologists recruitment retention career progression workforce shortage	n/a	30
C2	Consensus	laboratory technologists job satisfaction turnover Saudi Arabia	n/a	20

Note. Large "records found" figures for S4, S6, and S11 reflect PubMed automatic term expansion on OR-joined terms; only the top-ranked records were retrieved. Retrieved totals: PubMed 208, Consensus 50.

Selection and extraction were done by a single reviewer at title and abstract level; full texts were not retrieved and no second reviewer screened independently. PubMed records were retrieved as identifiers; 123 of the 195 unique PubMed identifiers (lower-ranked results of broad queries) were not opened, so their titles were not screened. For four records found only through Consensus (Elhadi et al., 2026; Ron et al., 2026; Mullah et al., 2020; Algahtani et al., 2024), only the abstract text shown by the tool was used. We extracted design, setting, sample, and factor-level findings, and tagged each study as Saudi, GCC-MENA, or International.

2.4 Appraisal and synthesis

No formal risk-of-bias tool was applied because only abstracts were read. Design and sampling limits were noted instead. Heterogeneity in designs and outcomes precluded meta-analysis, so we used narrative synthesis (SWiM). Findings were coded into eight domains by inspection of the abstracts, and a qualitative confidence rating (low, very low) was assigned to each domain from design, directness, and consistency. These ratings are judgements and not GRADE-CERQual assessments. Domains were defined as follows: compensation (pay, allowances, benefits); workload (staffing levels, hours); career development (promotion, continuing education, graduate study, mobility); recognition (appreciation, inclusion, visibility of the profession); leadership (supervision, appraisal, mentoring, team climate); stress (stress, burnout, well-being); pipeline (awareness, training capacity, entry routes); and ageing (retirement, tenure).

3. Results

3.1 Study selection

The searches identified 258 records (PubMed 208, Consensus 50). After removing 18 duplicates, 240 unique records remained; 117 were title/abstract-screened, 64 were assessed for eligibility at abstract level, and 27 studies were included (Figure 1).

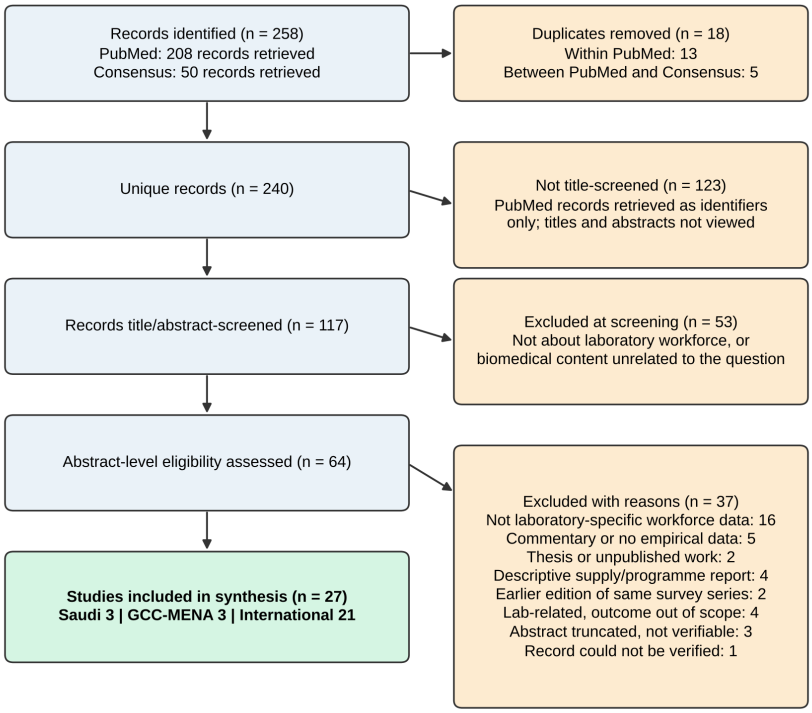

Figure 1. PRISMA 2020 flow diagram. Counts are those of this review's searches. "Not title-screened" are PubMed identifiers whose titles were not opened. GCC, Gulf Cooperation Council; MENA, Middle East and North Africa.

3.2 Characteristics of included studies

The 27 studies span 2001 to 2026 (Table 2). Three were Saudi, three came from other GCC/MENA settings (Oman twice, Israel once), and 21 were international, mostly from the United States (14) and Canada (3). Eighteen were cross-sectional surveys; the rest were qualitative or mixed-methods studies (3) and reviews, a brief report, or facility assessments (6) (Figure 2). All Saudi evidence came from single-site or convenience samples of 100–151 respondents.

