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GREEN LABORATORY PRACTICES AND TECHNICIANS' PARTICIPATION IN SUSTAINABLE OPERATIONS: A SYSTEMATIC REVIEW

Review question: What practices reduce waste or resource use in laboratories, and what helps technicians adopt them?

Faisal Abdulrahman Al Assiri[1*], Abdulrahman Abdullah Zoeir[2], Ahmed Hael Muhaylan Alanazi[3], Shaker Lafi Alsharari[4], Abdulkarim Jaiz Samran Alanazi[5], Sami Lafi Faleh Al Sharari[6], Nader Mohammad Awaji[7], Hanan Swilm Shaman[8], Sultan Mohammed Alkhannani[9]

[1] Corresponding Author, Medical laboratory technologist, labfaisal7@gmail.com, King Salman Armed Forces Hospital, Tabuk, Saudi Arabia

[2,3] Medical laboratory technologist, King Salman Armed Forces Hospital, Tabuk, Saudi Arabia

[4–9] Laboratory technician, King Salman Armed Forces Hospital, Tabuk, Saudi Arabia

Abstract

Background. Medical laboratories depend on single-use consumables, reagents, water and continuously running instruments, so they generate waste and consume resources at scale. How technicians come to adopt green practices is poorly mapped, especially in Saudi Arabia.

Methods. Systematic review following PRISMA 2020 reporting, without a registered protocol. PubMed (10 searches) and Consensus (2 searches) were searched on 23 November 2026. Of 143 records, 127 were screened by one reviewer at title/abstract level; 35 studies were included (5 Saudi, 30 international). Risk of bias was not formally assessed. Findings were synthesised narratively, with a qualitative certainty rating.

Results. The strongest quantitative evidence concerns test-ordering demand management: seven interventions reported 7%–66% lower order volumes (mostly uncontrolled before–after designs), and Saudi audits found 6.1% of repeated tests and 19% of lupus anticoagulant requests inappropriate. Pre-analytical choices matter: phlebotomy supplies produced over 50% of the solid waste in one analyzer study. Energy, water and governance measures rest mainly on expert guidance. On participation, Saudi surveys show roughly half of health workers with high knowledge or practice scores, only 26% with prior biomedical-waste training, and laboratory technicians scoring lower on practice than physicians (AOR 0.31). Training raised knowledge in a program that included technicians. No included study tested a technician-led intervention with waste outcomes, and none measured green practices inside a Saudi laboratory.

Conclusions. Practical priorities are appropriate ordering, pre-analytical consolidation and measured baselines, supported by training, named green champions and management backing. Evidence certainty is low to very low. Controlled, technician-centred studies in Saudi laboratories are needed.

Keywords: green laboratory; environmental sustainability; medical laboratory; laboratory technicians; biomedical waste; test stewardship; Saudi Arabia

1. Introduction

Medical laboratories sit at the centre of diagnosis, and their daily work uses plastic tubes, gloves, reagents, water and instruments that run around the clock. The result is clinical, infectious, sharps

and chemical waste alongside steady energy use. The World Health Organization estimates that about 85% of health-care waste is general, non-hazardous waste and about 15% is hazardous (World Health Organization, 2024). That is a sector-wide figure and not a laboratory-specific one. WHO frames sustainable health-care facilities around four areas: workforce, water, sanitation and waste, energy, and infrastructure and products (World Health Organization, 2020). A recent scoping review found few intervention studies in clinical laboratories and highly varied methods (Shorten et al., 2026).

Technology alone does not change what happens at the bench. Technicians handle specimens, consumables and analyzers directly, so segregation, reagent use, tube choice and equipment scheduling depend on them. In Saudi Arabia, the published literature has examined biomedical-waste knowledge and inappropriate test requests, but we found no study of green practices inside a Saudi laboratory. This review therefore asks two linked questions: which practices reduce waste or resource use in laboratories, and what helps technicians adopt them? We compare the Saudi picture with international evidence throughout.

2. Methods

2.1 Design and reporting

This is a systematic review reported against PRISMA 2020. No protocol was registered. It replaces an earlier narrative draft of the same topic (see Declarations).

