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COGNITIVE AND ORGANIZATIONAL FACTORS IN THE PREVENTION OF HEALTHCARE-ASSOCIATED INFECTIONS: A STRUCTURED NARRATIVE REVIEW

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Introduction. Healthcare-associated infections (HAIs) remain a major patient-safety problem in intensive care because critically ill patients are exposed to invasive devices, repeated contacts with healthcare workers, and prolonged treatment. Compliance with infection-prevention measures depends not only on professional knowledge but also on the conditions in which care is delivered.
Objective. To synthesize evidence on the relationship between healthcare workers' knowledge, infection-prevention practice, workload, staffing, and organizational support in intensive care and other high-risk hospital settings.
Materials and Methods. A structured narrative review was conducted using PubMed (MEDLINE) and Google Scholar. English-language search terms covered HAIs, infection prevention and control, healthcare workers' knowledge and practice, workload, staffing, intensive care, and organizational factors. Publications from 2016 to July 2026 were considered; one earlier study was retained because it provided foundational evidence on shift duration and organizational burden. Of 183 records identified, 49 publications met the eligibility criteria and were included in the qualitative synthesis. Evidence was organized into cognitive, behavioral, and organizational domains, with attention to study design and measurement method.
Results. Knowledge levels varied across professional groups and settings. Relatively high questionnaire scores did not consistently correspond to correct observed practice, especially for hand hygiene and standard precautions. Educational interventions improved knowledge, but their effect weakened when training was not reinforced. Workload, staffing shortages, time pressure, inadequate supplies, and limited organizational support were repeatedly associated with lower compliance and missed preventive care. Studies using direct observation, staffing data, or workload measures provided stronger support for these associations than self-reported surveys. The evidence indicates that knowledge is necessary but does not compensate for insufficient organizational capacity.
Discussion. The findings suggest that the knowledge–practice gap cannot be explained by insufficient training alone. Compliance is shaped by the interaction of professional competence with workload, staffing, access to supplies, and the local safety culture. Educational measures implemented without organizational changes are therefore unlikely to produce a sustained effect.
Conclusion. HAI prevention should be treated as an implementation problem involving both cognitive readiness and organizational capacity. Training should be combined with adequate staffing, workload monitoring, access to supplies, audit and feedback, and supportive safety leadership. Because most available studies are observational and heterogeneous, the findings should be interpreted as associations rather than proof of direct causation.
Keywords: healthcare-associated infections; infection prevention and control; healthcare workers; knowledge–practice gap; workload; staffing; intensive care; patient safety.

МЕДИЦИНАЛЫҚ КӨМЕККЕ БАЙЛАНЫСТЫ ИНФЕКЦИЯЛАРДЫҢ АЛДЫН АЛУДАҒЫ КОГНИТИВТІК ЖӘНЕ ҰЙЫМДАСТЫРУШЫЛЫҚ ФАКТОРЛАР: ҚҰРЫЛЫМДАЛҒАН НАРРАТИВТІК ШОЛУ

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Кіріспе. Медициналық көмекке байланысты инфекциялар қарқынды терапия бөлімшелеріндегі пациент қауіпсіздігінің маңызды мәселесі болып қала береді. Профилактикалық шаралардың орындалуы медицина

қызметкерлерінің біліміне ғана емес, сонымен қатар жұмыс жүктемесіне, кадрлық қамтамасыз етуге, ресурстардың қолжетімділігіне және ұйымдық қолдауға байланысты.
Мақсаты. Қарқынды терапия және инфекциялық қауіпі жоғары басқа да стационарлық бөлімшелерде медицина қызметкерлерінің білімі, инфекциялық бақылау шараларын іс жүзінде орындауы, жұмыс жүктемесі, кадрлық қамтамасыз ету және ұйымдық жағдайлар арасындағы байланысты сипаттайтын деректерді жинақтау.
Материалдар мен әдістер. PubMed (MEDLINE) және Google Scholar дерекқорларынан табылған жарияланымдарға құрылымдалған нарративтік шолу жүргізілді. Іздеу медициналық көмекке байланысты инфекциялар, инфекциялық бақылау, медицина қызметкерлерінің білімі мен тәжірибесі, жұмыс жүктемесі, кадрлық қамтамасыз ету және қарқынды терапияға қатысты терминдерді қамтыды. 2016 жылдан 2026 жылғы шілдеге дейінгі жарияланымдар қарастырылды; ауысым ұзақтығы мен ұйымдық жүктеме бойынша негізгі дерек беретін бір ертерек зерттеу сақталды. Табылған 183 жазбаның 49 жарияланымы сапалық синтезге енгізілді.
Нәтижелер. Білім деңгейі кәсіби топтар мен медициналық ұйымдар арасында айтарлықтай ерекшеленді. Сауалнамадағы жоғары көрсеткіштер әрдайым қол гигиенасы мен стандартты сақтық шараларының дұрыс орындалуына сәйкес келмеді. Оқыту білімді жақсартты, бірақ қайталау, бақылау және кері байланыс болмаған жағдайда әсері төмендеді. Жоғары жүктеме, кадр тапшылығы, уақыттың шектеулілігі, қорғаныш құралдарының жеткіліксіздігі және ұйымдық қолдаудың әлсіздігі профилактикалық талаптарды орындаудың төмендеуімен және қажетті іс-шаралардың өткізіп алынуымен байланысты болды.
Талқылау. Жинақталған деректер білім мен тәжірибе арасындағы алшақтықты тек персонал даярлығының жеткіліксіздігімен түсіндіруге болмайтынын көрсетеді. Профилактикалық талаптардың орындалуына кәсіби құзыреттілікпен қатар жұмыс жүктемесі, кадрлық қамтамасыз ету, ресурстардың қолжетімділігі және қауіпсіздік мәдениеті әсер етеді. Сондықтан ұйымдық өзгерістермен ұштастырылмаған оқыту шараларының тұрақты нәтиже беруі шектеулі.
Қорытынды. Инфекциялардың алдын алуды персоналдың когнитивтік дайындығы мен ұйымның стандарттарды орындауға қажетті жағдай жасау қабілетін біріктіретін енгізу міндеті ретінде қарастыру қажет. Оқыту жеткілікті кадрлық қамтамасыз етумен, жүктемені бақылаумен, ресурстарға қолжетімділікпен, аудитпен, кері байланыспен және қауіпсіздік мәдениетін қолдаумен толықтырылуы тиіс. Енгізілген зерттеулердің көпшілігі бақылаулық дизайнда болғандықтан, анықталған байланыстарды тікелей себеп-салдарлық қатынас ретінде түсіндіруге болмайды.
Түйінді сөздер: медициналық көмекке байланысты инфекциялар; инфекциялық бақылау; медицина қызметкерлері; білім мен тәжірибе арасындағы алшақтық; жұмыс жүктемесі; кадрлық қамтамасыз ету; қарқынды терапия; пациент қауіпсіздігі.

