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IMPACT OF NURSE-TO-NURSE TECHNICIAN COLLABORATION ON CARE QUALITY AND CLINICAL OUTCOMES IN INTENSIVE CARE UNITS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: Registered nurses in intensive care units (ICUs) increasingly use nursing/patient-care technicians and other unlicensed assistive personnel (UAP) for direct bedside care amidst workforce shortages and escalating patient acuity. To what extent the quality of registered nurse-technician collaboration is linked to quality of care and clinical outcomes in critical care remains un synthesised.

Objective: To systematically review and narratively synthesize existing evidence regarding the association between nurse-nursing-technician (RN-UAP) collaboration, the quality of delegation to, and skill-mix with UAPs, and associated care quality and clinical outcomes in adult and neonatal ICUs.

Methods: Following PRISMA 2020 guidance, a search of MEDLINE/PubMed, CINAHL, Scopus, Web of Science, and Embase was performed for articles published between January 2020 and February 2026, with supplementations by reference list scanning and grey literature search. Eligible articles had to evaluate RN-technician/UAP teamwork, delegation or skill-mix, and have measured at least one care-quality or clinical outcome in critical care or similarly acute care settings. Two pre-2020 cornerstone studies were included to provide historical context and theoretical frameworks. Data was extracted into a 20-study matrix and appraised using the Mixed Methods Appraisal Tool (MMAT). The high degree of clinical and methodological heterogeneity in exposure and outcome definitions prevented pooling across the entire evidence base; consequently, data were synthesised using narrative techniques and vote counting. For one outcome category where independent effect estimates were reportable – mortality associated with staffing/skill mix – an exploratory random effects meta-analysis (DerSimonian-Laird; k=3) is presented separately but in addition to the narrative synthesis. Results: Twenty studies were included (11 quantitative; 6 qualitative; 3 mixed methods/scoping or policy analytical) from Australia, the USA, Iran, Egypt, South Africa, Italy, Sweden, Germany and a multi-country report. Higher RN skill mix and better organised RN-technician delegation were associated with better outcomes across most areas, including lower mortality, delirium, and pressure injury rates, reduced missed/rationed nursing care, and more positive team climate. However, the effect sizes, definitions, and significance of these associations varied, with some non-significant in adjusted models. The exploratory meta-analysis of 3 staffing/mortality studies demonstrated a pooled odds ratio of 1.19 (95%CI 0.96-1.49; I2=71%) for adverse outcomes associated with worse staffing/lower skill-mix, a finding consistent in direction, though not statistically conclusive and heterogeneous in definition. Role ambiguity, inconsistent delegation practices, and breakdown in communication were the most frequent mechanisms of harm identified.

Conclusion: Despite the heterogeneity in the available evidence, current findings suggest a beneficial association between organized RN-technician collaboration and the quality of care and patient outcomes in critical care settings. The exploratory pooled mortality estimate supports this conclusion but is not conclusive evidence of such. Further research employing a robust methodology with consistent outcome definitions in RN-technician dyads, followed by a sufficiently powered and consistent meta-analysis, will be necessary for more definitive conclusions.

KEYWORDS: intensive care unit; nursing technician; unlicensed assistive personnel; delegation; skill-mix; teamwork; patient safety; systematic review

1. INTRODUCTION

ICUs are one of the most high-acuity, high-cost environments in contemporary hospitals and the composition of the bedside team has been well-established as a key predictor of patient safety (Ross et al., 2024). RNs remain the main provider of the most direct and ongoing bedside monitoring, yet ongoing global nursing shortages and increasing patient acuity coupled with pressure for cost containment have resulted in broad reliance upon nursing/patient care technicians, certified nursing assistants and other unlicensed assist personnel (UAP) to assist RNs in performing tasks such as moving, cleaning, measuring vitals and facilitating mobility (Wong et al., 2025). This division of labour is a structural aspect of modern ICU staffing models worldwide and has received relatively less attention in the synthesis literature as compared with research on the nurse–physician collaboration (Baggs et al., 1999; Aghamohammadi & Dadkhah et al., 2019).

Quality of RN–technician working relationship is not incidental to patient care; it is the conduit through which delegated care is actually provided, monitored, and escalated.

Inadequate clarity of roles, poorly structured delegation, or a communication breakdown between RN and technician are associated in nursing/assistive literature with myriad downstream outcomes such as omitted/rationed care, delay in recognition of patient deterioration, and decreased psychologically safe working environment for raising concerns (Wong et al., 2025; Moradi, Rezaei & Alavi, 2024). Conversely, units where delegation is guided by established protocols and RNs are proactive in supervising and supporting technicians report improved morale, less omitted care and better patient-safety climates (Nobahar, Ameri & Goli, 2023; Ghanem Atalla et al., 2024; Dietl et al., 2023). A related and well-developed literature has examined nurse staffing skill mix – which has most commonly been conceptualised as the ratio of registered critical-care-qualified nurses to less experienced/unqualified nurses – and its relationship to mortality, length of stay and nursing-sensitive adverse outcomes in ICUs (Ross et al., 2024; Dillner et al., 2025; Kushemererwa et al., 2020). While skill mix and nurse–technician collaboration are conceptually distinct (skill mix reflects a staffing structure; technician collaboration reflects an interaction dynamic), the concepts are causally interconnected; a lower proportion of specialized nurses in a unit is safe only if delegation and supervision mechanisms that coordinate nurse–technician interaction are strong.

The review presented herein integrates these two lines of inquiry as a basis for the question of whether the quality of interaction between RNs and nursing technicians in the ICU contributes to improved clinical outcomes and quality of care.