2.2 Eligibility criteria

Population: laboratory staff (technicians, technologists, scientists) or laboratories handling clinical specimens; health workers who handle laboratory waste were also eligible. **Exposure/intervention:** green or sustainable practices, waste or resource reduction, test demand management, or training and engagement aimed at staff. **Comparator:** any or none. **Outcomes:** waste, energy, water, consumable or cost reduction; staff knowledge, attitude, practice, participation, barriers or enablers. **Designs:** any empirical study, audit, review or formal guidance published 2010–2026 in English. Dental and research laboratories were excluded unless the study addressed technician practice directly.

2.3 Information sources and search

PubMed and Consensus were searched on 23 November 2026 (Table 1). PubMed queries used automatic term mapping and returned the most relevant records, so queries with large hit counts were screened only to the first 15–20 records. Two Saudi-specific searches were included to cover the national evidence base.

Table 1. Search strategy and records retrieved (23 November 2026).

ID	Database	Query	Total hits	Screened
P1	PubMed	green laboratory practices sustainability	1,958	20
P2	PubMed	laboratory staff sustainability engagement barriers facilitators	13	13
P3	PubMed	clinical laboratory environmental impact waste energy	85	20
P4	PubMed	Saudi Arabia laboratory medical waste management	63	20
P5	PubMed	laboratory test overutilization reduction intervention	14	14

ID	Database	Query	Total hits	Screened
P6	PubMed	Saudi Arabia healthcare workers biomedical waste knowledge practice	6	6
P7	PubMed	medical laboratory technologists sustainability environmental awareness survey	0	0
P8	PubMed	laboratory medicine carbon footprint reduction staff training	2	2
P9	PubMed	Saudi Arabia laboratory test utilization inappropriate requests	3	3
P10	PubMed	Saudi Arabia hospital sustainability green healthcare	53	15
C1	Consensus	medical laboratory technicians staff engagement green sustainable laboratory practices adoption	Not reported	15
C2	Consensus	Saudi Arabia clinical laboratory environmental sustainability waste reduction	Not reported	15

Consensus returns a relevance-ranked list without a total hit count on the plan used. Bibliographic details of Consensus-derived records were checked in PubMed or through the publisher DOI.

2.4 Selection, extraction and synthesis

One reviewer screened titles and abstracts and then judged eligibility at abstract level; full texts were not retrieved, and a single reviewer extracted data from abstracts. Risk of bias was not assessed with a formal tool, and meta-analysis was not attempted because designs and outcomes differed too much. We synthesised findings narratively by domain (following SWiM principles) and rated certainty qualitatively as low or very low, using study design, consistency, directness and sample as the basis; GRADE or CERQual was not applied. Percentage reductions in Figure 2 were taken from reported values, or computed from reported before and after values where noted in the caption. Every study was tagged Saudi, GCC/MENA or international.

