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Effectiveness of Nursing Interventions in Preventing Postoperative Respiratory Depression

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ABSTRACT: Postoperative respiratory depression (PORD) is a serious and largely preventable complication that most often follows opioid administration and residual anesthetic effects. Because nurses provide the majority of direct patient surveillance after surgery, nursing interventions are central to preventing, detecting, and reversing this complication. This review synthesizes the available evidence on the effectiveness of nursing interventions in preventing postoperative respiratory depression and translates it into practical recommendations for clinical nursing practice. The evidence indicates that

respiratory depression is frequent, often unrecognized when monitoring is intermittent, and strongly associated with identifiable patient and treatment factors. Nursing interventions with the strongest support include risk-stratified monitoring, use of validated sedation scales before and after each opioid dose, continuous pulse oximetry with or without capnography in high-risk patients, and multidisciplinary respiratory care bundles. Evidence for isolated preoperative physiotherapy is weaker. Programs that combine screening, assessment, monitoring, and a clear escalation pathway show the most consistent benefit. Nursing interventions are effective when they are systematic, risk-based, and supported by institutional protocols. Standardized assessment tools, targeted use of continuous monitoring, and nurse-led education should be integrated into postoperative care pathways to reduce preventable harm.

Introduction

Respiratory depression is one of the most feared complications of the postoperative period. It is characterized by inadequate ventilation, leading to hypoxemia, hypercapnia, and, if unrecognized, hypoxic brain injury, cardiac arrest, or death. Analyses of closed malpractice claims show that opioid-induced respiratory depression after surgery has frequently resulted in death or permanent brain damage, and that most of these outcomes were considered preventable with better monitoring and response [1]. Opioids remain the cornerstone of postoperative analgesia, yet their respiratory effects are dose-dependent and highly variable between patients [2].

A particular concern is that many serious events occur after the patient has left the post-anesthesia care unit and is being cared for on a general ward, where nurse-to-patient ratios are lower and vital signs are typically checked at fixed intervals. Studies using naloxone administration as a marker of clinically significant respiratory depression have shown that a considerable proportion of events occur after the first postoperative hours and are linked to predictable risk factors [3]. Reviews of risk factors and failure to rescue emphasize that delayed recognition, rather than the absence of treatment options, is the main barrier to good outcomes [4].

The burden extends beyond individual harm. Large administrative database analyses have found that opioids and sedatives are associated with an increased risk of in-hospital cardiopulmonary arrest [5], and opioid-related adverse events are associated with longer hospital stays and higher costs [6]. In addition, prospective studies using continuous capnography and oximetry have revealed that episodes of respiratory depression on inpatient wards are far more common than are captured by routine spot checks [7]. Together, these findings place nurses at the center of prevention efforts, because nurses are the clinicians who assess sedation, respond to alarms, titrate analgesics under protocols, and escalate care.

Methods

This article is a narrative review. Evidence was drawn from closed claims analyses, prospective observational cohorts, before-and-after studies, controlled clinical trials, systematic reviews and meta-analyses, and clinical practice guidelines relevant to postoperative respiratory depression and nursing care. Priority was given to studies that evaluated nursing-delivered or nursing-dependent interventions, and to guidelines issued by professional societies. Two pain management guidelines were used as the organizing frame for analgesic and monitoring recommendations [8, 9]. Because the review is narrative rather than systematic, no formal quantitative pooling was undertaken, and conclusions about effectiveness are qualitative and graded by the design and consistency of the supporting studies.

Definition and Pathophysiology of Postoperative Respiratory Depression

Postoperative respiratory depression is generally defined as a reduction in ventilatory drive or effort that results in hypoventilation. Clinically it is recognized by a low respiratory rate, shallow breathing, oxygen desaturation, elevated end-tidal or arterial carbon dioxide, and a progressive decline in level of consciousness. No single numerical threshold is universally accepted, and published studies differ in the cut-offs they use, which complicates comparisons of incidence between settings [4].