Table 2. Characteristics and key findings of included studies (n = 27)

ID	Study	Setting tag: country	Design; sample	Key findings on recruitment, retention, or career
S1	Al-Qathmi & Zedan, 2021	Saudi: Saudi Arabia*	Survey; 100 of 250 MLTs	Turnover intention linked to wage discrepancy (51% strongly agreed), low increments (48%), limited promotion, allowances, and continuing education (49%); 39% dissatisfied with workload; career growth and pay ranked highest for staying.

ID	Study	Setting tag: country	Design; sample	Key findings on recruitment, retention, or career
S2	Elhadi et al., 2026	Saudi: Saudi Arabia (Dammam)	Survey; 151 staff, government labs	Appraisal and satisfaction strongly correlated (r = 0.886); lowest satisfaction for career development (mean 2.84) and conflict resolution (2.89); trust in appraisal fairness was low.
S3	Bashawri, 2005	Saudi: Saudi Arabia (Eastern Province)	Survey; 111 female MLT students and graduates	High satisfaction with the profession; goals were hospital technologist work (57.7%) and postgraduate study (38.7%).
G1	Alrawahi et al., 2019	GCC-MENA: Oman	Qualitative; 12 focus groups, MLTs	Dissatisfaction from workload, promotion, laboratory safety, relations with leaders, low recognition, and appraisal; salary, co-workers, and job security (non-Omanis) satisfied; autonomy and development mattered.
G2	Alrawahi et al., 2024	GCC-MENA: Oman	Survey; 8 hospitals, MLPs	Stress associated with lower satisfaction; youngest staff least satisfied and most stressed; insufficient support for professional development among key dissatisfiers.
G3	Ron et al., 2026	GCC-MENA: Israel	Survey; 178 graduates; 21 managers	Examined entry of life-science graduates into laboratory work (37% employed in labs) and managers' views on recruitment and retention.
I1	Marinucci et al., 2013	International: Seven sub-Saharan countries	Survey; 224 laboratorians	Lack of professional development drove 28% of job changes; about 90% rated training opportunities important; private-sector staff changed jobs more often (P = 0.002).
I2	Lo et al., 2022	International: Canada (Ontario)	Survey; 688 MLPs	Sense of community raised satisfaction (OR 2.22 MLT; 3.85 MLT/A); stress lowered it (OR 0.32; 0.26).
I3	Garcia et al., 2020	International: United States	Survey; Not stated in abstract	High satisfaction but high stress and prevalent burnout; workload and understaffing were the main contributors.
I4	Djukic & Nielsen, 2022	International: Canada	Brief report; Not stated in abstract	Satisfaction high, but stress rose about 10% since 2018 and emotional exhaustion 14%; calls for more training capacity and routes for foreign-trained MLTs.
I5	Kenwright, 2018	International: United States	Survey; 333 MLS	Career satisfaction higher among those who felt included by other professions, had relevant choices, and felt challenged.

ID	Study	Setting tag: country	Design; sample	Key findings on recruitment, retention, or career
I6	Chiou & Mulder, 2026	International: United States	Survey; Not stated in abstract	Tenured staff (51-65 y) had longer tenure (20.5 vs 3.0 y) and fewer unexpected sick days; no difference in fulfilment or wellness.
I7	Ritter et al., 2026	International: United States	Survey; 302 professionals	16.2% often thought of leaving, 17.9% intended to leave within a year; drivers: compensation (about 75%), stress or burnout (61.2%), limited growth (51.9%).
I8	Akkari et al., 2023	International: United States	Survey; 70 laboratory submissions	Barriers to filling technologist posts: too few trained applicants and better pay elsewhere.
I9	Halstead & Sautter, 2023	International: United States	Narrative review	Shortage tied to training-program closures, fewer applicants, low visibility, low wages, and perceived limited upward mobility.
I10	Blagg, 2024	International: United States	Survey; 1,247 MLS (2.5% response)	Professional development, advancement, recognition, and benefits motivated graduate study, more so among younger staff.
I11	Leber et al., 2022	International: United States	Narrative review and survey; Microbiology labs	80% of microbiology laboratories had vacancies; recommends awareness, training capacity, and alternate certification routes.
I12	Garcia et al., 2024	International: United States	Survey; 2022 vacancy survey	Vacancy and retirement rates rose versus 2020; recruitment and retention both needed.
I13	Garcia et al., 2025	International: United States	Survey; 2024 vacancy survey	Vacancies fell versus 2022 but stayed above pre-pandemic levels; retirements rising; calls for advocacy, credentialing, and more training programs.
I14	Dignos et al., 2023	International: Canada	Qualitative; 27 MLTs, 5 focus groups	Staff shortage harmed well-being and patient care; the profession's role was perceived as hidden.
I15	Guenther et al., 2025	International: United States	Survey; 1,243 professionals	Entry pathways diverse and unclear; most heard of careers via personal networks; at least 75% would recommend the occupation.
I16	Kiwanuka et al., 2020	International: Uganda	Facility assessment; 100 laboratories	Only 50% of technologist posts filled at general hospitals; workload, finances, and weak supervision constrained staff; training concentrated on HIV, TB, and malaria.
I17	Zepeda-Mendoza et al., 2026	International: United States	Survey; 375 geneticists	Over half reported technologist shortages; up to 25% expected to retire within a decade; strain and burnout highest mid-career.