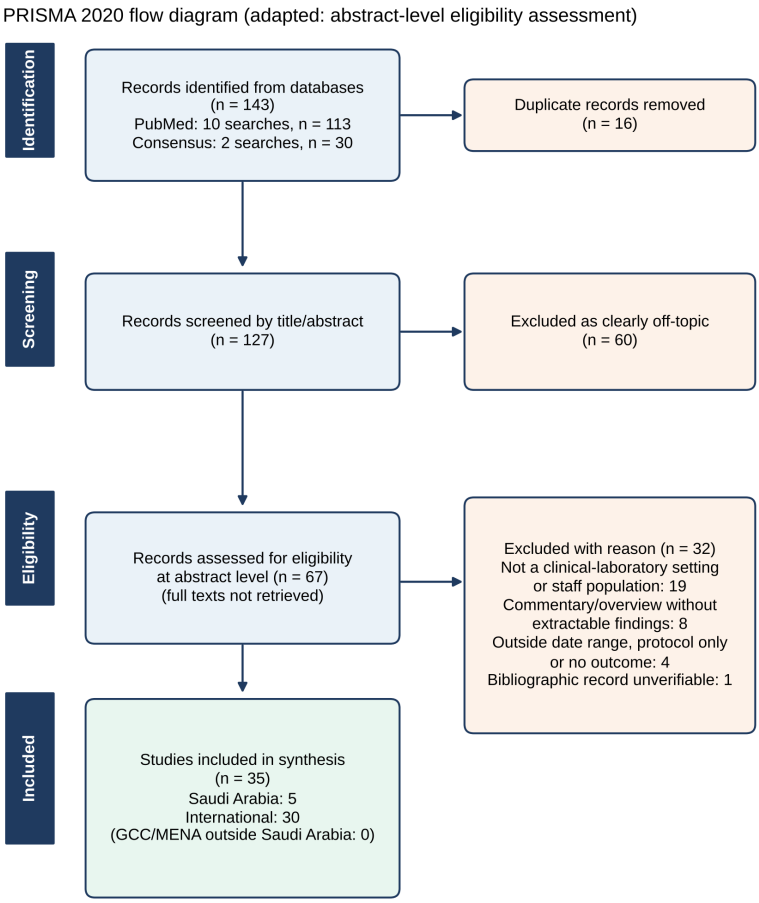
3. Results

3.1 Study selection

The searches returned 143 records. After 16 duplicates were removed, 127 records were screened and 60 were clearly off-topic. Of 67 records assessed at abstract level, 32 were excluded and 35

were included (Figure 1). Five studies were Saudi and 30 international; none came from other GCC or MENA countries.

Figure 1. PRISMA 2020 flow diagram, adapted to abstract-level eligibility assessment. Counts are from the searches in Table 1.



3.2 Characteristics of included studies

Table 2 lists the 35 studies in three groups: laboratory-sustainability guidance, reviews and audits (n = 16); staff knowledge, training and participation (n = 7); and test demand management (n = 12). Only four studies produced original quantitative waste data (Stangalini et al., 2026; Ejilemele & Singh, 2026a; Almasoud et al., 2024; Aljabry, 2015). Most intervention studies were single-site before–after designs without controls.

Table 2. Characteristics and main findings of included studies (Saudi = Saudi Arabia; Intl = international).

Study	Country	Tag	Design	Main finding
A. Laboratory sustainability: guidance, reviews and audits				
Lopez et al. (2012)	IFCC/APFCB panel	Intl	Proposals paper	Mitigation programme: environmental policy, senior-management support, staff training, audits and an environmental manager; reduce, reuse, recycle.

Study	Country	Tag	Design	Main finding
Thakur et al. (2024)	India	Intl	Narrative review	Sources of laboratory waste and energy use; staff training and sensitization named among the main levers.
Jovičić & Milinković (2025)	Serbia	Intl	Narrative review	Laboratories use 3–6 times the energy of an office building; HVAC may account for 40–60% and lighting up to 15%.
Badrick et al. (2025a)	Australia	Intl	Practical guidance	Six steps, including a green team of champions, a laboratory-wide action plan and EFLM/My Green Lab certification.
Arnoldo et al. (2025)	Canada	Intl	Recommendations	Reduce low-value testing with clinicians and patients; work with diagnostic manufacturers on lower-impact products.
Lowden & Henderson (2025)	Canada	Intl	Playbook (literature + expert input)	Recommendations on appropriate testing, energy, waste, water, green chemistry and procurement; staff engagement listed as a benefit.
Stangalini et al. (2026)	Italy	Intl	Single-laboratory audit (2024 data)	Inappropriate retesting: 2,931 extra tubes (26.7 kg). Redundant EDTA tubes: 356.14 kg. Pre-analytical changes could avoid >40 t waste and >€60,800 a year.
Ejilemele & Singh (2026a)	USA	Intl	Waste quantification, 4 analyzers	Per 100,000 basic metabolic panels, solid waste >4,000 kg, over 50% from phlebotomy supplies; 24-fold analyzer variation in dry waste.
Ejilemele & Singh (2026b)	USA	Intl	Narrative review	Workflow framework from test ordering to accreditation; no standard waste-, energy- or water-per-test metrics.
Pali-Schöll et al. (2023)	Austria (EAACI)	Intl	Narrative review	Practical suggestions for clinical practice, laboratories and meetings; health care contributes >4% of greenhouse gas emissions.
Gambella et al. (2026)	Italy	Intl	Narrative review (pathology)	Energy management, green chemistry, waste reduction, digital transformation and governance as transferable levers.