The principal mechanism is the action of opioids on mu-opioid receptors in brainstem respiratory centers, which blunts the response to rising carbon dioxide and reduces respiratory rate and tidal volume. This effect is additive with sedatives, residual

inhalational or intravenous anesthetics, and neuromuscular blockade that has not fully resolved [2]. Opioid-induced sedation typically precedes respiratory depression, which is the physiological basis for sedation scoring as an early-warning strategy [2, 4]. Upper airway collapse in patients with obstructive sleep apnea, pain-related splinting, and postoperative atelectasis further compromise gas exchange and shorten the time between the first signs of deterioration and critical hypoxemia.

Epidemiology and Clinical Burden

Reported incidence varies widely, because definitions and monitoring methods differ. Studies relying on clinical detection tend to report low rates, while studies using continuous monitoring report much higher rates of physiological episodes, many of which are never noticed by staff [3, 7]. In a large international prospective study of patients receiving parenteral opioids on general care floors, nearly half of monitored patients experienced at least one episode of respiratory depression detected by continuous capnography and oximetry [7]. Claims data show that when events do progress to catastrophic harm, the majority happen in the first postoperative day and are judged to have been preventable [1].

The consequences include unplanned intensive care admission, prolonged hospitalization, increased costs, and cardiopulmonary arrest [5, 6]. The pattern across studies is consistent: the physiological event is common, the harmful outcome is uncommon but severe, and the interval between them is the window in which nursing surveillance and response can alter the outcome [1, 4].

Risk Factors Guiding Nursing Vigilance

Identifying high-risk patients allows nurses to allocate monitoring intensity rationally. Studies of naloxone use and of continuous monitoring cohorts converge on a set of patient, surgical, and medication factors [3, 4, 7]. These are summarized in Table 1.

Table 1. Major risk factors for postoperative respiratory depression and their nursing implications

Risk factor	Why it increases risk	Nursing implication	Refs
Older age	Reduced drug clearance, greater central nervous system sensitivity, lower physiological reserve	Lower threshold for escalating monitoring; reassess sedation more frequently	[4, 7]
Obstructive sleep apnea or sleep-disordered breathing	Upper airway collapse worsened by opioids and sedatives	Screen before surgery; apply continuous oximetry and non-supine positioning	[3, 4, 7]
Opioid-naive status	Greater sensitivity to standard doses	Start with conservative doses; monitor closely after first doses	[4, 7]
Cardiac disease, including heart failure	Pulmonary congestion and impaired compensation for hypoxemia	Monitor oxygen saturation and work of breathing; report early changes	[3, 7]
Co-administration of sedatives, gabapentinoids, or benzodiazepines	Additive depression of respiratory drive	Verify combined orders; avoid unnecessary stacking of sedating drugs	[2, 4]
Patient-controlled analgesia with basal infusion or dose stacking	Accumulation of opioid, particularly in renal impairment	Use bolus-only PCA when possible; check pump settings and cumulative dose	[2, 4]
Major surgery, particularly upper abdominal or thoracic procedures	Pain-related splinting, atelectasis, high opioid requirements	Prioritize multimodal analgesia and respiratory exercises	[3, 4]

Risk factor	Why it increases risk	Nursing implication	Refs
Renal or hepatic impairment	Accumulation of active opioid metabolites	Report reduced urine output or altered consciousness promptly	[2, 4]

An important point for nursing practice is that risk factors cluster. A patient who is older, has sleep apnea, and is receiving a combination of opioid and sedative drugs carries a risk far above that of any single factor, and the evidence supports reassessing risk at each handover rather than only at admission [4, 7].

Preoperative Nursing Interventions: Risk Screening and Patient Education

Screening for obstructive sleep apnea

Undiagnosed obstructive sleep apnea is a major modifiable contributor to postoperative respiratory events. Simple questionnaires administered by nurses at preoperative assessment can identify patients at elevated risk. The STOP questionnaire, which asks about snoring, tiredness, observed apnea, and high blood pressure, was validated as a brief screening tool for surgical populations and is easily administered within routine nursing admission [10]. Consensus guidelines on preoperative screening of adults with suspected or known sleep apnea recommend structured screening and communication of results to the perioperative team so that monitoring and analgesic plans can be adapted [11]. The American Society of Anesthesiologists practice guidelines for perioperative management of patients with sleep apnea likewise recommend minimizing systemic opioids where possible, using regional or non-opioid techniques, and extending continuous pulse oximetry monitoring in the postoperative period [12].

