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Impact of Dialysis on Medication Pharmacokinetics

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This is to certify that the doctoral study by

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Executive Summary: Staff Education Project

Impact of Dialysis on Medication Pharmacokinetics

by

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Summary

This doctoral project was a staff education initiative to improve nurses' knowledge and comfort with dialysis-specific medication management. The project addressed a practice gap in which nurses at the clinical site had limited knowledge of medication administration for patients with end-stage renal disease. These patients have altered pharmacokinetics and high medication burden, which increases the risk of adverse drug events. Inappropriate management of medications during dialysis can lead to hypotension, ineffective treatment, and glucose instability, making this a critical nursing practice issue. The project answered the practice-focused question of whether a structured educational intervention would improve nurses' knowledge and comfort in implementing what they learned about managing medications for patients receiving hemodialysis. The ADDIE model was used to guide the project. All staff were invited to participate. The analysis involved comparing pre (N=23) and postintervention survey responses (N = 19) to assess changes in participants' knowledge and comfort. There was also an intent to implement learning question included on the posttest survey. Pre- and posttest average scores were 74.1% and 95.7%, respectively. Their comfort with the topic improved from 2.62 to 3.89. All participants reported intent to apply the new knowledge in patient care. Practice implications include positive social change for patients, staff, and the project site through improved knowledge that enhances nurses' critical thinking skills and confidence in administering medications to patients undergoing dialysis. These improvements may reduce medication-related errors, shorten the length of stay, and decrease morbidity and mortality in this vulnerable population. The project was developed using inclusive practices, and all staff were invited to participate.

Background

Patients with end-stage renal disease undergoing dialysis face highly complex medication regimens, and renal nurses often struggle to determine which medications are affected by the dialysis process and how to administer them safely. This practice gap is significant because hemodialysis alters drug clearance, increases the likelihood of medication removal, and elevates patients' risk for adverse drug events. Dialysis patients experience altered pharmacokinetics and substantial polypharmacy, averaging five to 14 medications and 17–25 doses per day, with frequent medication discrepancies that increase the risk of adverse drug events (Pai et al., 2020). Inappropriate timing or withholding of medications can lead to complications, such as intradialytic hypotension from mismanaged antihypertensives, ineffective antibiotic therapy due to dialytic removal, and glucose instability caused by changes in insulin clearance during dialysis (Arshad et al., 2021; Joint British Diabetes Societies, 2023). If left unaddressed, these issues may result in worsening infections, avoidable hypoglycemia or hyperglycemia, shortened dialysis sessions, higher hospitalization rates, and overall poorer patient outcomes. These risks highlight the need for improved nursing competency in dialysis-specific medication management to enhance patient safety and care quality (Pai et al., 2020).

I conducted this project to address this gap in knowledge and answer the following practice-focused question: Does structured educational intervention improve nurses' knowledge and comfort implementing what they learned about managing medications for patients receiving hemodialysis? The project was completed with registered nurses working on the renal and transplant inpatient unit of an inner-city

hospital, which was a population chosen due to their routine involvement in the care of patients undergoing hemodialysis. The purpose of this project was to enhance the renal nurses' competency in medication management during hemodialysis, reducing medication-related errors, and strengthening nursing decision-making to improve patient safety and outcomes.

Staff Education Project Development

To address this knowledge gap, I completed a literature review and created evidence-based education content. The analysis, design, development, implementation, and evaluation model provided the systematic framework for developing and executing this staff education project. Each phase guided the creation, dissemination, and assessment of an evidence-based intervention aimed at improving nurses' knowledge and comfort with dialysis-specific medication management.

During the analysis phase, I identified a practice gap regarding nurses' limited knowledge and inconsistent decision-making related to dialysis-specific medication administration. A needs assessment was conducted through informal staff discussions, review of unit-level medication-related errors and near misses, and clinical observations that revealed uncertainty regarding the management of antihypertensives, antibiotics, and insulin on dialysis days. This phase clarified the scope of the problem and established the educational priorities that informed the intervention's design.