КОГНИТИВНЫЕ И ОРГАНИЗАЦИОННЫЕ ФАКТОРЫ ПРОФИЛАКТИКИ ИНФЕКЦИЙ, СВЯЗАННЫХ С ОКАЗАНИЕМ МЕДИЦИНСКОЙ ПОМОЩИ: СТРУКТУРИРОВАННЫЙ НАРРАТИВНЫЙ ОБЗОР

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Введение. Инфекции, связанные с оказанием медицинской помощи, остаются одной из основных проблем безопасности пациентов в отделениях интенсивной терапии. Соблюдение профилактических мер зависит не только от знаний медицинских работников, но и от нагрузки, кадрового обеспечения, доступности ресурсов и организационной поддержки.
Цель. Обобщить данные о взаимосвязи знаний медицинских работников, фактического выполнения мер инфекционного контроля, рабочей нагрузки, кадрового обеспечения и организационных условий в отделениях интенсивной терапии и других подразделениях высокого риска.
Материалы и методы. Проведен структурированный нарративный обзор публикаций, найденных в PubMed (MEDLINE) и Google Scholar. Поиск включал термины, относящиеся к инфекциям, связанным с оказанием медицинской помощи, инфекционному контролю, знаниям и практике медицинских работников, нагрузке, кадровому обеспечению и интенсивной терапии. Рассматривались публикации за 2016–июль 2026 гг.; одна более ранняя работа была сохранена как основополагающий источник по продолжительности смен и организационной нагрузке. Из 183 найденных записей 49 публикаций были включены в качественный синтез.
Результаты. Уровень знаний существенно различался между профессиональными группами и учреждениями. Высокие показатели анкетирования не всегда соответствовали правильному выполнению процедур, особенно гигиены рук и стандартных мер предосторожности. Обучение улучшало знания, однако эффект снижался без повторного закрепления, наблюдения и обратной связи. Высокая нагрузка, дефицит персонала, нехватка

времени, ограниченный доступ к средствам защиты и недостаточная организационная поддержка были связаны со снижением соблюдения требований и пропуском профилактических мероприятий.
Обсуждение. Полученные данные показывают, что разрыв между знаниями и практикой нельзя объяснить только недостаточной подготовкой персонала. Соблюдение профилактических требований формируется под совместным влиянием профессиональной компетентности, нагрузки, кадрового обеспечения, доступности ресурсов и культуры безопасности. Поэтому изолированные образовательные меры без организационных изменений вряд ли обеспечат устойчивый эффект.
Заключение. Профилактику инфекций следует рассматривать как задачу внедрения, требующую сочетания когнитивной готовности персонала и организационной способности учреждения обеспечить выполнение стандартов. Обучение необходимо дополнять адекватным кадровым обеспечением, мониторингом нагрузки, доступом к ресурсам, аудитом, обратной связью и поддержкой культуры безопасности. Большинство включенных исследований имели наблюдательный дизайн, поэтому выявленные связи не следует интерпретировать как безусловно причинные.
Ключевые слова: инфекции, связанные с оказанием медицинской помощи; инфекционный контроль; медицинские работники; разрыв между знаниями и практикой; рабочая нагрузка; кадровое обеспечение; интенсивная терапия; безопасность пациентов.

Introduction

Healthcare-associated infections remain among the most frequent and consequential complications of hospital care. The problem is especially pronounced in anesthesiology, resuscitation, and intensive care units, where patients often have severe underlying disease, impaired host defenses, prolonged exposure to the hospital environment, and repeated invasive interventions. Mechanical ventilation, central venous and urinary catheters, extracorporeal support, and frequent manipulation of devices increase the number of opportunities for microbial transmission. In the EPIC III study, infection was recorded in a substantial proportion of intensive care patients and was associated with poorer clinical outcomes [1].

HAIs are generally understood as infections that arise in connection with healthcare delivery and were neither present nor incubating at the time of admission. They are associated with increased mortality, longer hospital stays, antimicrobial use, and additional costs [2]. Surveillance studies from intensive care settings consistently identify ventilator-associated pneumonia, bloodstream infection, urinary tract infection, and other device-associated infections among the main clinical forms [3,4]. Their distribution varies across hospitals and countries, but the combination of patient acuity and high device utilization makes intensive care a priority setting for prevention.

Infection prevention and control depends on reliable performance of routine measures: hand hygiene, appropriate use of personal protective equipment, aseptic technique, environmental cleaning, isolation precautions, and adherence to device-care bundles. These measures are implemented through repeated actions by healthcare workers and therefore require adequate knowledge of transmission routes, correct procedural skills, realistic risk perception, and consistent professional habits. Knowledge is a necessary foundation; however, it is not equivalent to performance. Studies repeatedly describe a gap between questionnaire-based knowledge and observed adherence to standard precautions [5,6].

This gap has practical importance. A worker may correctly identify the indications for hand hygiene yet omit the procedure during periods of high task intensity. Another may know the elements of a catheter-care bundle but be unable to complete them when staffing is insufficient or equipment is not immediately available. Workload, shift duration, interruptions, staffing levels, skill mix, access to supplies, supervisory support, and the local safety climate can therefore modify the extent to which knowledge is translated into practice [7,8]. These conditions are not secondary background variables; they shape the feasibility and reliability of preventive care.

Kazakhstan faces the same clinical and organizational challenges. Available studies from Astana and multicenter hospital surveys have documented HAIs, substantial antimicrobial use, and a prominent role of Gram-negative organisms, including infections occurring in critical care units [9,10]. At the same time, published evidence from Kazakhstan on healthcare workers' infection-

control behavior, nursing workload, staffing, and organizational safety remains limited. This creates a need to interpret local findings within the broader international evidence base while avoiding direct transfer of recommendations that may not fit staffing models, infrastructure, or resource availability.

Previous publications have often considered knowledge, hand hygiene, staffing, workload, or HAI epidemiology as separate topics. Such separation does not fully explain why educational programs may improve test scores without producing stable changes in practice. The present review addresses this limitation by examining the implementation pathway that connects cognitive readiness, organizational capacity, preventive behavior, and patient-safety outcomes. The intended contribution is not a new pooled estimate, but an integrated explanation of the knowledge–practice gap in high-risk hospital care.

The objective of this structured narrative review was to synthesize evidence on cognitive and organizational factors associated with HAI prevention. Three questions guided the analysis: (1) how are healthcare workers' knowledge and training related to preventive practice; (2) which organizational conditions facilitate or hinder adherence; and (3) how do cognitive and organizational factors interact in intensive care and other high-risk settings?