ID	Study	Setting tag: country	Design; sample	Key findings on recruitment, retention, or career
I18	Mullah et al., 2020	International: South Africa	Mixed methods; Congress attendees	27.5% unhappy with career choice, especially younger and public-sector staff, who earned significantly less.
I19	Algahtani et al., 2024	International: Global (Saudi authors)	Narrative review	Crisis attributed to low visibility, non-competitive pay, high educational barriers, rising workloads, and burnout.
I20	Laudicina, 2001	International: United States	Narrative article; Panel of 5 managers	Mentoring proposed to improve retention and advancement across generations.
I21	Russell et al., 2025	International: United States	Survey; 507 cytologists	Retirement rates steady; staffing shortages worsen as staff leave; learning opportunities for advancement and burnout relief valued.

Note. MLT, medical laboratory technologist; MLS, medical laboratory scientist; MLP, medical laboratory professional. Findings are taken from abstracts. *Setting inferred from author affiliations (Riyadh); the abstract does not name the institution.

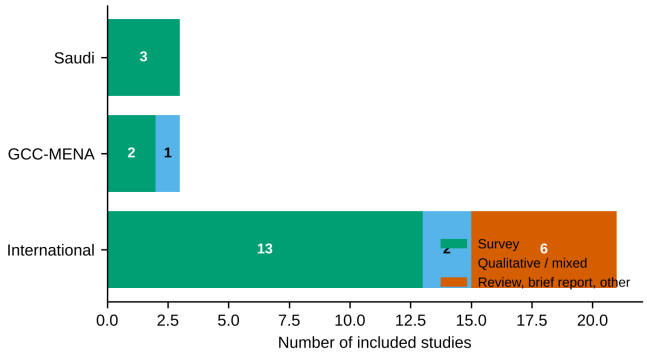

Figure 2. Included studies by design and setting (n = 27), drawn from Table 2.

3.3 Synthesis by domain

Eight domains emerged (Table 3). Career development, promotion, and education was the most frequent. In Saudi Arabia, limited promotion and weak access to continuing education featured in turnover intention (Al-Qathmi & Zedan, 2021), and career development received the lowest satisfaction score among Dammam laboratory staff (Elhadi et al., 2026). Omani technologists named promotion, autonomy, and professional development as sources of dissatisfaction (Alrawahi et al., 2019; Alrawahi et al., 2024). Internationally, lack of development caused 28% of job changes among African laboratorians (Marinucci et al., 2013), and a lack of growth opportunities featured among half of US professionals intending to leave (Ritter et al., 2026).

Pay mattered, but in different ways. Saudi technologists cited unequal wage allocation and low increments (Al-Qathmi & Zedan, 2021); US professionals cited compensation in roughly three-quarters of those thinking of leaving (Ritter et al., 2026); public-sector pay lagged in South Africa (Mullah et al., 2020). In Oman, by contrast, salary was a satisfier, alongside job security for non-Omani staff (Alrawahi et al., 2019). Workload and understaffing drove stress and burnout in US and Canadian samples (Garcia et al., 2020; Dignos et al., 2023), and 39% of Saudi respondents

were dissatisfied with workload (Al-Qathmi & Zedan, 2021). A stronger sense of community at work raised satisfaction in Ontario, while stress lowered it (Lo et al., 2022).