In the design phase, I intentionally developed the structure and components of the educational intervention to address the identified learning needs. Evidence-based topics were selected, with a focus on pharmacokinetic changes during hemodialysis and the implications for high-risk medications. Assessment tools were also designed during this

phase, including a nine-item knowledge test, a 5-point Likert comfort scale, and a postintervention intent-to-use question. I chose instructional strategies to align with adult learning principles, prioritizing clarity, accessibility, and relevance to clinical practice. The decision to use a poster presentation (Appendix A) and laminated quick-reference cards (Appendix B) ensured that information would remain available at the point of care.

The development phase involved creating and refining all educational and assessment materials. I developed content for the poster and quick-reference cards using current literature, clinical guidelines, and consultation with nephrology and pharmacy experts to ensure accuracy and clinical relevance. The pre- and posteducation surveys (Appendix C and D) were formatted and reviewed for clarity before distribution. All materials were prepared to comply with organizational standards for staff education and were tailored to support rapid uptake in a high-acuity inpatient environment.

During the implementation phase, I delivered the educational intervention to registered nurses on the inpatient renal and transplant unit. Nurses completed the preeducation survey to establish baseline knowledge and comfort levels. Educational materials were disseminated through a poster displayed in a central staff area, laminated quick-reference cards placed in charge nurse binders and medication stations, and announcements posted on the hospital intranet. Following the education period, nurses completed the posteducation survey, which included identical knowledge and comfort items as well as an item measuring their intent to use the information in practice.

The evaluation phase was focused on determining the effectiveness of the intervention. I analyzed the pre- and postintervention survey results using descriptive statistics to measure changes in participants' knowledge, comfort, and intent to apply the

educational content. Findings demonstrated substantial improvements in both knowledge and self-reported comfort, with all participants indicating their intention to incorporate the information into clinical practice. I also reviewed staff feedback to assess the accessibility and usefulness of the educational tools. These results informed the project's conclusions and my recommendations for sustaining and integrating dialysis-specific medication education into annual competencies and orientation programs.

Prior to the intervention, nurses completed a preeducational survey measuring their knowledge and comfort with medication considerations specific to dialysis. Following the baseline assessment, educational materials were delivered through an evidence-based poster presentation and laminated quick-reference cards placed in the charge nurse book and at each medication station to ensure ongoing accessibility. Updates, rollout dates, and opportunities for staff to ask questions were communicated through the hospital's intraweb, the central platform used for staff education and organizational announcements. After the educational phase, a postintervention survey containing the same items as the preintervention survey was disseminated to evaluate changes in knowledge and comfort. An additional intent question was added to the postintervention survey. Evidence collection consisted of comparing pre- and postintervention survey responses to determine whether the intervention improved nurses' understanding of medication management on dialysis days. Data analysis involved reviewing shifts in participants' self-reported comfort levels and identifying areas of improved clarity or persistent uncertainty. The evaluation process focused on measuring the effectiveness of the educational tools in increasing nurse comfort. In addition, quick-reference materials were provided to assist with utilization after the

education. These materials likely led to the result of 100% of the participants reporting their intent to use the information learned in practice (see Aghabarary et al., 2025; Al Nazly & Al Khatib, 2021; Wei et al., 2024).

Results

Twenty-one registered nurses completed the preintervention survey, and 18 nurses completed the postintervention survey following implementation of the structured educational intervention. Data analysis demonstrated improvements in nurses' knowledge and self-reported comfort related to dialysis-specific medication management. One hundred percent of the participants stated their intent to utilize the knowledge obtained when providing future patient care. Baseline data reflected limited to moderate comfort with dialysis-related medication considerations, with most participants reporting comfort levels of "moderately comfortable" or lower. Following the intervention, posttest results demonstrated a shift toward higher comfort with the majority of participants reporting being "comfortable" or "very comfortable" in managing medications for patients receiving hemodialysis. No participants reported low comfort levels after the intervention.

Participant knowledge outcomes improved across most survey items. Postintervention results showed higher rates of correct responses on questions related to antihypertensives, antibiotics, and insulin. The most substantial improvement was observed in Question 5, which increased from four correct responses at baseline to 16 correct responses postintervention, indicating improved understanding of high-risk medication management during dialysis. All postintervention participants (100%) reported their intent to incorporate the educational content into clinical practice,

reflecting strong perceived relevance and usability of the intervention. Additionally, qualitative staff feedback supported the value of the laminated quick-reference tools as accessible point-of-care resources.