Materials and Methods

Review design and reporting approach

This work was designed as a structured narrative review. A narrative approach was selected because the evidence base included heterogeneous study designs, settings, professional groups, measurement instruments, and outcomes. The review combined descriptive mapping with critical thematic synthesis rather than statistical pooling. Preparation and revision of the manuscript were guided by the principles of the SANRA instrument, particularly the need for a clearly stated objective, a transparent description of literature searching, appropriate referencing, scientific reasoning, and presentation of relevant endpoint data [50].

The review did not constitute a systematic review or meta-analysis. No pooled effect estimate was calculated, and no claim of exhaustive global coverage is made. Nevertheless, a structured search and explicit eligibility criteria were used to reduce arbitrary source selection and to make the basis of the synthesis clear.

Information sources and search strategy

Literature was searched in PubMed (MEDLINE) and Google Scholar. The search covered publications from 2016 to July 2026. The 2013 study by Stimpfel et al. [8] was retained outside the primary date range because it provides foundational evidence on long hospital shifts and organizational burden and was directly relevant to interpretation of workload-related findings.

The search strategy combined terms from four concept blocks: (1) healthcare-associated infection and hospital-acquired infection; (2) infection prevention, infection control, standard precautions, hand hygiene, and personal protective equipment; (3) healthcare workers, nurses, physicians, knowledge, attitude, practice, compliance, and training; and (4) workload, staffing, missed care, organizational factors, intensive care, and ICU. Boolean operators AND and OR were used to combine synonyms and concept blocks. Search terms were applied in English. Reference lists of relevant reviews and eligible articles were also examined to identify additional publications closely related to the review questions.

A representative search formulation was: ("healthcare-associated infection*" OR "hospital-acquired infection*" OR "nosocomial infection*") AND ("infection prevention" OR "infection control" OR "standard precaution*" OR "hand hygiene") AND ("healthcare worker*" OR nurse* OR physician*) AND (knowledge OR practice OR compliance OR training OR workload OR staffing OR "organizational factor*" OR "intensive care" OR ICU). Database syntax was adapted to the requirements of each source.

Eligibility criteria

Eligible publications examined one or more of

the following: HAI epidemiology in intensive care; healthcare workers' knowledge, attitudes, skills, or preventive practices; hand hygiene or standard-precaution compliance; education and training; staffing and nursing workload; missed care; organizational support; or associations between these factors and HAI-related outcomes. Studies involving physicians, nurses, other healthcare workers, or multidisciplinary teams were considered. Intensive care was the principal context, while studies from emergency departments and other high-risk hospital units were retained when they addressed mechanisms directly relevant to infection-prevention implementation.

Primary quantitative and qualitative studies, surveillance studies, mixed-methods studies, systematic reviews, rapid reviews, and meta-analyses were eligible. Conference abstracts, brief reports without sufficient methodological or outcome information, publications unrelated to the review questions, and records for which the full text could not be assessed were excluded. Studies focused exclusively on pathogen susceptibility without a link to prevention practice, staffing, workload, or organizational conditions were not used for the thematic conclusions.

Study selection and data extraction

Records were screened in two stages. Titles and abstracts were assessed first, followed by full-text evaluation of potentially relevant publications. The review team considered relevance to the predefined cognitive and organizational domains, the clarity of methods, and the availability of interpretable outcomes. The selection process identified 183 records, of which 65 were excluded at title and abstract screening. Full texts were assessed for 118 publications; 69 were excluded because the full text was unavailable, the content was not relevant to the review question, or the publication was a conference material. Forty-nine publications were included in the qualitative synthesis.

For each included publication, the following information was extracted where available: country and clinical context, participant group, design, sample size, method used to measure knowledge or practice, workload or staffing indicator, infection-prevention outcome, HAI outcome, principal association, and major methodological limitation. Data were organized in a working evidence matrix before thematic synthesis.

Critical appraisal and synthesis

Because the review included markedly different designs, a single formal risk-of-bias instrument was not applied across all publications. The evidence was appraised qualitatively. Greater interpretive weight was assigned to systematic reviews and meta-analyses, multicenter surveillance studies, prospective cohorts, studies using staffing or Nursing Activities Score data, and studies based on direct observation. Findings from single-center cross-sectional surveys and self-reported compliance measures were treated more cautiously because of selection, recall, and social-desirability bias.

The synthesis was conducted in four stages. First, findings were grouped into cognitive factors, observed preventive behavior, organizational conditions, and patient-safety outcomes. Second, agreement and inconsistency between studies were examined. Third, the role of measurement method was considered, particularly differences between self-report and direct observation. Fourth, an implementation pathway was developed to explain how cognitive readiness and organizational capacity jointly influence adherence. The synthesis was qualitative because definitions, instruments, populations, and outcome measures were too heterogeneous for meaningful statistical pooling.

Results

Study selection and profile of the evidence

The search and selection process resulted in 49 included publications (Figure 1). The evidence base comprised global and regional cross-sectional studies of knowledge, attitudes, and practices; studies of hand hygiene using self-report or direct observation; educational intervention studies; ICU surveillance cohorts; analyses of staffing and missed care; investigations using the Nursing Activities Score; and systematic reviews or meta-

analyses of workload, staffing, and HAI outcomes.

The publications represented diverse healthcare systems and resource settings. This diversity increased the relevance of recurring patterns but limited direct comparison of percentages. Knowledge and adherence were measured using non-equivalent questionnaires, locally developed scores, checklists, direct observation, electronic monitoring, administrative staffing data, and clinical surveillance. The findings are therefore presented as thematic patterns rather than as a single summary value.