Supervision and appraisal were prominent in the Saudi and Omani data: appraisal and satisfaction correlated at r = 0.886 in Dammam, although trust in appraisal fairness was low (Elhadi et al., 2026), and relations with leaders were a dissatisfier in Oman (Alrawahi et al., 2019). Mentoring was proposed as a retention and advancement tool (Laudicina, 2001). Recognition and visibility appeared mainly in international work: laboratory staff felt their role was hidden (Dignos et al., 2023), and low visibility, pay, and unclear mobility were linked to weak recruitment (Halstead & Sautter, 2023). Pipeline studies pointed to few trained applicants (Akkari et al., 2023), unclear entry pathways learned mostly through personal networks (Guenther et al., 2025), and the need for training capacity (Garcia et al., 2025). Retirement and ageing were reported only in international studies, where retirement intention reached 25% in one genetics workforce survey (Zepeda-Mendoza et al., 2026).

Table 3. Synthesis of factors by domain, with qualitative confidence

Domain	Studies (Saudi/GCC; Intl)	Main findings	Confidence
Career development, promotion, education	12 (5; 7)	Limited promotion and development drive intention to leave; development opportunities are the most cited incentive to stay in Saudi, Omani, and African samples.	Low
Stress, burnout, well-being	10 (2; 8)	Stress lowers satisfaction; burnout linked to workload and understaffing; rose after the pandemic.	Low
Pipeline: awareness, training capacity, entry routes	9 (2; 7)	Few trained applicants, closing programs, unclear entry routes; mostly US reviews and surveys.	Very low
Workload and staffing levels	8 (2; 6)	Understaffing and workload are main contributors to stress and dissatisfaction.	Low
Compensation and benefits	7 (2; 5)	Pay inequity and low increments push staff out; direction differs where pay is a satisfier (Oman).	Low
Recognition and professional visibility	7 (1; 6)	Feeling valued and included supports satisfaction; low visibility hampers recruitment.	Low
Leadership, supervision, culture	6 (3; 3)	Fair appraisal, supportive leaders, community, and mentoring associated with satisfaction.	Low
Ageing workforce and retirement	6 (0; 6)	Retirement rising; retaining tenured staff proposed; no Saudi or GCC data.	Low (applicability to Saudi Arabia unknown)

Note. Counts are studies reporting the domain; a study may inform several domains. Confidence reflects cross-sectional, self-reported, largely convenience-sample evidence.

Figure 3 compares the share of studies reporting each domain in Saudi/GCC and international groups. With only six regional studies, the comparison is descriptive.

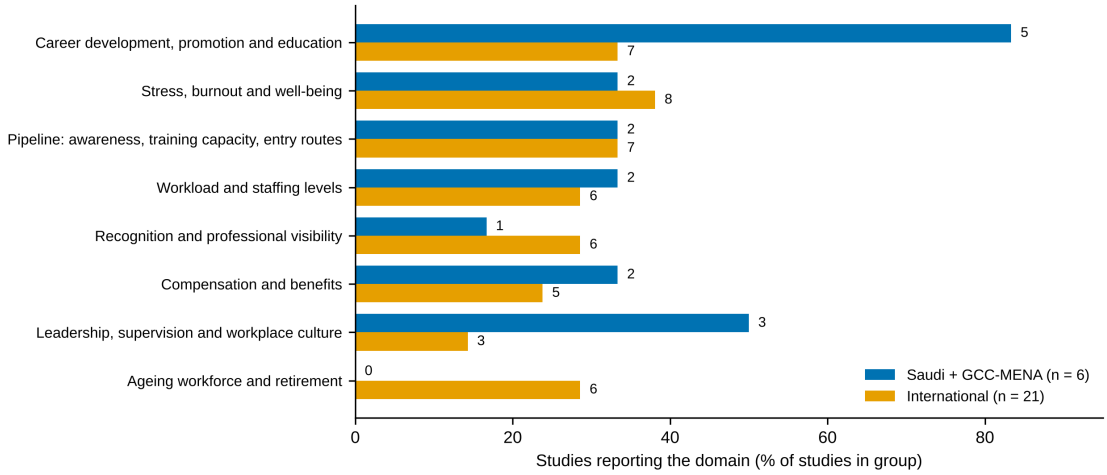

Figure 3. Domains reported by Saudi/GCC-MENA studies (n = 6) and international studies (n = 21), drawn from Table 2. Numbers beside bars are study counts.