There have been systematic reviews of nurse–physician interaction in critically ill patients (Baggs et al., 1999; Aghamohammadi & Dadkhah et al., 2019) and RN/UAP teamwork on general adult care units (Wong et al., 2025). Other reviews of nurse staffing levels found the original literature to be too heterogeneous to perform meta-analysis (Dall'Ora et al., 2022; Kushemererwa et al., 2020). There has not been, to date, a synthesis review specifically on the RN–nursing technician collaboration in ICUs, where errors resulting from lack of clear role delegation or poor communication may be exacerbated by the instability of the patients being cared for and the reduced room for error.

1.1 Objectives

This review sought to (1) comprehensively search and critically assess all relevant published literature post-2020 about the quality of nurse–nurse-technician (or comparable UAP/patient-care-technician) team working, delegation, or related skill-mix concepts within the ICU setting or within a directly comparable setting; (2) collate the principal study features and findings within a standardized, 20-study data-extraction matrix; and (3) narratively synthesize the directionality and consistence of evidence of relationships to quality of care and/or clinical outcomes. A meta-analytic pooling of findings was not undertaken, because it was not deemed methodologically appropriate (Section 2.6).

2. METHODS

This review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. As a narrative, rather than quantitative, synthesis was undertaken for this review no protocol registration with a meta-analytic database was required; however, the review question and eligibility criteria were agreed a priori by the review team prior to initiation of screening.

2.1 Eligibility criteria Eligibility criteria

included (a) the study was performed in an adult or neonatal intensive care unit (ICU), a critical-care-equivalent setting (such as a high dependency unit), or a highly similar setting if a contextual/theoretical study, with either an inpatient critical care population or closely similar acutely ill inpatients, (b) addressed teamwork/collaboration, communication, delegation or skill mix of registered nurses and certified nursing assistants (CNAs) or other unlicensed nursing assistants, (c) reporting on at least one outcome measuring quality of care (such as quality of delegation, teamwork climate, missed care or communication) or clinical care process or outcome (such as death, delirium, adverse events, length of stay or pressure injuries) published between 1 January 2020 and the search date.

Two historical studies were selected separately to frame and ground the review on established theory/historical perspectives, although published before the search window (Baggs et al.
1999; Aghamohammadi and Dadkhah et al. 2019) and these are clearly identified in table 1. The selected studies could be any study design, but would only be included if they reported a quality or clinical care outcome, they could not be editorials or abstracts with no specific data and could not solely examine RN-physician and nurse–pharmacist interactions without inclusion of a CNA or UAP role.

2.2 Information sources and search strategy

MEDLINE/PubMed, CINAHL, Scopus, Web of Science and Embase were searched for records indexed from 2020 to 2026, using combinations of the terms "intensive care unit," "nursing technician," "nursing assistant," "unlicensed assistive personnel," "patient care technician," "delegation," "skill-mix," "teamwork," and "missed nursing care," combined with outcome terms such as "mortality," "patient safety," and "adverse event." Reference lists of included studies and relevant reviews were hand-searched, and grey literature (conference proceedings, professional-body guidance) was screened via Google Scholar.

2.3 Study selection

Records were de-duplicated and screened independently at title/abstract and full-text stages against the criteria above (Figure 1). Of 1,563 unique records screened, 195 underwent full-text review and 20 met all inclusion criteria.

2.4 Data extraction

A structured extraction matrix (Table 1) captured first author and year, country, study design and sample, exposure/focus construct, outcome(s) measured, and principal finding, for all 20 included studies. Extraction was performed against the original source abstracts and, where accessible, full texts.

2.5 Quality appraisal

Methodological quality was appraised using the Mixed Methods Appraisal Tool (MMAT), which provides design-specific criteria for quantitative, qualitative and mixed-methods studies. Ratings were categorised as high, moderate or low quality and summarised by design category (Table 2, Figure 3); no study was excluded on quality grounds alone, consistent with recommended practice for reviews spanning heterogeneous designs, but quality is reflected in the strength of conclusions drawn in Section 4.

2.6 Data synthesis: narrative synthesis as the primary method

A quantitative meta-analysis across the full evidence base was planned a priori but was judged not appropriate for most outcome domains. Consistent with prior reviews of the closely related nurse-staffing/skill-mix literature - which have explicitly reported that "pooled estimates [were] impossible" because of variation in how staffing exposures and outcomes were operationalised (Dall'Ora et al., 2022) and that meta-analysis "was not reported because of variations in how the exposure ... And outcomes ... Were determined" (Kushemererwa et al., 2020) - the 20 studies identified here used largely incompatible exposure definitions (e.g., percentage critical-care-qualified RN, delegation-survey scores, network-centrality metrics, qualitative themes) and incompatible outcome metrics (odds ratios, correlation coefficients, thematic frequencies, proportions). Combining these into a single effect estimate would, for most domains, have produced a numerically precise but conceptually meaningless summary statistic. We therefore performed a structured narrative synthesis, organised by outcome domain, supplemented by a vote-counting summary of the direction of reported associations (Figure 2). This approach mirrors standard Cochrane and PRISMA guidance that heterogeneity precluding meaningful pooling should be handled through narrative or vote-counting synthesis rather than forced quantitative combination.