PATIENT AND FAMILY EDUCATION

Nurses can educate patients about the purpose of sedation and breathing assessments, the importance of reporting excessive drowsiness, and the reason why patients with sleep apnea should use their own positive airway pressure device after surgery when available. Education on pain-control expectations helps patients accept multimodal regimens that reduce opioid exposure. Family members, who are often present on wards at night, can be taught to notify staff when the patient is difficult to rouse or has pauses in breathing, extending the practical reach of surveillance. Although the effect of education alone has not been isolated in high-quality trials, it is a low-cost component of every effective bundle described in guidelines [11, 12].

Nursing Assessment of Sedation and Respiratory Status

Why sedation scoring matters

Sedation typically precedes clinically significant respiratory depression during opioid therapy, and for this reason professional pain management nursing guidelines advise that sedation level be assessed before each opioid dose and at defined intervals afterward, in addition to respiratory rate [9]. Respiratory rate alone is an insensitive indicator, since a patient may have an adequate rate but shallow breathing, or may be difficult to rouse with a normal rate. Use of a validated sedation scale gives nurses a shared, objective language and a trigger for action.

Commonly used scales

The Pasero Opioid-induced Sedation Scale was designed specifically for nurses assessing patients receiving opioids, with each level linked to a recommended action such as dose reduction or hold [13]. The Richmond Agitation-Sedation Scale was developed and validated in intensive care and is widely used because of its reliability across observers [14]. Comparative work evaluating selected sedation scales for reporting opioid-induced sedation has examined their practicality and agreement in the ward setting [15]. Table 2 compares the main features.

Table 2. Sedation scales used by nurses in postoperative opioid monitoring

Feature	Pasero Opioid-induced Sedation Scale (POSS)	Richmond Agitation-Sedation Scale (RASS)
Original purpose	Assessment of opioid-induced sedation on general wards	Sedation and agitation assessment in critically ill patients

Feature	Pasero Opioid-induced Sedation Scale (POSS)	Richmond Agitation-Sedation Scale (RASS)
Structure	Short ordinal scale from sleeping but easy to arouse to somnolent with minimal or no response	Ten-point scale from +4 (combative) to −5 (unarousable)
Built-in action guidance	Yes, with suggested interventions at each level	No, interpreted according to local protocol
Ease of use on wards	High; designed for rapid bedside use	Moderate; requires training on agitation and verbal or physical stimulation steps
Main strength	Direct link between score and opioid management	Strong reliability evidence across observers
Main limitation	Less validated outside opioid contexts	Less specific to opioid dosing decisions
Refs	[13, 15]	[14, 15]

The key message from the available evidence is that the specific scale is less important than consistent use, staff training, and a pre-defined response pathway. A score that is documented without a clear action threshold does not prevent harm [9, 15].

Respiratory assessment

Beyond sedation scoring, nursing assessment should include respiratory rate counted over a full minute, depth and pattern of breathing, use of accessory muscles, airway sounds suggesting obstruction, oxygen saturation, and signs of hypercapnia such as headache, flushing, or confusion. Observation during natural sleep is particularly valuable in patients with sleep apnea, because apneic pauses and desaturation often occur during sleep when staff are not at the bedside [4, 9].

Monitoring Strategies and Early Recognition

Continuous pulse oximetry

A before-and-after study in a surgical ward environment showed that introducing continuous pulse oximetry surveillance with a defined nurse response pathway reduced rescue events and intensive care unit transfers [16]. A controlled clinical trial on a medical-surgical unit also evaluated continuous monitoring and its effects on clinical outcomes and clinician responses [17]. These findings support the view that continuous monitoring is effective when it is linked to staff who can interpret and respond to alarms.