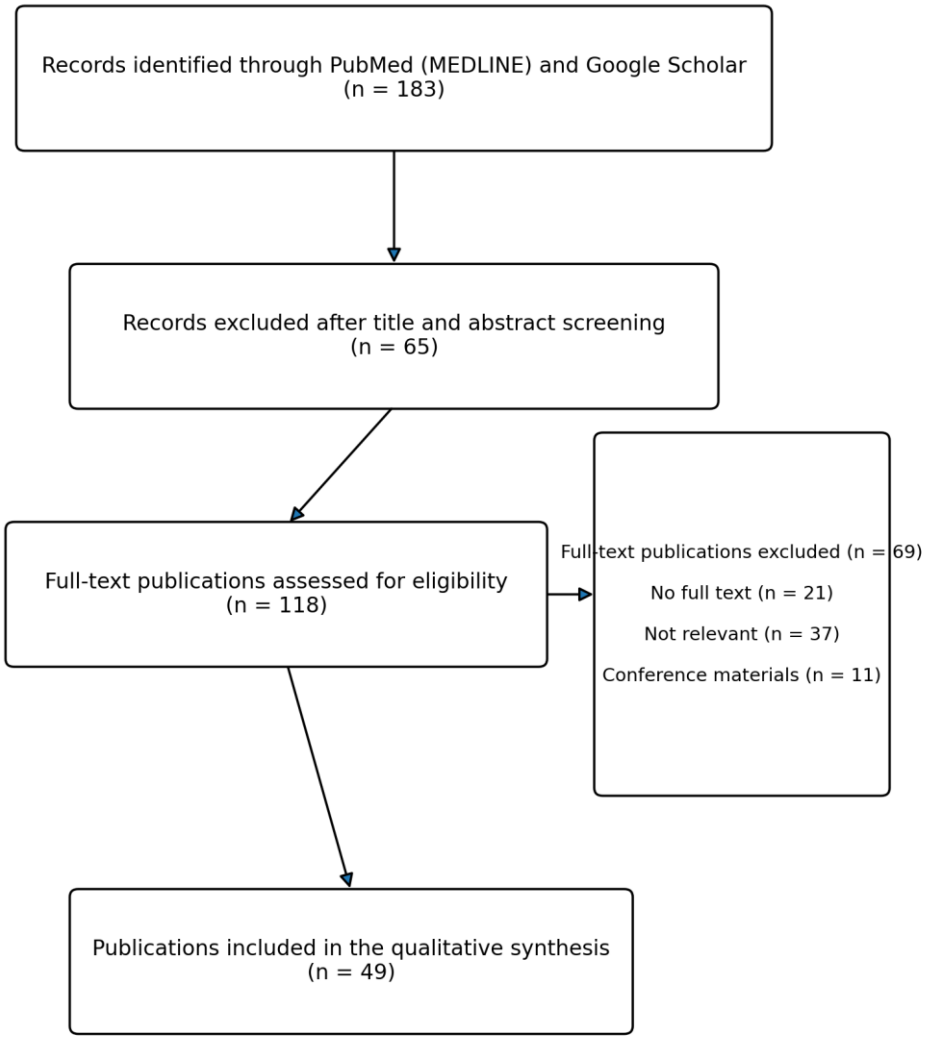


Figure 1. Study selection process

Table 1 - Main analytical domains and patterns identified in the included literature

Domain	Typical indicators	Main pattern	Representative references

Domain	Typical indicators	Main pattern	Representative references
Knowledge and risk understanding	Knowledge scores, transmission routes, standard precautions	Knowledge ranged from limited to high; higher scores did not consistently predict observed adherence.	[5,6,11–13,15,18–21,42]
Training and skill retention	Pre/post training scores, time since last training, technique assessment	Training improved knowledge and short-term performance, but gains weakened without reinforcement, supervision and feedback.	[14–18]
Hand hygiene and standard precautions	Observed or self-reported compliance, completeness of technique, PPE use	Observed practice was usually lower than self-report; high opportunity density and interruptions reduced reliability.	[7,16–18,23–26,44,45]
Staffing and workload	Nurse-to-patient ratio, Nursing Activities Score, task volume, shift duration	Higher workload and lower staffing were associated with missed care, lower compliance and adverse outcomes.	[8,22,27–35,46,47,49]
Organizational support	Supplies, protocols, leadership, audit, feedback, safety culture	Knowledge was more likely to translate into practice when supplies, protocols, monitoring and managerial support were available.	[19,21,26,42–45]
HAI and patient outcomes	HAI prevalence, device-associated infection, mortality, length of stay	HAIs remained common in ICU populations; staffing and workload were associated with infection and outcome measures, although most evidence was observational.	[1–4,9,10,27–30,34,35,38–41,47,48]

Cognitive factors: knowledge, beliefs, and practical competence

The included studies did not support a uniform description of healthcare workers' knowledge. In a global cross-sectional study, mean knowledge indicators were relatively high among physicians and nurses, although professional-group differences remained [11]. Other studies reported considerably lower levels, often between 40% and 60%, particularly when questionnaires assessed detailed indications, transmission mechanisms, or application of standard precautions rather than general awareness [6,12,13,18,19]. These differences probably reflect variation in training, professional composition, instruments, scoring thresholds, and clinical context.

The most consistent finding was not simply inadequate knowledge but the separation between knowing and doing. Participants frequently reported awareness of infection-prevention requirements while demonstrating lower compliance in practice [5,6,11–13]. This difference was especially apparent when self-reported behavior was compared with direct observation. Self-report is vulnerable to recall and social-desirability bias, while observation may be influenced by the Hawthorne effect; nevertheless, repeated discrepancies suggest

that theoretical knowledge alone is an incomplete proxy for safe practice.

Hand hygiene illustrates this problem. Several studies found that healthcare workers recognized its importance, but correct execution of all required steps was observed in only a proportion of participants [16–18]. Knowledge of indications did not guarantee adequate duration, coverage of all hand surfaces, or performance at every opportunity. In neonatal and intensive care settings, deficits persisted in specific areas despite acceptable overall scores [18,20]. These findings indicate that cognitive assessment should distinguish declarative knowledge from procedural competence.

Training generally improved knowledge and immediate test performance. Targeted educational programs produced statistically significant gains [14], and staff with more recent training tended to perform better than those whose training had occurred earlier [15]. However, one-time instruction did not reliably produce sustained adherence. The evidence favors recurrent training combined with skills assessment, direct observation, feedback, and reinforcement within clinical workflows. Training is therefore best understood as one component of an implementation system rather than an isolated intervention.

Experience, educational level, access to protocols, and availability of protective equipment were also associated with knowledge and practice [19]. Their effects were inconsistent across studies, suggesting that individual characteristics operate within the local work environment. An experienced worker may perform poorly in an overloaded unit, while a less experienced worker may follow protocols reliably when supervision, supplies, and workflow design are adequate. The relation between cognitive factors and behavior is therefore conditional rather than linear [21,42].

Organizational factors: workload, staffing, resources, and work design

Organizational conditions determine whether preventive procedures can be completed reliably during routine care. In intensive care, workload is not captured by patient numbers alone. It also reflects patient acuity, frequency of interventions, documentation, monitoring, admissions, transfers, emergency events, isolation procedures, and the number of device-related tasks. A single critically ill patient may generate a large number of hand hygiene opportunities and aseptic procedures within a short period.

Cross-sectional evidence shows that nurses and other healthcare workers frequently identify workload and lack of time as barriers to standard precautions [22,25]. These self-reports are consistent with observational findings. Chang et al. found that hand hygiene compliance remained relatively stable up to approximately 30 opportunities per hour and then decreased by about one percentage point for each additional opportunity [7]. A separate prospective study using continuous electronic measures also found an inverse relationship between workload and hand hygiene performance even in a highly trained and well-staffed setting [23]. These studies strengthen the interpretation that workload is not merely a perceived excuse but a measurable constraint.

High patient-load periods were also associated with reduced compliance with broader infection-control protocols, including personal protective equipment [24]. The effect was not limited to a single procedure. Under time pressure, healthcare workers must prioritize urgent clinical tasks, and preventive actions may be delayed, abbreviated, or omitted. This mechanism is consistent with research on missed nursing care, in which more than 70% of nurses reported omission of at least one required activity during a shift [29]. Preventive and supportive tasks are particularly vulnerable because their consequences may not be immediately visible.