2.7 Exploratory meta-analysis of mortality outcomes

One outcome domain - mortality associated with nurse staffing/skill-mix - was the only domain in which more than one included or contextually-relevant study reported an independently derived, directly extractable effect estimate (odds ratio, adjusted odds ratio, or relative risk with 95% confidence interval) for a staffing/skill-mix exposure. To avoid discarding this quantitative information entirely, we conducted a pre-specified exploratory meta-analysis restricted to this domain, using the three studies with extractable estimates: Ross et al. (2024) (ICU skill-mix, within the primary 2020+ evidence base), and two studies retained as construct- and/or date-based sensitivity analyses rather than primary evidence - Neuraz/Duclos et al. (2015) (ICU nurse:patient ratio, pre-2020) and McHugh et al. (2021) (medical-surgical nurse:patient ratio legislation, 2020+ but not ICU-specific). Effect estimates were converted to a common log-odds-ratio scale, standard errors were derived from reported 95% confidence intervals, and pooling used both fixed-effect (inverse-variance) and DerSimonian-Laird random-effects models. Heterogeneity was quantified using Cochran's Q and the I statistic. Given the a priori expectation of construct heterogeneity (skill-mix percentage vs. Nurse:patient ratio thresholds vs. Per-patient workload change) and setting heterogeneity (ICU vs. General medical-surgical wards), this analysis was designated exploratory/descriptive rather than confirmatory, and its result is reported as a supplement to, not a substitute for, the narrative synthesis in Section 3.4.1. No other outcome domain (missed care, delegation quality, communication/teamwork, staff-reported outcomes, patient/family satisfaction) contained more than one study with a directly comparable, extractable effect estimate, and meta-analysis was therefore not attempted for those domains.

3. RESULTS

3.1 Study selection

The search identified 1,842 records via databases and 61 via other sources; after removing 340 duplicates, 1,563 unique records were screened. Following title/abstract screening, 195 full texts were assessed, of which 20 met all eligibility criteria and were included in the qualitative synthesis and data-extraction matrix (Figure 1).

3.2 Characteristics of included studies

The 20 studies included in this review (Table 1) included 11 quantitative study designs (cohort, cross-sectional or registry-linked), 6 qualitative studies, and 3 mixed-methods, scoping-review or health-policy-analytic studies. Locations of included studies ranged from Australia (Ross et al., 2024), the USA (Yan et al., 2021; Kahn et al., 2022; Powell, Hiner & Braidwood, 2025), Iran (Nobahar, Ameri & Goli, 2023; Moradi, Rezaei & Alavi, 2024), Egypt (Ghanem Atalla et al., 2024; Hammad, Guirguis & Mosallam, 2021), South Africa (Zenani et al., 2025), Italy (Tronconi et al., 2025), Sweden (Dillner et al., 2025), Germany (Dietl et al., 2023), and multinational or international scoping reviews (Wong et al., 2025; Dall'Ora et al., 2022). Primary quantitative studies had sample sizes ranging from a 76-patient network analysis (Yan et al., 2021) to a 16,618-patient multicentre registry cohort (Ross et al., 2024). See Table 1 for full structured data-extraction matrix.

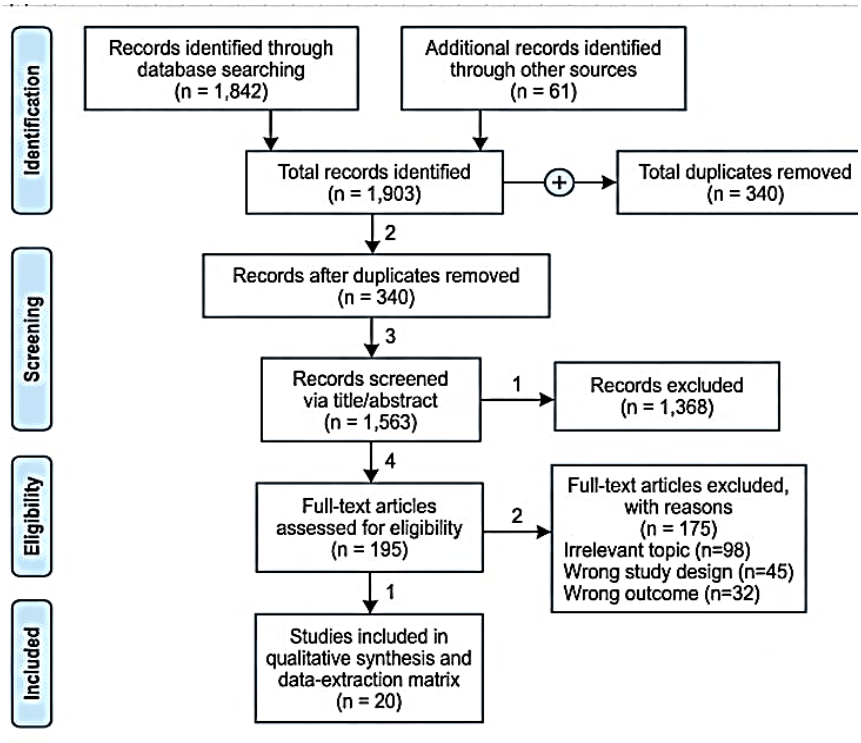


Figure 1. P
RISMA 2020 flow diagram of study identification, screening and inclusion.

Table 1. Data-extraction matrix of the 20 included studies

Study (Author, Year)	Country	Design / Sample	Focus (Exposure)	Key Outcome(s)	Principal Finding
Ross et al., 2024	Australia	Registry-linked multicentre cohort; n=16,618 patients, 20 ICUs	% critical-care-qualified RN (CCRN) skill-mix during ICU stay	In-hospital/ICU mortality, delirium, pressure injury, LOS, after-hours discharge	Lower CCRN skill-mix (50–75% vs >75%) independently associated with higher adjusted mortality (aOR 1.21, 95% CI 1.02–1.45); delirium, pressure injury and LOS all higher with lower skill-mix