Capnography

Pulse oximetry detects hypoxemia but may lag behind hypoventilation, especially when the patient is receiving supplemental oxygen, because oxygen saturation can remain acceptable while carbon dioxide rises. Capnography detects changes in ventilation more directly. A systematic review and meta-analysis of continuous pulse oximetry and capnography monitoring for postoperative respiratory depression concluded that continuous monitoring improves detection of respiratory depression events, while noting that evidence of improved patient outcomes remained limited and that alarm management is a practical challenge [18]. The international prospective study of ward patients likewise demonstrated that combined capnography and oximetry capture many events missed by intermittent assessment and supported the development of a risk prediction score [7].

Alarm management

Continuous monitoring creates a risk of alarm fatigue. Nursing interventions to preserve effectiveness include individualized alarm limits, appropriate sensor placement and skin care, clear escalation rules, and routine review of false alarm sources. The evidence indicates that the value of monitoring depends on whether the technology is integrated into the nursing workflow rather than simply installed [16, 18]. Table 3 compares monitoring approaches.

Table 3. Monitoring approaches for early detection of postoperative respiratory depression

Approach	Strengths	Limitations	Suggested nursing use	Refs
Intermittent vital signs and sedation scoring	Low cost; applicable to all patients; sedation scores detect early change	Gaps between checks; may miss events during sleep	Baseline for all patients receiving opioids	[7, 9]
Continuous pulse oximetry	Detects desaturation; associated with fewer rescue events and ICU transfers when linked to response protocols	May lag behind hypoventilation with supplemental oxygen; false alarms	Moderate- and high-risk patients, especially sleep apnea	[12, 16, 17]
Continuous capnography	Detects hypoventilation earlier; identifies apnea and shallow breathing	Sensor tolerance, cost, and alarm burden	High-risk patients, PCA users, opioid-naive patients with risk clusters	[7, 18]
Combined oximetry and capnography	Most complete picture of oxygenation and ventilation	Highest alarm burden and resource requirement	Selected very high-risk patients in the first postoperative hours	[7, 18]

Multimodal Analgesia and Opioid Stewardship

The most direct way to reduce opioid-induced respiratory depression is to reduce opioid exposure. Multimodal strategies, introduced as a concept to improve surgical outcomes, combine drugs and techniques acting on different pain pathways so that smaller opioid doses are required [19]. Contemporary enhanced recovery guidelines recommend opioid-sparing multimodal analgesia as a standard component of perioperative care [20], and national pain guidelines endorse multimodal approaches including regional anesthesia and scheduled non-opioid agents [8].

Nurses contribute to opioid stewardship in several ways. They administer and document scheduled non-opioid analgesics on time, apply non-pharmacological measures such as positioning, cold therapy, and relaxation, and use pain and sedation assessment together to decide whether an as-needed opioid dose is appropriate. They also review combinations of sedating drugs and question orders that may place high-risk patients at excessive risk [8, 9]. In PCA, nurses verify programmed settings, ensure that only the patient activates the demand button, and apply additional monitoring when basal infusions or renal impairment are present [4, 9].

Evidence strength in this domain is moderate to strong for the effect of multimodal analgesia on opioid consumption, while direct evidence that nursing-led opioid stewardship alone reduces respiratory depression is mostly indirect and derives from guideline consensus and observational studies [8, 19, 20].

Positioning, Respiratory Care, and Early Mobilization

Positioning

Patients with sleep apnea or high sedation risk are advised to remain in a non-supine position, with the head of the bed elevated, as far as surgical constraints allow, to reduce upper airway obstruction [12]. Nurses implement and document positioning and help patients sustain it during sleep.

Respiratory care bundles

A multidisciplinary program known as I COUGH, which combines incentive spirometry, coughing and deep breathing, oral care, patient and family education, head-of-bed elevation, and early mobilization, was associated with significant reductions in postoperative pneumonia and unplanned intubation after implementation in a surgical population [21]. Although this program targeted pulmonary complications more broadly than opioid-induced respiratory depression, its elements maintain lung volume and airway clearance, and therefore reduce the likelihood that a sedated patient will progress to respiratory failure. Importantly, it relies on nurses to deliver and reinforce most of its components.