Study	Country	Tag	Design	Main finding
Farlie et al. (2024)	UK	Intl	Expert panel (IVF laboratory)	Recommendations on building a workplace sustainability culture, life-cycle analysis and waste prevention.
Shorten et al. (2026)	Multi-country	Intl	Scoping review	Few intervention studies; most work from the USA, UK and Australia; heterogeneous methods and outcomes.
Devis et al. (2025)	Belgium	Intl	Narrative review	Reducing unnecessary testing yields cost and environmental benefits without compromising patient safety, per interventional studies.
Badrick et al. (2025b)	Australia	Intl	Task-force overview	Laboratories should cut energy, water and hazardous waste while maintaining quality.
Scott (2022)	UK	Intl	Opinion paper	Embeds sustainability in quality improvement within biomedical science education.
B. Staff knowledge, training and participation				
Aykal et al. (2025)	Türkiye	Intl	Pre-/post-training study	Four-session programme for academics, residents, technicians and administrators; knowledge rose significantly, especially among residents and technicians; face-to-face and online formats did not differ ($p = 0.137$).
Ahmed et al. (2026)	Pakistan	Intl	National e-survey, 12 laboratories	LED lighting 75%, electronic reporting 91.7%, water-saving 8.3%, renewable energy 0%. Barriers: resources 58.3%, staff awareness 50%, finance 41.7%.
Yurt et al. (2024)	Türkiye	Intl	Cross-sectional survey, n = 130	Only 10.8% had sustainability education; 74.6% unaware of green chemistry; 96% switched off equipment; top barrier education/awareness (46.2%).
Hazır et al. (2026)	Türkiye	Intl	Scale development, n = 194 dental technicians	84.0% had never heard of "green laboratory"; 89.7% had no environmental training; knowledge → practice $\beta = 0.553$, attitude → practice $\beta = 0.362$ ($R^2 = 0.560$).

Study	Country	Tag	Design	Main finding
Thirunavukkarasu et al. (2022)	Saudi Arabia (north)	Saudi	Cross-sectional KAP survey, n = 384	High knowledge, attitude and practice scores in 47.1%, 65.1% and 49.5%. Laboratory technicians had lower practice scores than physicians (AOR 0.31, 95% CI 0.11–0.53).
Alahmari & Alshagrawi (2024)	Saudi Arabia (4 regions)	Saudi	Cross-sectional survey, n = 501	Moderate knowledge (M = 31.14, SD = 4.89); only 26% had prior biomedical-waste training; training was associated with knowledge.
Reddy & Al Shammari (2017)	Saudi Arabia (Hail)	Saudi	Cross-sectional KAP survey, n = 135	Good knowledge 54.8%, attitude 48.9%, practice 49.6%; knowledge, attitude and practice correlated; training recommended.
C. Test demand management				
Bindraban et al. (2018)	Netherlands	Intl	Narrative review, 84 studies	Education, order entry, audit and feedback nearly all cut order volume; only 15 studies followed sustainability up to two years.
Lang (2020)	UK	Intl	Review, 31 studies	11.8% of tests failed a minimum retesting interval (2011–2020); 14.3% cancelled; €2.9 M saved.
Baird (2019)	USA	Intl	Narrative review	Choosing Wisely: >500 recommendations; reductions in waste reported, durability still to be shown.
Minerowicz et al. (2015)	USA	Intl	Before–after, residents	Education plus weekly peer feedback: 21% fewer tests (941 per week).
Tawfik et al. (2016)	USA	Intl	Prospective before–after	Sharing charges and usage: resident services 5.56 → 5.17 tests per patient-day ($p < 0.001$); hospitalists not significant.
McDonald et al. (2017)	Canada	Intl	Interrupted time series	Trainee-led daily “time-outs”: cost per admission $117 → $66.
Conroy et al. (2021)	USA	Intl	QI project, ICU	Fellow-led, multidisciplinary: sustained 20% fewer tests per patient-day with stable counterbalance metrics.