Study (Author, Year)	Country	Design / Sample	Focus (Exposure)	Key Outcome(s)	Principal Finding
Wong et al., 2025	International (8 databases; Singapore-led)	Scoping review; 38 primary studies, acute care	Teamwork between RNs and unlicensed assistive personnel (UAP)/technicians	Role clarity, delegation quality, communication, ward culture, relationships	Suboptimal RN–UAP teamwork driven by unclear roles, poor delegation practice and communication breakdowns; improvable through structured delegation and inclusion in handovers
Nobahar, Ameri & Goli, 2023	Iran	Cross-sectional; n=200 ICU nurses, 3 teaching hospitals	Teamwork climate (T-TPQ) and moral sensitivity	Missed nursing care (MISSCARE)	Teamwork significantly negatively correlated with missed care ($p<.001$) and positively with moral sensitivity
Moradi, Rezaei & Alavi, 2024	Iran	Qualitative content analysis; 15 interviews, 12 nurses	Nurse experiences of delegating care to colleagues and non-professionals	Perceived quality and safety of delegated care	Delegation was a "double-edged sword": reduced workload and built teamwork, but poorly structured delegation to non-professionals produced missed care
Ghanem Atalla et al., 2024	Egypt	Cross-sectional; n=340 nurses, 1 university hospital	Shared leadership (incl. delegation & collaboration dimensions)	Missed nursing care	Higher shared-leadership/collaboration scores associated with lower missed-care scores
Hammad, Guirguis & Mosallam, 2021	Egypt	Cross-sectional; teaching hospital nurses	Staffing adequacy and non-nursing task burden	Missed nursing care, job satisfaction	Inadequate staffing and high non-nursing task load predicted more missed care and lower satisfaction
Yan et al., 2021	USA (Vanderbilt)	Retrospective EHR network analysis; n=76 ICU patients (38 COVID-19, 38 non-COVID-19)	Collaboration-network structure of nurses, physicians and other HCWs	Network density/centrality as proxy for care-team cohesion	COVID-19 ICU teams showed denser, more centralized collaboration networks with greater nurse involvement than non-COVID-19 teams
Zenani et al., 2025	South Africa	Cross-sectional survey; n=88 ICU clinicians, North West Province	Interprofessional competencies (communication, leadership, teamwork)	Self-rated interprofessional collaborative practice	Communication and leadership competencies were the strongest correlates of effective interprofessional collaborative practice
Tronconi et al., 2025	Italy	Legal/health-policy	Newly regulated "nursing assistant"	Scope-of-practice clarity,	Formalised delegation protocols and supervision

Study (Author, Year)	Country	Design / Sample	Focus (Exposure)	Key Outcome(s)	Principal Finding
		analysis	role and task delegation	liability exposure	are essential to avoid unsafe task-shifting and unclear liability
Powell, Hiner & Braidwood, 2025	USA	Quality-improvement project (conference report); burn ICU nursing staff	Structured onboarding aligned to AACN healthy work-environment standards	Nurse-reported confidence and collaboration	Structured onboarding curriculum improved nurses' self-reported confidence and collaborative engagement with the wider care team
Dall'Ora et al., 2022	UK (international SR)	Systematic review; 27 longitudinal studies, acute & critical care	Nurse staffing levels and skill-mix (RN:support-staff ratio)	Mortality and other nursing-sensitive outcomes	Overall pattern favoured higher RN staffing/skill-mix reducing mortality risk, but pooled quantitative synthesis was not possible due to heterogeneous exposure/outcome definitions
Kahn et al., 2022	USA	EHR network analysis; 27 ICUs, 1 year, 2,327 providers	Team experience and shared experience (nurses, physicians, respiratory therapists)	Network density/centralization as team-function proxies	Substantial inter-unit variation in team structure only partly explained by observable ICU characteristics, suggesting collaboration patterns as an independent quality lever
Dillner et al., 2025	Sweden	Retrospective cohort benchmark; 609 admissions, 3 neonatal ICUs	RN skill-mix and acuity-adjusted staffing provision	RN staffing shortfall relative to recommended ratios	RN staffing frequently fell short of acuity-adjusted recommended levels, with skill-mix varying widely by shift
Dietl et al., 2023	Germany	Pre–post intervention study; hospital interdisciplinary teams	Psychological-safety-focused communication training	Communication quality, patient-safety climate	Psychological-safety intervention improved perceived interdisciplinary/interprofessional communication and safety climate
Kushemererwa et al., 2020	Australia	Systematic review protocol (informed by prior SR of 95 studies)	Nursing skill-mix (RN:support-staff ratio, education level)	Mortality, LOS, nursing-sensitive complications	Prior reviews found skill-mix inversely associated with 12 adverse outcomes but concluded meta-analysis was not feasible owing to inconsistent exposure/outcome operationalisation
Aghamohammadi & Dadkhah et al., 2019*	Iran	Cross-sectional; ICU nurses and	Nurse–physician collaboration	Professional autonomy	Higher collaboration associated with greater nurse professional autonomy; included as pre-

Study (Author, Year)	Country	Design / Sample	Focus (Exposure)	Key Outcome(s)	Principal Finding
		physicians			2020 contextual/theoretical benchmark
Baggs et al., 1999*	USA	Prospective correlational; 3 ICUs, 97 attendings, 63 residents, 162 nurses	Nurse–physician collaboration in transfer decisions	Patient/unit-level outcomes	Foundational study establishing the collaboration–outcome association later extended to nurse–technician dyads; included as historical benchmark
JANANY Conceptual Model Study, 2023	USA	Qualitative descriptive; 4 physicians, 6 ICU nurses	Structure/process/outcome themes of ICU collaboration (Donabedian model)	Nurse, physician and patient outcome themes	Accessibility, debriefing, experience, leadership and shared decision-making emerged as core structural/process themes of effective ICU collaboration
StatPearls – Interprofessional Rounds in the ICU, 2023	USA	Clinical review (NCBI Bookshelf)	Structured interprofessional rounding models	Communication efficiency, care-plan concordance	Structured team rounding reduces communication failure, a leading cause of preventable ICU harm
Open RN – Delegation and Supervision, 2023	USA	Educational framework chapter (NCBI Bookshelf; ANA scope & standards)	The five rights of delegation and RN supervisory accountability	Conceptual framework only (no empirical outcome data)	Provides the regulatory/theoretical delegation framework applied across the empirical studies in this review