Staffing is closely related to workload but should be considered separately. A reduced number of staff members increases task density and limits the ability to redistribute work during deterioration, admission, or emergency procedures. Systematic reviews have linked lower staffing levels with hospital-acquired conditions and HAIs [27,28]. Unit-

level and multisource studies similarly reported associations between staffing, missed care, safety attitudes, quality, and infection outcomes [29,30]. Short-term staffing reductions may affect infection risk within the following days, which is biologically plausible because lapses in asepsis or device care may precede clinical recognition of infection.

Workload studies using the Nursing Activities Score show that required nursing time may approach or exceed available capacity [31–33]. During admission, deterioration, or high-acuity care, direct patient-care demands increase further. When workload exceeds staffing capacity, adherence cannot be treated solely as an individual motivational issue. The problem becomes one of work-system design, including task allocation, skill mix, shift scheduling, supply placement, and protected time for infection-prevention activities.

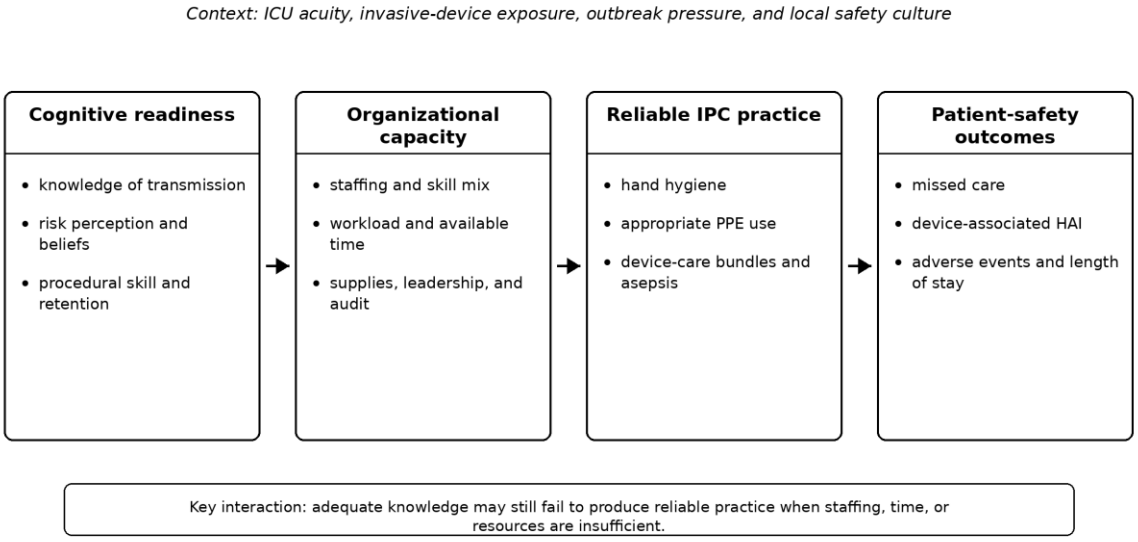
Resource availability and organizational support modify the effect of workload. Access to hand-rub dispensers, personal protective equipment, written protocols, functioning isolation facilities, and timely replacement of supplies reduces the effort required to perform preventive actions [19,26]. Leadership, audit, and feedback also matter. Staff are more likely to treat infection prevention as a non-negotiable component of care when expectations are consistent, data are visible, and supervisors respond to system barriers rather than attributing every lapse to individual negligence [42–45].

Interaction between cognitive and organizational factors

The evidence supports an interaction model. Cognitive readiness includes knowledge of transmission, risk perception, understanding of protocols, and practical skills. Organizational capacity includes staffing, workload, time, supplies, supervision, audit, feedback, and safety culture. Reliable preventive behavior is most likely when both are adequate. Weakness in either component can disrupt implementation.

When cognitive readiness is low, staff may not recognize an indication for hand hygiene, may use personal protective equipment incorrectly, or may fail to understand the purpose of a bundle element. When organizational capacity is low, staff may recognize the correct action but omit it because several urgent tasks compete for the same time. Education primarily addresses the first pathway; staffing, workflow redesign, point-of-care supplies, and leadership address the second. A program limited to training may therefore improve knowledge scores without reducing missed care.

This interaction also explains variation between settings. The same educational intervention may be effective in a unit with stable staffing and accessible supplies but have little impact in a unit with sustained overload. Conversely, increasing staffing without addressing knowledge gaps or local norms may not ensure correct practice. Multicomponent interventions are more consistent with the causal structure suggested by the evidence than single interventions aimed only at individual behavior.



Association with HAIs and other patient-safety outcomes

HAIs remain common in intensive care populations, although reported prevalence varies widely because of differences in case mix, surveillance definitions, device utilization, and healthcare systems [38–41,46]. Device-associated infections are especially important because their prevention depends on repeated, standardized care processes. Surveillance studies show that HAIs are associated with mortality and other adverse outcomes [38,39,48].

The relationship between organizational factors and infection outcomes is supported by several lines of evidence. Reviews and observational studies associate nursing workload with infections, pressure injuries, medication errors, mortality, and poorer patient-focused outcomes [34,35]. Prospective work has linked staffing and workload with ventilator-associated pneumonia and mortality [47]. Similar relationships have been described for other device-associated infections [48]. These findings are clinically coherent, but causal interpretation should remain cautious because staffing and workload are also influenced by patient severity, unit type, resources, and case complexity.

During infectious outbreaks, workload increases because of isolation measures, additional monitoring, communication requirements, and staff absence [36]. Adherence may remain incomplete despite greater awareness of infection risk [37]. Outbreak conditions therefore reveal the limits of relying on motivation alone: heightened concern does not remove time constraints, supply problems, or staffing shortages.

Evidence relevant to Kazakhstan

Kazakhstan-specific evidence confirms the clinical relevance of HAIs but remains insufficient for a detailed analysis of cognitive and organizational mechanisms. The observational study from a critical care unit in Astana and the later multicenter point-prevalence survey documented HAI and antimicrobial-use patterns consistent with the wider international literature [9,10]. These studies establish the importance of surveillance, but they do not provide a complete national picture of healthcare workers' knowledge, observed adherence, staffing adequacy, or nursing workload.

The main research gap is therefore not the absence of international evidence, but the limited availability of standardized local data linking staff knowledge, direct observation of practice, objective workload indicators, staffing, and HAI outcomes. Future studies in Kazakhstan should use validated instruments, clearly defined denominators, device-days, nurse-to-patient ratios, Nursing Activities Score or comparable workload measures, and

prospective surveillance. Multicenter designs would allow comparison between hospitals and help distinguish local organizational effects from differences in patient severity.

The design and principal analytical domain of all included publications are summarized in Supplementary Table 1 [1–49].