Study	Country	Tag	Design	Main finding
Keppel et al. (2020)	Austria	Intl	Retrospective evaluation	Removing tests from ward profiles: hsTropT −66.1%; NT-proBNP −52.8% with education alone.
Tchou et al. (2020)	USA	Intl	QI project, PICU	Training then policy: point-of-care blood gas tests 0.94 → 0.41 per patient-day, sustained 15 months.
Castellanos et al. (2018)	Germany	Intl	Prospective ON/OFF study	Decision support: 0.807 → 0.662 tests per day in the first phase; effect not sustained.
Almasoud et al. (2024)	Saudi Arabia (Riyadh)	Saudi	Retrospective cohort, 109,929 tests	6.1% of repeated tests inappropriate; estimated waste SAR 2,364,410.
Aljabry (2015)	Saudi Arabia (Riyadh)	Saudi	Descriptive audit, 274 requests	19% of lupus anticoagulant requests failed ISTH criteria; cost SAR 41,080.

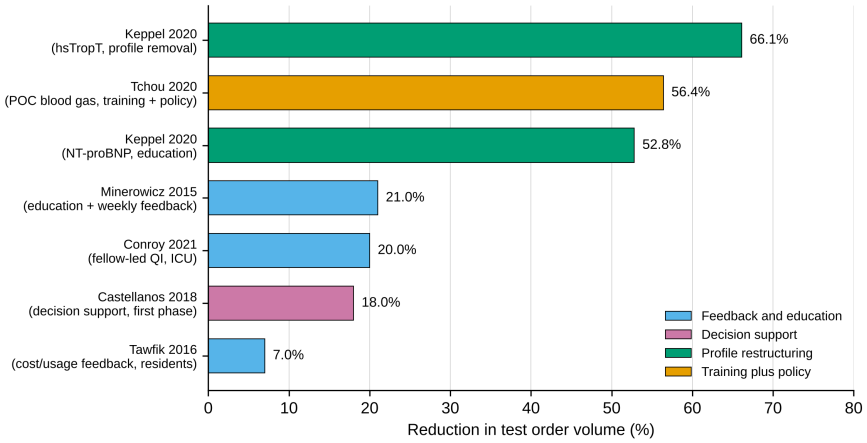
KAP = knowledge, attitude, practice; QI = quality improvement; AOR = adjusted odds ratio; HVAC = heating, ventilation and air conditioning; MRI = minimum retesting interval; PICU = pediatric intensive care unit.

3.3 Practices that reduce waste or resource use

Ordering and pre-analytical practice. This domain has the most numerical evidence. One Italian audit estimated that retesting inside minimum intervals and redundant tubes created avoidable waste of tens of tonnes a year (Stangalini et al., 2026). A US study of four analyzers found that phlebotomy supplies produced over half of the solid waste for basic metabolic panels, and that analyzers differed up to 24-fold in dry waste (Ejilemele & Singh, 2026a). A review of 31 studies found that 11.8% of tests failed a minimum retesting interval in 2011–2020 (Lang, 2020). Demand-management interventions reduced order volumes in nearly all of 84 hospital studies, but only 15 followed results for up to two years (Bindraban et al., 2018). Figure 2 shows the seven interventions that reported a volume reduction we could express as a percentage.

Figure 2. Reported reduction in test order volume by intervention. Values are as reported, except Tawfik (resident services, 5.56 → 5.17 tests per patient-day) and Tchou (0.94 → 0.41 tests per patient-day), which were computed from the reported before and after values. Castellanos shows

the first of two decision-support phases; the effect was not sustained. Designs were mostly uncontrolled before–after.