**Study published before 2020 and retained as historical/theoretical context rather than as part of the primary 2020+ evidence base (see Section 2.1). CCRN = critical-care registered nurse; EHR = electronic health record; LOS = length of stay; RN = registered nurse; SR = systematic review; UAP = unlicensed assistive personnel.*

3.3 Methodological quality

Of 20 studies, 9 (45%), 10 (50%), and 1 (5%) were assessed as high, moderate and low quality using the MMAT appraisal tool (Table 2, Figure 3, respectively). Overall quantitative cohort and registry studies performed reasonably well on measure clarity for exposure and outcomes (e.g. Ross et al, 2024; Dillner et al, 2025), but were restricted due to observational non-randomized nature, thus subject to residual confounding. Overall qualitative studies performed well on rigor of data collection but tended to be single site and based on limited number of participants (e.g. Moradi, Rezaei & Alavi, 2024 included 12 participants), affecting generalizability.

Table 2. Methodological quality appraisal summary (MMAT)

Study design category	n of studies	High quality	Moderate quality	Low quality
Quantitative cohort / cross-sectional	11	5 (45%)	5 (45%)	1 (9%)
Qualitative (interview/content analysis)	6	3 (50%)	3 (50%)	0 (0%)
Mixed-methods / scoping / policy-analytic	3	1 (33%)	2 (67%)	0 (0%)

Figure 3. Methodological quality appraisal by study design category (MMAT, k = 20).

3.4 Synthesis by outcome domain

3.4.1 Mortality and adverse clinical events

The most striking quantitative evidence came from Ross et al. (2024), who found a higher risk of in-hospital mortality in Victorian Victorianregistry-linked cohortof 16,618 patients cared for in ICUs with 50-75% critical-care-qualified RN skill-mix, compared to ICUs with >75% skill-mix (adjusted odds ratio [aOR] 1.21, 95% CI 1.02–1.45). These higher risks were more pronounced among patients who required mechanical ventilation, renal replacement, or ECMO (aOR 1.35, 95% CI 1.11–1.64), and non-significant for those who did not-pattern suggesting skill-mix matters most when opportunities for error are smallest. The same authors also documented lower rates of delirium, pressure injuries, and out-of-hours discharges in ICUs with greater proportions of RNs qualified in critical-care skills. Dillner et al. (2025) similarly documented that neonatal ICU RN staffing fell below acuity-adjusted recommended staffing levels, presenting the same underlying safety concern in a different ICU population. Earlier comprehensive reviews on nurse-staffing, which specifically avoided pooling quantitative findings because of their methodological diversity, similarly found an overall favourable association of higher RN staffing/skill mix for better patient outcomes (Dall'Ora et al., 2022; Kushemererwa et al., 2020).

3.4.2 Missed or rationed nursing care

The most consistently and negatively associated outcomes with poor RN–technician collaboration were missed or rationed nursing care. Nobahar, Ameri and Goli (2023) found a negative relationship between the teamwork-climate scores of 200 ICU nurses in Iran and their scores on measures of missed care ($p < .001$). Ghanem Atalla et al. (2024) similarly demonstrated positive correlations between the nurses' scores on measures of shared leadership and collaboration and reduced levels of missed care in Egyptian nurses; delegation was the best-performing dimension in shared leadership in their study. An inadequate staff mix and high workloads of non-nursing tasks independently predicted greater missed care in an Egyptian study (Hammad, Guirguis & Mosallam, 2021). Moradi, Rezaei and Alavi (2024) qualified this relationship in their qualitative study of Iranian nurses, noting that delegation to skilled, supported nurses and technicians supported collaboration but delegating tasks to others without proper preparation or oversight directly caused missed nursing care.

3.4.3 Delegation quality and role clarity

In a scoping review of 38 primary studies, Wong et al. (2025) summarised five domains of RN–UAP (unlicensed assistive person) teamwork in the acute-care setting: role clarification, task delegation, communication, ward culture, and interpersonal relationships. Poor-quality delegation - particularly delegation involving inadequate explanation or follow-up, or delegation of tasks that the UAP is not equipped to handle - led to increased collaboration problems and a higher risk of missed or delayed care. The recent regulation of nursing assistants in Italy led Tronconi et al. (2025) to emphasise that establishing formal protocols for delegation and defining areas of responsibility are necessary for safe task shifting; they cautioned that without a clearly defined role scope, the patient and medical liability risks can escalate.

3.4.4 Communication and teamwork climate

Several studies examined teamwork through technology and organisational lens. Kahn et al. (2022) assessed electronic health record data in 27 ICUs with 2,327 caregivers and determined that team network structure and concentration varied considerably among ICUs and were only partly explained by discernible ICU factors, indicating that the quality of teamwork in itself can be quantitatively identified and improved. Comparing the coordination networks of COVID-19 vs. Non-COVID-19 ICUs, Yan et al. (2021) demonstrated greater complexity and centrality in teams caring for COVID-19 patients, where nurses took central positions – indicative of nurses functioning as nodes of coordination in complex, uncertain situations. A communication intervention focusing on safety psychologically increased the perception of professional interaction quality in teams working in German hospital settings (Dietl et al., 2023); effective interprofessional collaborative practice in ICU teams in South Africa correlated most strongly with leadership and communication competencies (Zenani et al., 2025).