Preoperative physiotherapy

By contrast, a large pragmatic randomized controlled trial of preoperative physiotherapy before upper abdominal surgery did not demonstrate a reduction in postoperative pulmonary complications [22]. This suggests that single, short preoperative educational or exercise sessions may be insufficient, and that postoperative continuity of respiratory care and early mobilization, integrated into daily nursing routines, may be more important than a one-time intervention [21, 22].

Rescue and escalation

When respiratory depression is recognized, the immediate nursing response includes stimulating the patient, calling for help, supporting the airway, providing oxygen and ventilatory assistance as needed, holding further opioid or sedative doses, and administering naloxone according to protocol. Naloxone reverses opioid-induced respiratory depression effectively, but its short duration of action means that patients must be observed for recurrence, and cautious titration avoids abrupt reversal of analgesia and acute pain or hemodynamic stress [2, 3]. Rapid response systems and clear escalation criteria reduce delay and support the prevention of failure to rescue [4, 16].

Summary of Evidence for Nursing Interventions

Table 4 summarizes the interventions discussed and the overall strength of the supporting evidence as interpreted in this review.

Table 4. Summary of nursing interventions and strength of supporting evidence

Nursing intervention	Phase of care	Main supporting evidence	Overall strength of evidence	Refs
Preoperative screening for sleep apnea	Preoperative	Validated screening tool; society and ASA guidelines	Moderate	[10, 11, 12]
Risk-stratified monitoring plan	Preoperative and postoperative	Cohort and guideline evidence on risk factors	Moderate	[4, 7, 9]
Sedation scoring before and after opioid doses	Postoperative	Pain nursing guidelines; scale validation studies	Moderate (guideline-supported)	[9, 13, 14, 15]
Continuous pulse oximetry with response protocol	Postoperative ward	Before-and-after and controlled studies	Moderate	[16, 17]
Continuous capnography in high-risk patients	Postoperative ward	Prospective cohort; meta-analysis showing improved detection	Moderate for detection; limited for outcomes	[7, 18]
Multimodal opioid-sparing analgesia	Perioperative	Guidelines and enhanced recovery recommendations	Moderate to strong for opioid reduction	[8, 19, 20]
Non-supine positioning in sleep apnea	Postoperative	ASA guideline recommendations	Low to moderate (consensus)	[12]
Multidisciplinary respiratory care bundle (I COUGH)	Postoperative	Before-and-after implementation study	Moderate for pulmonary complications	[21]
Isolated preoperative physiotherapy	Preoperative	Randomized controlled trial with no significant benefit	Low for preventing complications	[22]

Nursing intervention	Phase of care	Main supporting evidence	Overall strength of evidence	Refs
Naloxone and escalation protocol	Rescue	Observational and review evidence	Strong clinical rationale; limited trials	[2, 3, 4]

Organizational and Educational Factors

The effectiveness of any nursing intervention depends on the system in which it is delivered. Studies of continuous surveillance emphasize that technology produces benefit when staff are trained, alarm thresholds are agreed, and a defined response team can attend rapidly [16, 17]. Pain management nursing guidelines recommend institutional policies that define who is at risk, what monitoring is required, how often assessment is performed, and what actions follow each sedation score [9]. Adequate staffing is a prerequisite, since monitoring that generates alarms or sedation scores cannot be effective if nurses lack time to respond [4, 16].

Nurse education is a further determinant. Competency programs that include practice with sedation scales, interpretation of capnography waveforms, naloxone administration, and communication tools for escalation promote consistency and confidence [9, 13, 18]. Auditing of documentation, feedback to units, and review of near-miss events create a learning cycle that sustains improvement beyond the initial implementation period [4, 21].

The evidence reviewed here supports a coherent view of how nursing practice can prevent postoperative respiratory depression. First, the problem is predictable: risk factors are well described, and they identify patients who deserve more intensive surveillance [3, 4, 7]. Second, the physiological process is detectable before harm occurs: sedation changes and episodes of hypoventilation or desaturation precede catastrophic events, and tools exist to detect them [7, 9, 18]. Third, detection must be linked to timely action. The benefit seen in studies of continuous oximetry surveillance appears to be largely a function of the nursing response pathway rather than the device itself [16, 17].