Supplementary Table 1 - Design and principal review domain of the included publications

No.	Publication	Design/source type	Principal domain in this review
1	Vincent J.L., Sakr Y., Singer M., Martin-Loeches I., Machado F.R., Marshall J.C., Finfer S., Pelosi P., Brazzi L., Aditianingsih D., Timsit J.F., Du B., Wittebole X., Máca J., Kannan S., Gorordo-Delsol L.A., De Waele J.J., Mehta Y., Bonten M.J.M., Khanna A.K., Kollef M., Human M., Angus D.C. (2020) Prevalence and outcomes of infection among patients in intensive care units in 2017. JAMA, vol. 323, no 15, pp. 1478–1487.	Multicenter prevalence study	ICU infection epidemiology
2	Haque M., Sartelli M., McKimm J., Abu Bakar M. (2018) Health care-associated infections – an overview. Infectious Drug Resistance, vol. 11, pp. 2321–2333.	Narrative overview	HAI epidemiology and prevention
3	Mitharwal S.M., Yaddanapudi S., Bhardwaj N., Gautam V., Biswal M., Yaddanapudi L. (2016) Intensive care unit-acquired infections in a tertiary care hospital: An epidemiologic survey and influence on patient outcomes. American Journal of Infection Control, vol. 44, no 7, pp. e113–e117.	Epidemiologic survey	ICU-acquired infection and outcomes
4	Araç E., Kaya Ş., Parlak E., Büyüktuna S.A., Baran A.İ., Akgül F., Gökler M.E., Aksöz S., Sağmak Tartar A., Tekin R., Yıldız Y., Günay E. (2019) Evaluation of infections in intensive care units: A multicentre point-prevalence study [Yoğun bakım ünitelerindeki enfeksiyonların değerlendirilmesi: çok merkezli nokta prevalans çalışması]. Mikrobiyoloji Bulteni, vol. 53, no 4, pp. 364–373.	Multicenter point-prevalence study	ICU infection epidemiology
5	Campo L.K.C., Remon A.R. (2025) Knowledge and practices of nurses on the prevention and control of healthcare-acquired infections in a private tertiary hospital in Baguio City. Acta Medica Philippina, vol. 59, no 3, pp. 92–103.	Cross-sectional KAP study	Knowledge and nursing practice
6	Iliyasu G., Dayyab F.M., Habib Z.G. et al. (2016) Knowledge and practices of infection control among healthcare workers in a tertiary referral center in	Cross-sectional KAP study	Knowledge and infection-control practice

No.	Publication	Design/source type	Principal domain in this review
	North-Western Nigeria. Annals of African Medicine, vol. 15, no 1, pp. 34–40.		
7	Chang N.N., Schweizer M.L., Reisinger H.S., Jones M., Chrischilles E., Chorazy M., Huskins W.C., Herwaldt L. (2022) The impact of workload on hand hygiene compliance: Is 100% compliance achievable? Infection Control and Hospital Epidemiology, vol. 43, no 9, pp. 1259–1261.	Observational workload study	Workload and hand hygiene
8	Stimpfel A.W., Sloane D.M., Aiken L.H. (2013) The longer the shifts for hospital nurses, the higher the levels of burnout and patient dissatisfaction. Health Affairs, vol. 32, no 2, pp. 250–258.	Observational workforce study	Shift duration and organizational burden
9	Viderman D., Khamzina Y., Kaligozhin Z., Khudaibergenova M., Zhumadilov A., Crape B., Azizan A. (2018) An observational case study of hospital-associated infections in a critical care unit in Astana, Kazakhstan. Antimicrobial Resistance and Infection Control, vol. 7, p. 57.	Observational case study	Kazakhstan ICU epidemiology
10	Semenova Y., Yessmagambetova A., Akhmetova Z., Smagul M., Zharylkassynova A., Aubakirova B., Soiak K., Kosherova Z., Aimurziyeva A., Makalkina L. et al. (2024) Point-prevalence survey of antimicrobial use and healthcare-associated infections in four acute care hospitals in Kazakhstan. Antibiotics, vol. 13, no 10, p. 981.	Point-prevalence survey	Kazakhstan HAI and antimicrobial use
11	Khatrawi E.M. et al. (2023) Evaluating the knowledge, attitudes, and practices of healthcare workers regarding high-risk nosocomial infections: A global cross-sectional study. Health Science Reports, vol. 6, no 9, p. e1559.	Global cross-sectional study	Knowledge, attitudes and practices
12	Desta M. et al. (2018) Knowledge, practice and associated factors of infection prevention among healthcare workers in Debre Markos referral hospital, Northwest Ethiopia. BMC Health Services Research, vol. 18, no 1, p. 465.	Facility-based cross-sectional study	Knowledge and practice
13	Olatade M.J., RM R., RPHNE B.N.S. (2021) Knowledge and preventive practices of nosocomial infections among health workers in two selected tertiary hospitals in Ogun State. International Journal of Caring Sciences, vol. 14, no 1, p. 174.	Cross-sectional KAP study	Knowledge and prevention practice
14	Goyal M., Chaudhry D. (2019) Impact of	Educational intervention study	Training and knowledge

No.	Publication	Design/source type	Principal domain in this review
	educational and training programs on knowledge of healthcare students regarding nosocomial infections, standard precautions and hand hygiene: A study at a tertiary care hospital. Indian Journal of Critical Care Medicine, vol. 23, no 5, p. 227.		
15	Fortunka K. et al. (2024) Knowledge and training needs in nosocomial infection among hospital staff in the City of Kielce, Poland: A cross-sectional study. Journal of Nursing Management, vol. 2024, no 1, p. 9243232.	Cross-sectional study	Knowledge and training needs
16	Garba M.B., Uche L.B. (2019) Knowledge, attitude, and practice of hand washing among healthcare workers in a tertiary health facility in northwest Nigeria. Journal of Medicine in the Tropics, vol. 21, no 2, pp. 73–80.	Cross-sectional KAP study	Hand hygiene knowledge and practice
17	Gwarzo G.D. (2018) Hand hygiene practice among healthcare workers in a public hospital in North-Western Nigeria. Nigerian Journal of Basic and Clinical Sciences, vol. 15, no 2, pp. 109–113.	Observational study	Hand hygiene practice
18	Adegboye M.B. et al. (2018) Knowledge, awareness and practice of infection control by health care workers in the intensive care units of a tertiary hospital in Nigeria. African Health Sciences, vol. 18, no 1, p. 72.	Cross-sectional ICU study	Knowledge and infection-control practice
19	Geberemariyam B.S., Donka G.M., Wordofa B. (2018) Assessment of knowledge and practices of healthcare workers towards infection prevention and associated factors in healthcare facilities of West Arsi District, Southeast Ethiopia: A facility-based cross-sectional study. Archives of Public Health, vol. 76, no 1, p. 69.	Facility-based cross-sectional study	Knowledge and associated factors
20	Zhou J., Chen S. (2022) Knowledge, attitudes, and practices of NICU doctors and nurses toward prevention and control of nosocomial infection with multidrug-resistant organisms. Frontiers in Pediatrics, vol. 10, p. 817030.	Cross-sectional NICU study	Knowledge, attitudes and practices
21	Khan H.A., Baig F.K., Mehboob R. (2017) Nosocomial infections: Epidemiology, prevention, control and surveillance. Asian Pacific Journal of Tropical Biomedicine, vol. 7, no 5, pp. 478–482.	Narrative review	HAI epidemiology and prevention
22	Amedy O.S., Naqshbandi V.A., Saido G.A. (2023) Association between nurse	Cross-sectional study	Workload and compliance