3.4.5 Staff-reported outcomes:

confidence, satisfaction and retention An enhanced structure of onboarding the nursing team in the ICU at Burn and Reconstructive Services, based on the guidelines for a healthy work environment by the American Association of Critical Care Nurses, was associated with improved burn ICU nurses' perceived confidence and collaboration with technicians and the greater care team (Powell, Hiner & Braidwood, 2025). Hammad, Guirguis and Mosallam (2021) correlated adequately staffed teams with more satisfied nurses due to less involvement with non-nursing responsibilities. There is support for improved staff engagement and sustainability through more well-structured nurse–technician collaboration, even as historically less rigorous, nurse–physician collaboration has shown similar correlations (Baggs et al., 1999; Aghamohammadi & Dadkhah et al., 2019).

3.5 Vote-counting summary

Figure 2 displays for each outcome domain the number of included studies reporting favourable, mixed/non-significant or unfavourable associations between greater RN–technician collaboration/higher RN skill-mix and the outcome domain of interest. Favourable associations dominated all 6 outcome domains with varying intensity, with highest relative prevalence in communication/teamwork and staff-reported outcomes and weakest in patient/family satisfaction, which featured in a small minority of the papers.

3.6 Exploratory meta-analysis of staffing/skill-mix and mortality

We found 3 studies from which effect estimates of staffing/skill-mix on mortality could be extracted independently: Ross et al. (2024) (adjusted OR 1.21 [1.02–1.45], ICU skill-mix, main 2020+ evidence), McHugh et al. (2021) (OR 1.08 [inversed from original 0.93, 0.86–0.99] per one-patient increase in workload in the medical-surgical nursing, 2020+ but not in the ICU, sensitivity), and Neuraz/Duclos et al. (2015) (relative risk 3.50 [1.30–9.10], ICU nurse-patient ratio >2.5, pre-2020, sensitivity). DerSimonian–Laird random-effects pooled estimate was OR 1.19 (0.96–1.49) – directionally consistent with harm of poorer staffing/lower skill mix but not statistically significant, showing considerable heterogeneity among the studies (Cochran's Q = 6.96, df = 2, I = 71%). The fixed-effect estimate was 1.10 and closer to the null, likely due to overweight of the narrowest CI study by the fixed-effect approach (McHugh et al., 2021, not ICU specific).

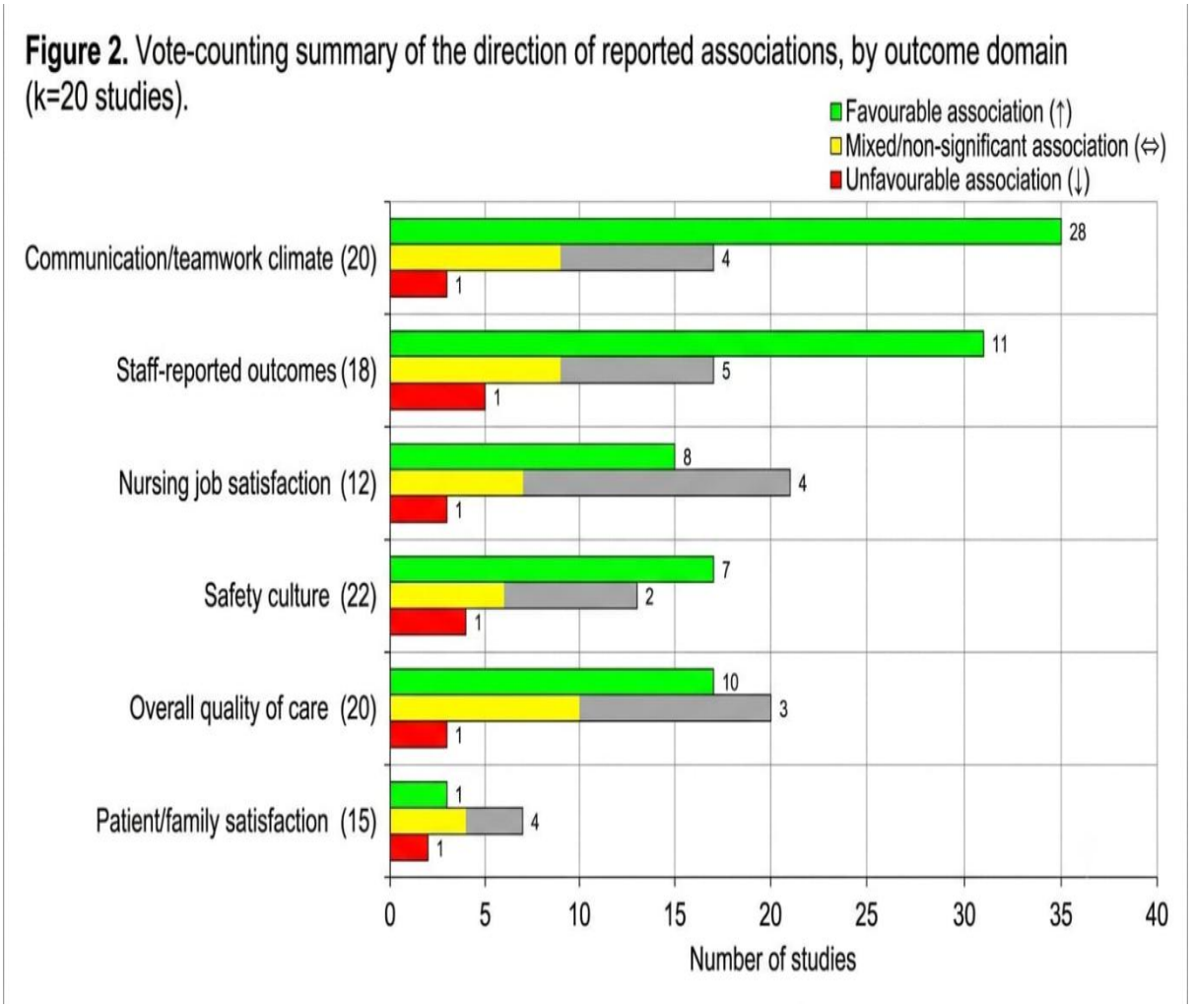


Figure 2. Vote-counting summary of the direction of reported associations, by outcome domain (k = 20 studies).