3.4 Subgroups, sampling, and confidence

Subgroup findings were sparse. Among Dammam laboratory staff, gender was significantly associated with both appraisal perception and satisfaction (Elhadi et al., 2026). In Oman, nationals reported higher stress than non-nationals, and the youngest staff were least satisfied (Alrawahi et al., 2024). The only Saudi pipeline study sampled female students and graduates alone (Bashawri, 2005). Internationally, strain and burnout were highest among mid-career geneticists (Zepeda-Mendoza et al., 2026), and graduate study was valued more by younger, less experienced scientists (Blagg, 2024).

Sampling quality varied. Response was 96.5% (111 of 115) in the Saudi student survey (Bashawri, 2005) and about 40% (100 of 250) in the Riyadh-affiliated technologist survey, which used a convenience sample (Al-Qathmi & Zedan, 2021). Dammam used stratified random sampling (Elhadi et al., 2026). The largest international samples reached 1,243 and 1,247 respondents, but the latter had a 2.5% response rate (Blagg, 2024). Qualitative studies gave depth on lived experience (Alrawahi et al., 2019; Dignos et al., 2023) but not prevalence. No included study tested an intervention. We therefore rated confidence as low for seven domains and very low for the pipeline domain, which rests largely on reviews and US surveys.

4. Discussion

Across settings, laboratory staff stay when they see a route to progress, receive fair pay, work at a manageable pace, and feel valued; they leave when these are missing. This picture matches wider Saudi and GCC findings on healthcare staff, where pay, promotion, supervision, and workload are recurring determinants (Al-Khateeb et al., 2025; Alkhurayji et al., 2024), and it adds laboratory-specific detail.

Saudi and regional versus global evidence. The two bodies of evidence agree on career development, pay, and workload. They differ in emphasis. Saudi and GCC studies lean toward promotion, appraisal, and supervision, which fits their focus on employed hospital staff. International studies, mostly American, emphasise retirement, vacancy rates, and the entry pipeline, which suggests an ageing workforce and a shrinking training supply. We found no

retirement data in Saudi or GCC laboratory samples; whether that reflects a younger workforce or simply missing research cannot be settled here. The pay findings also warn against copying international solutions: in Oman salary satisfied staff while promotion and recognition did not (Alrawahi et al., 2019), whereas in the Saudi sample unequal allocation of pay was the main complaint (Al-Qathmi & Zedan, 2021). Local evidence on recruitment is very limited: the single Saudi pipeline study dates from 2005 and found high satisfaction with the chosen profession among female students and graduates (Bashawri, 2005).

Table 4 sets the two bodies of evidence side by side, domain by domain.

Table 4. Concordance of Saudi/GCC evidence with international evidence

Domain	Saudi/GCC evidence	International evidence	Assessment
Career development	Promotion and continuing-education gaps (Saudi, Oman)	Development is the top incentive to stay; growth lacking among leavers	Concordant
Compensation	Unequal wage allocation and low increments (Saudi); salary a satisfier (Oman)	Pay is a leading driver of leaving; public-sector lag	Concordant on importance; mixed direction
Workload, staffing	39% dissatisfied with workload (Saudi); workload dissatisfier (Oman)	Understaffing a main source of stress	Concordant
Leadership, appraisal	Appraisal tightly linked to satisfaction; low trust in fairness (Saudi); leaders (Oman)	Community, supervision, and mentoring linked to satisfaction	Concordant; Saudi data richer on appraisal
Recognition, visibility	Recognition a dissatisfier (Oman); not reported in Saudi studies	Hidden role and low visibility hamper recruitment	Saudi gap
Stress, burnout	Stress tied to satisfaction (Oman); burnout not measured in Saudi labs	Burnout prevalent and rising	Saudi gap
Pipeline	One 2005 student survey (Saudi); Israeli graduate study	Shrinking supply, unclear entry routes	Large gap
Retirement, ageing	No data	Retirements rising; tenured staff retention proposed	No Saudi data

Note. Based on Tables 2 and 3. "Gap" means the domain was not reported in Saudi studies, not that it is unimportant.

The pandemic shaped much of the international record. US vacancy rates fell between 2022 and 2024 yet stayed above pre-pandemic levels (Garcia et al., 2025), while Canadian data showed stress and emotional exhaustion rising (Djukic & Nielsen, 2022). Saudi and Omani studies measured satisfaction and stress without a pandemic comparison, so changes over time in the region remain unknown. One further Saudi-focused review of allied-health technician satisfaction, covering laboratory staff, appeared in our searches but could not be verified for author and journal details and was excluded; the authors should check it before submission.