No.	Publication	Design/source type	Principal domain in this review
	compliance and workload regarding patient safety: A cross-sectional study. Advances in Bioresearch, vol. 14, no 5, pp. 168–179.		
23	Scheithauer S., Batzer B., Dangel M., Passweg J., Widmer A. (2017) Workload even affects hand hygiene in a highly trained and well-staffed setting: A prospective 365/7/24 observational study. Journal of Hospital Infection, vol. 97, no 1, pp. 11–16.	Prospective electronic observational study	Workload and hand hygiene
24	Almutairi A.G.A. et al. (2024) Evaluating infection control compliance during high-patient-load periods in emergency departments: A mixed-methods study. Cultura: International Journal of Philosophy of Culture and Axiology, vol. 21, no 2s, pp. 13–23.	Mixed-methods study	High patient load and compliance
25	Tiara N. et al. (2024) Workload and universal precautions compliance among health workers in emergency rooms. Indonesia Jurnal Perawat, vol. 9, no 2, pp. 1–11.	Cross-sectional study	Workload and standard precautions
26	Brooks S.K. et al. (2021) Factors affecting healthcare workers' compliance with social and behavioural infection control measures during emerging infectious disease outbreaks: rapid evidence review. BMJ Open, vol. 11, no 8, p. e049857.	Rapid evidence review	Organizational and behavioral barriers
27	Mitchell B.G. et al. (2018) Hospital staffing and healthcare-associated infections: A systematic review of the literature. The Joint Commission Journal on Quality and Patient Safety, vol. 44, no 10, pp. 613–622.	Systematic review	Staffing and HAI
28	Shin S., Park J.H., Bae S.H. (2019) Nurse staffing and hospital-acquired conditions: A systematic review. Journal of Clinical Nursing, vol. 28, no 23–24, pp. 4264–4275.	Systematic review	Staffing and hospital-acquired conditions
29	Alanazi F.K. et al. (2023) Healthcare-associated infections in adult intensive care units: A multisource study examining nurses' safety attitudes, quality of care, missed care, and nurse staffing. Intensive and Critical Care Nursing, vol. 78, p. 103480.	Multisource observational study	Staffing, missed care and HAI
30	Shang J. et al. (2019) Nurse staffing and healthcare-associated infection: Unit-level analysis. JONA: The Journal of Nursing Administration, vol. 49, no 5, pp. 260–265.	Unit-level observational study	Staffing and HAI

No.	Publication	Design/source type	Principal domain in this review
31	Sardo P.M.G. et al. (2023) Nursing workload assessment in an intensive care unit: A retrospective observational study using the Nursing Activities Score. Nursing in Critical Care, vol. 28, no 2, pp. 288–297.	Retrospective observational study	Nursing Activities Score
32	Dauvergne J.E. et al. (2025) Workload assessment using the Nursing Activities Score in intensive care units: Nationwide prospective observational study in France. Intensive and Critical Care Nursing, vol. 87, p. 103866.	Prospective multicenter observational study	Nursing Activities Score
33	Li L., Zou X., Chen H. (2025) Workload in ICU nurses: A systematic review and meta-analysis of the Nursing Activities Score. Intensive and Critical Care Nursing, vol. 91, p. 104086.	Systematic review and meta-analysis	ICU nursing workload
34	Oliveira A.C., Garcia P.C., Nogueira L.S. (2016) Nursing workload and occurrence of adverse events in intensive care: A systematic review. Revista da Escola de Enfermagem da USP, vol. 50, pp. 683–694.	Systematic review	Workload and adverse events
35	Ross P. et al. (2023) Nursing workload and patient-focused outcomes in intensive care: A systematic review. Nursing and Health Sciences, vol. 25, no 4, pp. 497–515.	Systematic review	Workload and patient outcomes
36	Hessels A.J. et al. (2019) Impact of infectious exposures and outbreaks on nurse and infection preventionist workload. American Journal of Infection Control, vol. 47, no 6, pp. 623–627.	Observational workload study	Outbreak-related workload
37	Weldetinsae A. et al. (2023) Adherence to infection prevention and control measures and risk of exposure among healthcare workers: A cross-sectional study from the early period of the COVID-19 pandemic in Addis Ababa, Ethiopia. Health Science Reports, vol. 6, no 6, p. e1365.	Cross-sectional outbreak study	Adherence to infection-control measures
38	Li R.J. et al. (2023) A prospective surveillance study of healthcare-associated infections in an intensive care unit from a tertiary care teaching hospital from 2012–2019. Medicine, vol. 102, no 31, p. e34469.	Prospective surveillance study	ICU HAI epidemiology
39	Rosenthal V.D. et al. (2023) The impact of healthcare-associated infections on mortality in ICU: A prospective study in Asia, Africa, Eastern Europe, Latin America, and the Middle East. American Journal of Infection Control, vol. 51, no 6, pp. 675–682.	Prospective multicountry study	HAI and mortality

No.	Publication	Design/source type	Principal domain in this review
40	Odoom A., Donkor E.S. (2025) Prevalence of healthcare-acquired infections among adults in intensive care units: A systematic review and meta-analysis. Health Science Reports, vol. 8, no 7, p. e70939.	Systematic review and meta-analysis	ICU HAI prevalence
41	Blot S. et al. (2022) Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, prevention and contributions of new technologies. Intensive and Critical Care Nursing, vol. 70, p. 103227.	Narrative review	ICU HAI epidemiology and technology
42	Alhumaid S. et al. (2021) Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: A systematic review. Antimicrobial Resistance and Infection Control, vol. 10, no 1, p. 86.	Systematic review	Knowledge and compliance factors
43	Al-Qahtani L.A.S. et al. (2025) Enhancing healthcare worker safety: Effective infection control strategies in medical settings. TPM: Testing, Psychometrics, Methodology in Applied Psychology, vol. 32, no S1, pp. 895–904.	Practice-oriented review	Infection-control strategies
44	Elseesy N.A.M. et al. (2023) Compliance among registered nurses and doctors in critical care units: Challenges affecting their adherence to standard precautions. Healthcare, vol. 11, no 22, p. 2975.	Cross-sectional critical-care study	Standard-precaution compliance
45	Alharbi A.F. et al. (2024) Compliance with health security protocols among medical staff in intensive care units: A comprehensive analysis. Cultura: International Journal of Philosophy of Culture and Axiology, vol. 21, no 3s, pp. 164–181.	Observational/comprehensive analysis	ICU protocol compliance
46	Almenyan A.A., Albuduh A., Al-Abbas F. (2021) Effect of nursing workload in intensive care units. Cureus, vol. 13, no 1.	Narrative review	ICU nursing workload
47	Jansson M.M., Syrjälä H.P., Ala-Kokko T.I. (2019) Association of nurse staffing and nursing workload with ventilator-associated pneumonia and mortality: A prospective, single-center cohort study. Journal of Hospital Infection, vol. 101, no 3, pp. 257–263.	Prospective cohort study	Workload, staffing, VAP and mortality
48	Bianco A. et al. (2018) Prospective surveillance of healthcare-associated infections and patterns of antimicrobial resistance of pathogens in an Italian intensive care unit. Antimicrobial	Prospective surveillance study	HAI and antimicrobial resistance