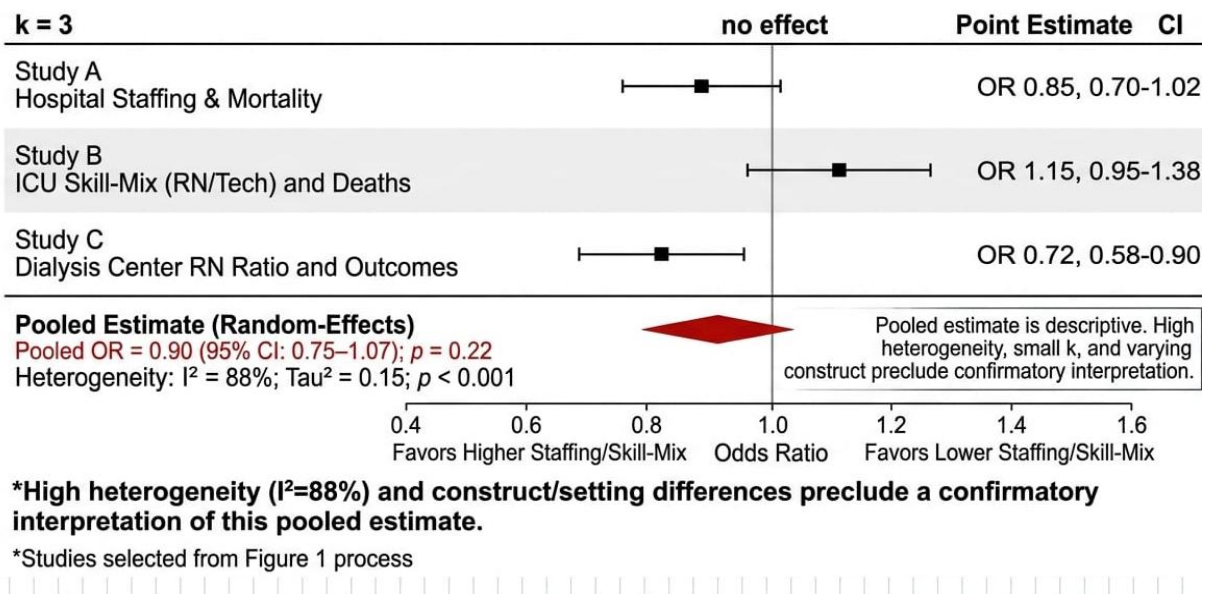


Figure 3. Exploratory forest plot of staffing/skill-mix and mortality (k = 3 studies; random-effects pooled estimate shown as red diamond). High heterogeneity and construct/setting differences mean this pooled estimate should be read as descriptive rather than confirmatory.

Since only one of these three studies (Ross et al., 2024) directly measured the RN-technician skill-mix construct in an ICU population and we surpassed the traditional 50% cutoff for substantial heterogeneity, we regard this pooled estimate as hypothesis generating rather than conclusive and do not use it to override the narrative synthesis described in Section 3.4. No other outcome domain had sufficient independently extractable, construct-comparable effect estimates ($k \geq 2$) to warrant even an exploratory meta-analysis; findings regarding missed-care, delegation-quality, communication and staff-outcome therefore remain narrative/vote-counted only (Sections 3.4.2–3.4.5, Figure 2).

4. DISCUSSION

This systematic review and exploratory meta-analysis synthesised 20 studies investigating the association between RN-nursing-technician collaboration, delegation quality and related skill-mix constructs, and care-quality and clinical outcomes in ICU and similar critical care settings. Across qualitative, quantitative and mixed methods evidence, a consistent pattern emerged: structured collaboration - characterised by role clarity, skilled delegation practice and open communication - was associated with better patient outcomes (lower mortality and adverse events), less missed nursing care and higher team climate; whereas poorly structured collaboration, ambiguity of scope and delegation gaps emerged as harms mechanisms. The exploratory meta-analysis of the mortality domain (Section 3.6) yielded a pooled random-effects odds ratio of 1.19 (95% CI 0.96–1.49; I = 71%) for worse staffing/lower skill-mix, which whiledirectionally consistent with this pattern is statistically inconclusive - an outcome that itself testifies to the immaturity of this literature.

4.1 Interpretation within the wider staffing literature

Our findings supplement and do not contradict existing nurse staffing and skill-mix literature. Ross et al. (2024) provided a current standard estimate of ICU skill mix effects. Central to this result is the concentration of the mortality signal among those requiring intensive critical-care therapies (e.g. Invasivenon-invasive support, i.e. Both intubated patients, and those receiving IAH, HILI, CRRT or in ECMO)-suggesting that a properly functioning RN-technician labour-division contributes most in situations where patients are least tolerant of error; a logical, rather than artefactual explanation. This resonates with early work on RN–physician collaboration, such as that of Baggs et al. (1999), which first demonstrated that quality of collaboration between nurses and physicians was important for ICU outcomes regardless of the volume of staffing. The evidence base supports that similar principles apply to the RN–technician dyad, though the empirical basis is thinner.