Energy and water. Laboratories use three to six times the energy of an office building, with HVAC possibly accounting for 40–60% of use (Jovičić & Milinković, 2025). Evidence on effect sizes is thin: a Pakistani survey of 12 laboratories found LED lighting in 75% but water-saving technology in 8.3% (Ahmed et al., 2026).

Waste handling. Guidance stresses segregation by source, correct sharps containers and less packaging (World Health Organization, 2024). Material contaminated with blood or specimens must not be moved into general recycling streams simply to cut waste volumes. Saudi data on handling come from knowledge surveys, not measured waste (Section 3.4).

Governance and measurement. Expert guidance recommends a named green team or environmental manager, senior-management support, audits, and integration with the quality system and certification (Badrick et al., 2025a; Lopez et al., 2012; International Organization for Standardization, 2022). Reviewers note that waste-, energy- and water-per-test metrics are not yet standardised (Ejilemele & Singh, 2026b). Table 3 summarises certainty by domain.

Table 3. Synthesis by domain with qualitative certainty rating.

Domain	Evidence in included studies	Consistency and direction	Certainty (qualitative)
Test ordering and demand management	10 international interventions or reviews; 2 Saudi audits of inappropriate requests	Consistent reduction in volume (7%–66%); durability rarely tested	Low: uncontrolled designs, single sites
Pre-analytical consolidation and blood volume	1 audit, 1 waste quantification	Large avoidable waste estimated; not tested as an intervention	Very low: modelled, single site
Energy and water	Reviews; 1 national survey	Plausible savings; few measured effects	Very low: guidance and estimates
Waste segregation and handling	3 Saudi KAP surveys; WHO guidance	Knowledge and practice gaps; no waste outcomes	Low for gaps; very low for outcomes

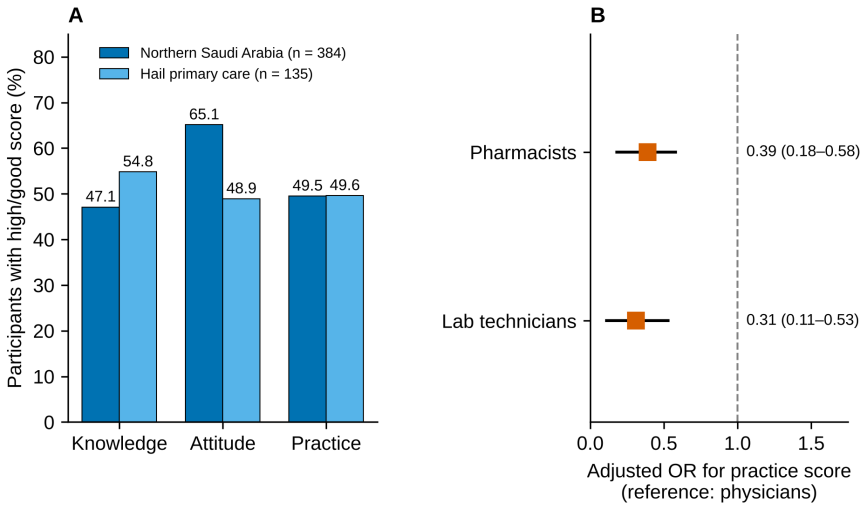
Domain	Evidence in included studies	Consistency and direction	Certainty (qualitative)
Training and awareness	1 pre/post program; 3 surveys with low training rates	Training raises knowledge; effect on waste unknown	Low: knowledge outcomes only
Governance, green team, certification	Expert guidance; 1 certification after training	Consistent recommendation; no comparative data	Very low: expert opinion
Digital decision support	1 ON/OFF study	Early 18% reduction, not sustained	Very low: single study

Ratings are the authors' qualitative judgements, not GRADE or CERQual assessments.