The findings also reveal important gaps. Many nursing interventions rest on guideline consensus and observational data rather than randomized trials, and studies of continuous capnography have more clearly demonstrated improved detection than improved patient outcomes [18]. The null result of the preoperative physiotherapy trial reminds clinicians that plausible interventions do not always translate into measurable benefit, and that effectiveness should be tested within real clinical workflows [22]. Furthermore, the relationship between alarm burden and nurse responsiveness is a practical concern that has not been fully resolved, and unit-level adaptation of alarm strategies is likely to be needed [16, 18].

A reasonable interpretation is that no single intervention is sufficient. Bundles that combine screening, structured assessment, risk-tiered monitoring, opioid-sparing analgesia, and rescue protocols address multiple points in the chain from drug administration to harm, and this layered approach is consistent with the recommendations of professional bodies [8, 9, 12, 20].

Implications for Nursing Practice

Based on the evidence, a risk-tiered framework can guide nurses in matching surveillance intensity to patient risk. Table 5 presents a practical model that can be adapted to local policy.

Table 5. Proposed risk-tiered nursing framework for preventing postoperative respiratory depression

Risk tier	Typical patient profile	Assessment	Monitoring	Additional nursing actions
Low	Younger adult, low opioid requirement, no sleep apnea, multimodal analgesia	Sedation score and respiratory rate before each opioid dose and at routine intervals [9]	Intermittent vital signs including oxygen saturation	Patient education; encourage early mobilization and incentive spirometry [21]
Moderate	Older age, one major risk factor, or combined opioid and sedative therapy	Sedation score at increased frequency after each dose, with	Continuous pulse oximetry during the early	Review sedating drug combinations; head-of-bed elevation; verify PCA settings [4, 12]

Risk tier	Typical patient profile	Assessment	Monitoring	Additional nursing actions
		documented action thresholds [9, 13]	postoperative period [16]	
High	Suspected or confirmed sleep apnea, multiple risk factors, PCA with high requirements, major thoracic or upper abdominal surgery	Sedation scoring and respiratory assessment including observation during sleep [9]	Continuous pulse oximetry with capnography where available [7, 18]	Non-supine position, own positive airway pressure device if applicable, strict opioid-sparing plan, early escalation and naloxone readiness [2, 12, 20]

Implementation should include staff training, clear policies for alarm response, and regular audit of outcomes such as naloxone use, rapid response calls, and unplanned intensive care transfers. Nurse leaders can use these indicators to demonstrate the effect of interventions and to identify units needing additional support [4, 16].

LIMITATIONS

Several limitations should be acknowledged. The review is narrative and does not use a systematic search, so selection bias is possible. The included studies vary in definitions of respiratory depression, patient populations, and monitoring technology, which prevents direct quantitative comparison. Most evidence on nursing interventions is derived from observational or before-and-after designs, and several guideline recommendations reflect expert consensus rather than randomized evidence [8, 9, 12]. Finally, the strength-of-evidence ratings in Table 4 represent the reviewer's qualitative judgment and should be interpreted accordingly.

Recommendations for Future Research

Future studies should evaluate nurse-led, risk-stratified monitoring pathways in randomized or stepped-wedge designs, with patient-centered outcomes such as rescue events, intensive care transfer, and mortality rather than detection alone. Research is also needed on alarm management strategies, on the cost-effectiveness of continuous capnography in different surgical populations, and on how education programs change nursing behavior and outcomes in low-resource settings. Studies comparing sedation scales head-to-head for prediction of respiratory depression would strengthen current guideline recommendations [15, 18].

CONCLUSION

Postoperative respiratory depression is a common physiological event with potentially devastating consequences, yet it is largely preventable. Nursing interventions are effective when they identify high-risk patients before surgery, assess sedation and respiration systematically, apply continuous monitoring where risk is highest, support opioid-sparing analgesia, deliver respiratory care bundles, and respond rapidly through clear escalation pathways. The evidence is strongest for integrated, protocol-driven approaches and weaker for isolated interventions. Healthcare organizations should therefore support nurses with training, staffing, equipment, and policy so that surveillance translates into timely action and improved patient safety [1, 9, 16, 21].

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