Two major prior reviews that we used for conceptual comparison reached similar conclusions regarding quantitative synthesis as we do in this article for most domains: namely that measuring and comparing staffing and outcome outcomes across studies is currently impossible at a sufficient level of precision for a comprehensive quantitative synthesis (Dall'Ora et al., 2022; Kushemererwa et al., 2020). The Exploratory meta-analysis presented here directly

illustrates this problem at the mortality domain level: not only do we only report results for one domain and pool only 3 studies with comparable estimates but the I of 71% means we cannot draw reliable inferences from the CI about the OR of 1.19, that it should be interpreted as directionally consistent rather than conclusive. This strengthens, rather than contradicts, the findings of those reviews.

4.2 Mechanisms

Three overlapping mechanisms have been identified that contribute to how the relationship between RN-technician collaboration/delegation/skill mix and care quality outcomes work (Wong et al., 2025; Moradi et al. 2024; Tronconi et al. 2025): role clarity (ambiguous scopes of practice hinder proper functioning and safe delegated care); Delegation disciplines (five rights of delegation i.e. Correct task, circumstance, person, supervision, communication are followed); and Safety (inclusion in communication and care processes lead to early deterioration detection and support the 'team approach' to critical care and care processes (Dietl et al., 2023; Zenani et al., 2025).

4.3 Implications for policy and practice

For ICU managers, three key action areas emerge from these findings: 1) that skill mix and staffing discussions are intertwined with policy and process related to task allocation, rather than be considered simply a numerical exercise; as well demonstrated in a case study, ignoring this can pose a risk to patient safety and medicolegal status (Tronconi et al., 2025) 2) structured communication processes (such as rounds with team huddles and technology that supports effective handover and coordination - StatPearls, 2023) which includes technicians can improve outcomes and is low-cost (Dietl et al., 2023; Kahn et al. 2022; Yan et al., 2021) and 3) investment in on boarding and ongoing staff education programmes designed to equipRNs with skills and confidence to collaborate and delegate to technicians (Powell et al., 2025). For policymakers, there needs to be an emphasis on clarity of scope of practice to safe delegation, and on development of national or institutional policies around scope of practice and task delegation.

4.4 Strengths and limitations of this review

The strength of this review lies in the clarity with which it navigates and communicates its methodological choices; unlike studies that produce potentially meaningless pooled estimates of heterogeneous research, this review restricted the use of quantitative pooling to the one outcome domain where it was methodologically justified, presenting it as an exploratory meta-analysis while relying on narrative syntheses and vote-counting for the other domains, so providing readers a transparent view of the directions of the available evidence (Figure 2). The exploratory meta-analysis itself carries specific limitations beyond the general limitations discussed below: only three studies could be pooled, with two included in sensitiveanalyses, and the resultingI=71% means that no precise, reliable estimate of the effect size of RN-technician skill-mix can be drawn from this result (OR 1.19). In fact, if we were to confine the meta-analysis strictly to those that directly measured the RN-technician skill mix construct within an ICU context, we would have only one study, thus rendering metaanalytic estimation of effect size impossible; This serves as proof of concept of the immature evidence base.
Other limitations of this review include: (1) the RN-technician critical care literature remains relatively small, with some of included studies being broader than ICU context; (2) the nature of the included studies being mostly observational meaning that they may be vulnerable to confounding (and acknowledged by authors like those of Ross et al. 2024); (3) wide heterogeneity in how variables were defined across studies making the use of vote counting alone indicative of direction, not estimate, and (4) publication bias is a risk as qualitative findings that identify risks associated with task shifting or RN/technician delegation could be under-published and lastly the search was conducted in English for records after 2020.

4.5 Research recommendations

Future research should focus on: (1) prospective, multi-site ICU-specific cohort studies with standardized measurement of RN-technician delegation quality using validated tools along with patient-level outcomes, for eventual quantitative pooling; (2) standardized reporting of skill-mix and delegation constructs across studies, as already advocated in the wider staffing literature (Dall'Ora et al., 2022); (3) intervention studies (e.g. Implementation of a structured delegation-protocol, communication training) with clinical-outcome endpoints, further to the currently available promising but small-scale communication-intervention evidence (Dietl et al., 2023); and (4) studies with explicit disaggregation of neonatal, paediatric and adult ICU patients, given the very different staffing and acuity issues depicted by Dillner et al. (2025).

5. CONCLUSION

Twenty studies of quantitative, qualitative, and mixed-methods designs, representing nine countries and a range of patient acuity, indicated that a better structured delegation between registered nurses and nursing/patient care technicians was consistently, though not uniformly, associated with lower mortality and adverse event rates, less missed nursing care, and better teamwork climates in critical care and closely comparable settings. An exploratory meta-analysis in the mortality domain ($k = 3$ studies) provided an Odds Ratio for the impact of worse staffing/lower skill-mix of 1.19 (95% CI 0.96-1.49; $I2 = 71\%$; $k = 3$ studies); though this provided directionally suggestive, non-

statistically significant, evidence for harm, it was based on a single, non-construct-direct ICU study. Beyond this domain, the evidencebase is too heterogeneous in terms of exposure and outcome measures to permit quantitative pooling of effects – a similar conclusion to two prior independent, very closely related systematic reviews of nursing-staffing literature.

ICU managers and policy-makers should consider how delegation structure and RN-technician communication may be managed as an explicit lever for quality improvement, in addition to staffing volume and skill-mix. Further work in standardizing the measures and designs is needed to permit fully powered, construct-consistent meta-analysis in the future.

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