At the organizational level, the intervention supported more consistent medication-related decision-making and improved unit-based standardization of dialysis-specific medication guidance. Project limitations included a small sample size, implementation at a single site, and reliance on self-reported measures rather than direct observation or patient-level outcomes. The reduced number of posttest respondents may have introduced response bias. Despite these limitations, the project demonstrates that brief, structured, and low-cost educational interventions can effectively enhance nursing knowledge and comfort. These findings have implications beyond the local setting by supporting the broader adoption of scalable, evidence-informed educational strategies to improve medication safety for patients receiving hemodialysis.

Conclusions

Implementing this educational project has the potential to significantly improve organizational outcomes by enhancing medication safety and reducing adverse events among patients receiving dialysis, ultimately supporting higher-quality care and more efficient resource use. By increasing nurses' comfort and knowledge of how dialysis alters the pharmacokinetics of key medications, the project strengthens clinical decision-making, reduces practice variability, and promotes greater consistency in medication administration across the renal and transplant care unit. Further recommendations include reinforcing the educational content through annual competency validation, integrating dialysis-specific medication considerations into nursing orientation and continuing

education, and ensuring sustained access to point-of-care reference materials. Expanding interdisciplinary collaboration with pharmacy services may also optimize medication timing and individualized patient counseling on dialysis days. The implications for nursing practice include improved patient safety, enhanced professional autonomy, and greater accountability in managing complex medication regimens (see Aghabarary et al., 2025; Osuchukwu et al., 2024). Beyond clinical outcomes, this project contributes to positive social change by promoting equitable and culturally responsive care for a medically vulnerable and socioeconomically diverse population, aligning with principles of diversity, equity, and inclusion (see Aryal et al., 2024; Walker et al., 2023). Strengthening nurse education in this area also helps reduce kidney health disparities, fosters trust between patients and healthcare providers, and supports more person-centered chronic disease management (see Rhee et al., 2022).

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Appendix A: Poster Presentation

Medication on Dialysis

How Hemodialysis Alters Pharmacokinetics and Impacts Nursing Care

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Insulin and Hemodialysis

Pharmacokinetics (PK):

- Renal Clearance: 30- 80% of insulin is normally cleared by the kidneys.
- In CKD/ESRD: Reduced clearance → higher circulating insulin levels
- Risk: increased risk of hypoglycemia, especially in patients with advanced kidney disease.

Dialysis Effect:

- Removal: Some insulin may be removed during hemodialysis.
- Sensitivity: Insulin sensitivity often "improves after dialysis" due to removal of uremic toxins and correction of acidosis.
- Implication: Patients may require lower doses on dialysis days compared to non-dialysis days.

Nursing Tips:

- Glucose Monitoring: Check blood glucose before, during, and after dialysis.
- Meal Timing: Ensure the patient has eaten prior to dialysis to reduce hypoglycemia risk.

- Clinical Judgment:

- If pre-dialysis glucose is low → contact the provider for possible dose adjustment.
- Consider holding insulin if the patient is not eating or glucose is borderline.
- Patient Safety: Educate patients to recognize **hypoglycemia symptoms** (shakiness, sweating, confusion, dizziness).

Examples of Insulin Preparations:
Rapid-Acting: Lispro, Aspart, Glulisine
Basal (Long-Acting): Glargine, Detemir, Degludec

Antihypertensives

Dialyzable Agents (Removed by HD):

Examples: **Atenolol, Lisinopril, Metoprolol tartrate, Hydralazine, Enalapril**

- Issue: ***Can be cleared during dialysis,*** leading to decreased drug levels.
- Clinical Impact: May cause ***post-dialysis rebound hypertension*** or inadequate BP control.

Non-Dialyzable / Preferred Agents:

Examples: **Amlodipine, Nifedipine XL, Carvedilol, Clonidine, Losartan**

- Benefit: ***Not significantly removed*** by dialysis.
- Advantage: Provide stable, sustained BP management across dialysis and non-dialysis days.