3.4 What helps technicians adopt green practices

Direct evidence on technicians is limited. The Saudi studies surveyed mixed groups of health workers. In northern Saudi Arabia, high knowledge, attitude and practice scores were found in 47.1%, 65.1% and 49.5% of 384 workers, and laboratory technicians had lower practice scores than physicians (AOR 0.31, 95% CI 0.11–0.53) (Thirunavukkarasu et al., 2022). In Hail primary care, 54.8%, 48.9% and 49.6% scored well on knowledge, attitude and practice (Reddy & Al Shammari, 2017). A four-region survey found moderate knowledge, with only 26% of 501 workers trained in biomedical-waste management and knowledge tied to prior training (Alahmari & Alshagrawi, 2024). Figure 3 plots the Saudi results.

Figure 3. Saudi evidence on participation. (A) Share of participants with high or good knowledge, attitude and practice scores in two surveys. (B) Adjusted odds ratios for practice score among laboratory technicians and pharmacists versus physicians in the northern Saudi survey, with the 95% confidence intervals as reported (Thirunavukkarasu et al., 2022). Dashed line = no difference.



Elsewhere, a training program for academics, residents, technicians and administrators raised knowledge, with notable gains among technicians (Aykal et al., 2025). Surveys in Türkiye and Pakistan named missing education and awareness as leading barriers (46.2% and 50%) and limited resources as another (Ahmed et al., 2026; Yurt et al., 2024). Among dental technicians, knowledge predicted practice directly (β = 0.553) and through attitude (Hazır et al., 2026). In test-ordering projects, change was often led by front-line trainees using feedback, time-outs or policy (Conroy

et al., 2021; McDonald et al., 2017; Minerowicz et al., 2015); we found no equivalent technician-led study. Table 4 maps participation factors to this evidence.

Table 4. Factors linked to technician participation and the evidence behind them.

Factor	Evidence in included studies	Strength and directness
Training and awareness	Knowledge gains after a four-session program including technicians (Aykal et al., 2025); only 10.8% and 26% trained (Yurt et al., 2024; Alahmari & Alshagrawi, 2024)	Direct for knowledge; indirect for practice
Management support and named roles	Environmental policy, management support and an environmental manager (Lopez et al., 2012); green team of champions (Badrick et al., 2025a)	Expert guidance only
Feedback and measurement	Weekly peer feedback cut orders 21% (Minerowicz et al., 2015); usage feedback helped residents but not hospitalists (Tawfik et al., 2016); no standard metrics (Ejilemele & Singh, 2026b)	Direct for clinicians; indirect for technicians
Front-line ownership	Trainee- and fellow-led projects sustained reductions (Conroy et al., 2021; McDonald et al., 2017)	Indirect: physicians, not technicians
Resources and tools	Limited resources 58.3% and finance 41.7% as barriers (Ahmed et al., 2026)	Direct, small sample (12 laboratories)
Role-specific gaps	Technicians' lower practice scores (Thirunavukkarasu et al., 2022); knowledge → attitude → practice pathway (Hazır et al., 2026)	Direct but cross-sectional
Recognition and certification	EFLM certification followed training (Aykal et al., 2025); certification step in practical guidance (Badrick et al., 2025a)	Indirect

Incentive schemes and protected time, listed in the earlier draft as likely enablers, were not tested in any included study.

4. Discussion

4.1 Principal findings

Three findings stand out. First, the most measurable gains come from asking for fewer unnecessary tests and from changing how samples are collected, not from new equipment. Second, evidence on energy, water and governance is mainly expert guidance, so claims about specific savings should wait for local measurement. Third, technician participation is described more than it is tested: surveys show training gaps and role-specific differences, but no included study evaluated a technician-led change against waste outcomes.

4.2 Saudi Arabia compared with the international evidence

The Saudi and international pictures agree on the main barrier. International surveys report weak education on sustainability (Ahmed et al., 2026; Yurt et al., 2024), and Saudi surveys report low training and moderate knowledge (Alahmari & Alshagrawi, 2024; Reddy & Al Shammari, 2017; Thirunavukkarasu et al., 2022). They differ in what has been studied. International work includes laboratory audits and structured guidance, whereas Saudi work has measured health-worker knowledge and test appropriateness: 6.1% of repeated tests in a Riyadh outpatient cohort were

inappropriate, with an estimated SAR 2.36 million wasted (Almasoud et al., 2024), and 19% of lupus anticoagulant requests missed guideline criteria (Aljabry, 2015). Local evidence on green practice in laboratories is therefore limited, and the nearest comparable data come from Türkiye and Pakistan. We found no study from other GCC or MENA countries.