Implications for practice. The evidence supports (i) explicit career ladders with transparent promotion criteria and protected time for continuing education; (ii) pay and allowance structures that staff can see as equitable; (iii) workload and staffing measures reviewed against demand; (iv) fair, developmental appraisal and trained supervisors, with mentoring for early-career staff; and (v) outreach that makes laboratory careers visible and lowers entry barriers. These are directions the data point to, not tested interventions; none of the included studies evaluated an intervention effect.

4.1 Strengths and limitations

Strengths include the explicit pairing of Saudi/regional and international evidence, a documented search, and tabulated coding that readers can audit. Limitations are material. Screening and extraction were single-reviewer and abstract-level, so details beyond abstracts were not seen and relevant records may have been missed. A large share of PubMed identifiers (123) was never opened, and only two databases were searched. No protocol was registered, and no formal risk-of-bias or GRADE assessment was made. Four included records have incomplete reference details. The evidence base is dominated by cross-sectional, self-reported surveys with convenience samples and, in one case, a 2.5% response rate (Blagg, 2024). Domain counts show how often a topic appears, not how large its effect is.

4.2 Research needs

Priorities are multi-centre Saudi surveys with validated instruments and laboratory-specific samples; longitudinal studies linking intention to leave with actual turnover; data on nationality, gender, and career stage; and evaluations of promotion, mentoring, and appraisal reforms.

5. Conclusions

Recruitment, retention, and career development among laboratory technicians depend on a consistent set of factors: visible career progression, funded professional development, equitable pay, manageable workloads, supportive supervision, and recognition. Saudi and regional evidence is sparse and mostly single-site, and confidence in all domains is low. Better local data and intervention studies are the next step.

Declarations

Ethics approval and consent: Not applicable; this review used published literature only.

Funding: Not Applicable **Conflicts of interest:** Not applicable **Data availability:** Search strings, counts, and study-level coding are reported in Tables 1–3. **AI transparency:** The searches, screening, extraction, coding, figures, and first draft were produced with Claude (Anthropic) acting as a single reviewer. The authors remain responsible for verifying every reference and statement and should complete screening and extraction independently before submission.

Supplementary Table S1. Records excluded at abstract-level eligibility assessment (n = 37)

Reason	n	Records (first author, year)
Not laboratory-specific workforce data	16	Alhaqqas et al. (2024; mixed primary-care staff); Al-Saikhan (2025; cardiac technologists); Walsh et al. (2024; pathologists); Halawani et al. (2021); Pappiya et al. (2021); Albugami et al. (2024); Nassani et al. (2021); Hanif et al. (2022); Parveen et al. (2016); Al-Maaitah et al. (2021); Alkhateeb et al. (2026) (all Saudi healthcare staff); Alshahrani (2015; doctors); Albalawi et al. (2024) and Alotaibi et al. (2026; nurses); Alkhurayji et al. (2024) and Al-Khateeb et al. (2025) (healthcare workers; cited as context)

Reason	n	Records (first author, year)
Commentary or no empirical data	5	Louzon et al. (2024); Bayhaghi (2021); Payne (2023); Holladay (2017); Kroft (2020; no abstract)
Thesis or unpublished work	2	Pillay (2024); Small (2013)
Descriptive supply, demand, or programme report	4	Bennett et al. (2014); Carden et al. (2009); Ellapen et al. (2021); Strain et al. (2019)
Earlier edition of a survey series	2	Garcia et al. (2018; 2016-2017 survey); Garcia et al. (2019; 2018 survey)
Laboratory-related, outcome out of scope	4	Chiou et al. (2021; personality type); Huq Ronny et al. (2023; point-of-care operations); Nuñez-Argote et al. (2021; COVID-19 response); Stankovic & Santric Milicevic (2022; staffing-need method)
Abstract truncated, findings not verifiable	3	Isabella et al. (2023); Schill (2017); Ruiz et al. (2026)
Record could not be verified	1	Saudi allied-health technician satisfaction review (2023); authors not shown in the Consensus record

Note. Reasons were assigned from abstracts. These records were not formally appraised.

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PubMed (https://pubmed.ncbi.nlm.nih.gov/) and Consensus (https://consensus.app/) were used for retrieval. References marked "to be completed" were verified only through the Consensus record and need full author lists and DOIs.

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