Nursing Tips:
Pre-HD: Check BP & med timing
During: Monitor for hypotension
Post-HD: Recheck BP → watch for spikes
Educate: Avoid dialyzable meds before HD; stress adherence to long-acting agents
Communicate: Report persistent BP swings → med changes may be needed

Clinical Case Example

Patient on atenolol had a post-dialysis BP spike
Cause: Atenolol was removed during dialysis, reducing its effect.
Intervention: Provider switched to non-dialyzable agent (e.g., carvedilol) → BP control improved.

Antibiotics & Hemodialysis

Key Point: Many antibiotics are dialyzable → may need dose adjustment or supplemental post-HD dosing

Examples:
- **Vancomycin:** Dialyzable → give after HD or adjust dose
- **Gentamicin / Tobramycin:** Highly dialyzable → monitor drug levels closely
- **Cefazolin / Ceftriaxone / Cefepime:** Partially removed → may require adjustment
- **Levofloxacin / Ciprofloxacin:** Minimally dialyzable → usually standard dosing (monitor renal function)

Nursing Tips:
•Always verify if an antibiotic is **dialyzable**
•Confirm **timing with dialysis** (pre vs. post)
•Monitor **drug levels** when applicable (esp. vancomycin, aminoglycosides)
Clinical Pearl: Dialyzability influenced by **water solubility, protein binding, and volume of distribution**

Anticoagulants & Hemodialysis

Warfarin: Not removed by dialysis → monitor International Normalized Ratio (INR)
Heparins: Unfractionated heparin is used during dialysis; low molecular weight heparins can accumulate in kidney failure
Direct Oral Anticoagulants
:Dabigatran → dialyzable; may need timing adjustment
Apixaban → preferred option in dialysis; not removed
Rivaroxaban → minimally removed
Antiplatelet Agents: Aspirin, Clopidogrel, Ticagrelor (not removed; increased bleeding risk)
Case: Patient on dabigatran developed a gastrointestinal bleed → dialysis lowered drug level

Appendix B: Hemodialysis & Medications: Quick Reference

Hemodialysis & Medications: Quick Reference

Insulin

- **Normal PK**: 30–80% cleared by kidneys
- **In kidney failure**: ↓ clearance → prolonged action → ↑ hypoglycemia risk
- **During dialysis**: Some insulin removed; improved insulin sensitivity
- **Nursing Note**:
    - Monitor glucose **before, during, and after dialysis**
    - **Lower doses** are often needed on dialysis days

Examples (common in ESRD patients):

- *Rapid-acting*: Lispro (Humalog), Aspart (NovoLog), Glulisine (Apidra)
- *Basal*: Glargine (Lantus, Basaglar), Detemir (Levemir), Degludec (Tresiba)
- *Premixed*: Humalog Mix 75/25, NovoLog Mix 70/30

⚠ *Case*: Recurrent hypoglycemia on dialysis days = reduced clearance + ↑ sensitivity

Antibiotics

Many antibiotics are dialyzable, requiring dose adjustment or supplemental post-dialysis doses. Timing is crucial

- **Vancomycin. Dialyzable: often given after dialysis or dose adjustment**
- **Gentamicin/Tobramycin; Highly dialysable, monitor levels closely**
- **Cefazolin//Cefepime: Partial removal, dose adjustment**

Antihypertensives

- **Dialyzable (removed by dialysis):**
    - Atenolol (β-blocker)
    - Lisinopril (ACE inhibitor)
    - Metoprolol tartrate (short-acting β-blocker)
    - Hydralazine (vasodilator)
    - Enalapril (ACE inhibitor)
- **Not dialyzable (preferred):**
    - Amlodipine (calcium channel blocker)

- Nifedipine XL (calcium channel blocker)
- Carvedilol (β-blocker)
- Clonidine (α2-agonist)
- Losartan (ARB – minimally removed)

- **Nursing Note**:
  - Avoid giving dialyzable meds **before dialysis**
  - Prefer long-acting, non-dialyzable agents for BP control