No.	Publication	Design/source type	Principal domain in this review
	Resistance and Infection Control, vol. 7, no 1, p. 48.		
49	Chang L.Y. et al. (2019) The relationship between nursing workload, quality of care, and nursing payment in intensive care units. Journal of Nursing Research, vol. 27, no 1, p. e8.	Observational/economic study	Workload, quality and payment

Discussion

Principal findings

This review identifies a recurrent implementation gap in HAI prevention. Knowledge of infection-control principles is important, but knowledge scores alone do not describe the reliability of clinical practice. The gap is most visible when self-reported compliance is compared with direct observation and when task density increases. Educational interventions improve knowledge, yet their effects are less stable when training is not accompanied by supervision, feedback, accessible supplies, and realistic workload.

Workload and staffing emerged as central organizational factors. Their relevance was supported by surveys, direct observations, electronic monitoring, workload measures, staffing analyses, and reviews. The consistency across methods strengthens the conclusion that excessive task demand can reduce compliance. At the same time, most studies were observational, and workload is correlated with patient acuity and other organizational variables. The evidence therefore supports an association and a plausible mechanism rather than a simple, isolated causal effect.

Scientific contribution and interpretation

The contribution of this review lies in integrating cognitive and organizational evidence into a single implementation pathway. Existing studies often ask whether workers know infection-control requirements or whether workload is associated with outcomes. The combined analysis shows that these questions are interdependent. Knowledge defines what should be done; organizational capacity determines whether it can be done consistently; observed practice links both domains to patient outcomes.

This framework helps explain why apparently contradictory findings can coexist. A hospital may report high knowledge and low compliance because the limiting factor is organizational. Another may have adequate staffing but poor technique because cognitive readiness or local norms are weak. A third may improve after training because workload is manageable and supplies are available. The effect of any intervention therefore depends on the weakest part of the local implementation system.

The model also changes the interpretation of non-compliance. Some lapses reflect individual misunderstanding or unsafe habits and require education, competency assessment, or accountability. Others reflect workload, interruptions, or unavailable resources and require system redesign. Treating all deviations as individual failure risks producing repetitive training without correcting the conditions that make reliable performance difficult.

Implications for practice and management

Infection-prevention programs should combine educational and organizational measures. Education should be recurrent, profession-specific, and linked to observed practice rather than limited to attendance or post-test scores. Competency assessment should include correct hand hygiene technique, aseptic procedures, use of personal protective equipment, and device-care bundles. Immediate feedback is preferable to delayed aggregate reporting because it connects the observation to the clinical context.

Workload should be monitored with measures that reflect patient acuity and task intensity. Nurse-to-patient ratios alone may not capture the burden of admissions, deterioration,

isolation, or complex device care. The Nursing Activities Score and local workload indicators can support staffing decisions [31–33]. Units should examine whether infection-prevention tasks are disproportionately omitted during peak periods and whether supplies are positioned at the point of care.

Organizational support should include stable access to hand-rub products and protective equipment, clear local protocols, visible leadership, non-punitive reporting of system barriers, regular audit, and feedback. Data on HAI, device utilization, compliance, staffing, and missed care should be reviewed together. Separate dashboards may obscure the relationship between work conditions and safety outcomes.

For Kazakhstan, implementation research should accompany surveillance. Hospitals need local evidence on how staffing models, workload, training, resource availability, and safety culture affect adherence. Such data would allow infection-control strategies to move beyond general recommendations and address the specific constraints of individual units.

Strengths and limitations

A strength of the review is the joint analysis of cognitive readiness and organizational capacity. The inclusion of studies using different methods allowed comparison between self-reported knowledge, observed behavior, objective workload measures, staffing data, and clinical outcomes. The review also distinguishes between evidence of association and evidence of causation and provides a conceptual framework that can guide local assessment and intervention design.

The review has important limitations. It is a structured narrative review rather than a systematic review, and selection bias cannot be excluded. Searches were limited to PubMed and Google Scholar, which may have missed relevant nursing, organizational, psychological, or non-English literature indexed elsewhere. Google Scholar searches are less reproducible than searches in bibliographic databases. Only publications with assessable full text were included, which may have introduced availability bias.

The included publications differed substantially in design, populations, settings, definitions, and measurement instruments. Many studies were single-center and cross-sectional. Knowledge and compliance were frequently self-reported and may have been overestimated. Direct observation is more behaviorally informative but may itself alter practice. Formal risk-of-bias scoring was not applied across all designs, and the evidence was synthesized qualitatively. Primary studies and secondary reviews were considered together, creating a possibility of overlapping evidence; conclusions were therefore based on recurring patterns rather than counts of statistically independent datasets.

Organizational factors were not measured with equal depth. Workload and staffing were more commonly reported than leadership, safety culture, supply-chain reliability, workflow design, or team communication. Evidence from Kazakhstan and Central Asia was limited. These constraints reduce the precision and local generalizability of the conclusions and identify priorities for future research.

Conclusion

The prevention of healthcare-associated infections depends on both cognitive readiness and organizational capacity. Knowledge and training are necessary, but they do not reliably translate into practice when workload is excessive, staffing is insufficient, supplies are difficult to access, or organizational support is weak. Across diverse settings, higher workload and lower staffing were associated with missed preventive care, poorer adherence to standard precautions, and adverse patient outcomes.

Infection-control strategies should therefore combine recurrent competency-based education with workload monitoring, adequate staffing, point-of-care resources, audit and feedback, and visible safety leadership. The available evidence is heterogeneous and predominantly observational; conclusions should be interpreted as associations supported by a plausible implementation pathway. Prospective multicenter studies in Kazakhstan are needed to link validated measures of knowledge, observed practice, staffing, workload, and HAI outcomes.

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