4.3 Implications for laboratory sections

Pre-analytical work is where technicians and phlebotomy staff hold most control: tube selection, blood volume and sample consolidation. Because phlebotomy supplies were the largest single source of solid waste in one analyzer study (Ejilemele & Singh, 2026a), phlebotomy sections are a logical place to pilot measurement. Table 5 lists actions and indicators drawn from the earlier draft, now labelled as proposals; they are not outcomes of this review. Any action must preserve biosafety and result quality, and ISO 15189:2022 offers the management-system frame (International Organization for Standardization, 2022).

Table 5. Proposed starting actions and indicators for laboratory sections (proposals adapted from the earlier draft; not validated by included studies).

Section	Proposed action	Indicator
Clinical chemistry	Review repeat-test rules; audit reagent expiry	Inappropriate repeats (%); reagent loss (% of value)
Hematology	Track tube and quality-control material use	Tubes per 1,000 tests; control material waste
Blood bank	Review reagent and component stock and cold chain	Expired reagents and components (n)
Microbiology	Plan culture media use and stock	Media discarded (% of stock)
Immunology/serology	Review test scheduling and reagent expiry	Reagent loss (% of value)
Specimen reception	Improve acceptance at collection and transport	Rejected samples (% of total)
Phlebotomy	Consolidate tubes; right-size blood volume	Tubes per patient; rejected samples (%)
Quality and management	Cut unnecessary printing; periodic audit	Electricity per 1,000 tests; hazardous waste (kg per 1,000 tests); staff trained (%)

Electricity (kWh), water (L) and hazardous waste (kg) per 1,000 tests, reagent loss (%), sample rejection (%) and staff trained (%) were the indicators proposed in the earlier draft. A baseline must be set before any target.

4.4 Strengths and limitations

Strengths include a documented search, Saudi-specific searches, and figures built only from reported numbers. The limitations are material. Screening and extraction were done by one reviewer at abstract level, so errors and missed studies are possible. Only two databases were searched, PubMed queries with many hits were screened to the first 15–20 records, and Embase, Scopus and grey literature were not searched. Risk of bias was not formally assessed, and certainty ratings are judgements. Many included records are narrative reviews or guidance, which limits what can be said about effect. Findings from clinicians' test-ordering projects may transfer only partly to technicians.

5. Conclusions and recommendations

The best-supported ways to cut waste in laboratories are appropriate test ordering and pre-analytical consolidation, with energy, water and governance measures resting on expert guidance. Technicians' adoption is limited by gaps in training, and Saudi data show laboratory technicians scoring lower on practice than physicians. For laboratory sections, we suggest the following:

- Measure first: record baseline waste, energy, water and rejected-sample rates before setting targets.
- Train all grades of staff, including technicians, and record the proportion trained.
- Name a sustainability lead or champion in each section, with management backing.
- Start with ordering and pre-analytical changes, and keep a safety and quality counter-measure for each.
- Run a small pilot in one section (for example phlebotomy) before scaling, and report results with a control or comparison where possible.
- Do not send blood- or specimen-contaminated material to general recycling.

Future work should test technician-led interventions in Saudi laboratories with waste outcomes, controlled designs and follow-up beyond two years.

Declarations

Ethics approval and consent: Not applicable; this is a review of published literature.

Funding: not applicable

Conflicts of interest: not applicable

Data availability: All search queries and counts are in Table 1; extracted data are in Table 2.

Protocol and registration: No protocol was registered.

Relation to earlier draft: This version replaces the authors' earlier narrative review of the same topic. Its practices table, indicators and six-month plan are retained only as proposals (Table 5).

AI transparency: An AI assistant (Claude, Anthropic) helped with literature retrieval, data extraction from abstracts, figure generation and drafting. The authors remain responsible for verifying the content before submission.

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