⚠️ *Case*: Post-dialysis BP spike on atenolol = drug removed during treatment

💉 Anticoagulants

- **Warfarin**: Not removed → monitor INR closely
- **Heparins**:
  - UFH (unfractionated heparin): used during dialysis
  - LMWH (enoxaparin, dalteparin): accumulates in renal failure → ↑ bleeding risk
- **DOACs (Direct Oral Anticoagulants):**
  - Dabigatran (Pradaxa): removed by dialysis
  - Apixaban (Eliquis): preferred in dialysis, not removed
  - Rivaroxaban (Xarelto): minimally removed
  - Edoxaban (Savaysa): generally avoided in dialysis
- **Antiplatelets (not removed by dialysis, but ↑ bleeding risk):**
  - Aspirin
  - Clopidogrel (Plavix)
  - Ticagrelor (Brilinta)

⚠️ *Case*: Dabigatran + GI bleed → dialysis lowers drug level (dialyzable)

Appendix C: Hemodialysis & Medications Knowledge Survey: Posttest

Instructions: Circle the best answer for each question. For question 10, circle the number that best reflects your comfort level.

On a scale of 1–5, how comfortable do you feel in your knowledge of how dialysis impacts medication pharmacokinetics?

- ○ 1 – Not comfortable at all
- ○ 2 – Slightly comfortable
- ○ 3 – Moderately comfortable
- ○ 4 – Comfortable
- ○ 5 – Very comfortable

Knowledge Questions (1–9)

1. Which statement about insulin in ESRD patients is TRUE?
   - ○ A. Insulin clearance is increased in kidney failure
   - ○ B. Insulin is not affected by dialysis
   - ○ C. Insulin clearance is reduced, increasing hypoglycemia risk
   - ○ D. No dose adjustments are needed on dialysis days

2. Which of the following insulin types is basal?
   - ○ A. Lispro
   - ○ B. Aspart
   - ○ C. Glargine
   - ○ D. Glulisine

3. A 65-year-old patient takes atenolol before dialysis. What is the expected effect after dialysis?
   - ○ A. BP remains the same
   - ○ B. BP may increase because atenolol is removed
   - ○ C. BP decreases dramatically
   - ○ D. Atenolol is not affected by dialysis

4. Which antihypertensive is generally NOT removed by dialysis?
   - ○ A. Lisinopril
   - ○ B. Metoprolol tartrate
   - ○ C. Amlodipine
   - ○ D. Atenolol

5. Which anticoagulant is dialyzable and may require timing adjustments around dialysis?
   - ○ A. Warfarin
   - ○ B. Apixaban
   - ○ C. Dabigatran
   - ○ D. Aspirin

6. Low-molecular-weight heparin (LMWH) in ESRD patients:
○ A. Is safe without dose adjustment
○ B. Accumulates and may increase bleeding risk
○ C. Is removed entirely by dialysis
○ D. Does not require monitoring

7. Which of the following antibiotics is commonly dialyzable?
○ A. Vancomycin
○ B. Gentamicin
○ C. Cefazolin
○ D. All of the above

8. For phosphate binders in dialysis patients:
○ A. They are removed during dialysis
○ B. Timing with meals is important
○ C. Dose should always be given after dialysis
○ D. They have no effect on phosphate levels

9. Which factor MOST influences whether a drug is removed by dialysis?
○ A. Route of administration
○ B. Water solubility, protein binding, and volume of distribution
○ C. Cost of the medication
○ D. Patient's age only

After attending this education, do you intend to communicate more proactively and confidently with nephrologists or other providers about medication adjustments for patients receiving hemodialysis?

Yes
No
Maybe

Appendix D: Hemodialysis & Medications Knowledge Survey: Pretest

ANSWERS HIGHLIGHTED

Hemodialysis & Medications Knowledge Survey: Pre-Test

Instructions: Circle the best answer for each question. For question 10, circle the number that best reflects your comfort level.

PRE EDUCATION COMFORT QUESTION

On a scale of 1–5, how comfortable do you feel in your knowledge of how dialysis impacts medication pharmacokinetics?

- 1 – Not comfortable at all
- 2 – Slightly comfortable
- 3 – Moderately comfortable
- 4 – Comfortable
- 5 – Very comfortable

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