Adverse drug reactions associated with commonly prescribed medications: mechanisms, risk factors, clinical manifestations and management strategies

Amit Chawla[*1], Nadeem[2], Anil Kumar Soni[3], Dinesh Kumar Kasnia[4], Pyare Lal Bhaskar[5]

*[*1]Professor Cum Principal, Faculty of Pharmacy, Tantia University, Sri Ganganagar, Rajasthan, India*

[2]Research Scholar, Department of Public Health, St. Francis College, Brooklyn, New York, United States of America

[3]Associate Professor, Faculty of Science, Dept of Zoology, Tantia University Sri Ganganagar, Rajasthan, India

[4]Assistant Professor, Faculty of Pharmacy, Tantia University, Sri Ganganagar, Rajasthan, India

[5]Principal, Shekhawati Institute of Pharmacy, Rajasthan University of Health Science, Sikar, Rajasthan, India

DOI: 10.5281/zenodo.23880307

Abstract:

Adverse drug reactions (ADRs) are unintended and harmful responses to medicines used at normally recommended doses. They range from mild, self-limiting symptoms to severe events involving organ failure, disability or death. Although modern medicines provide substantial benefits, their safety depends on appropriate selection, prescribing, dispensing, administration, monitoring and patient participation. This narrative review summarises the principal mechanisms of ADRs, common classification systems, patient- and treatment-related risk factors, clinical manifestations associated with widely prescribed medication groups, and practical strategies for assessment, management and prevention. Predictable reactions commonly result from the known pharmacological action of a medicine or excessive exposure, whereas unpredictable reactions may involve immune hypersensitivity, reactive metabolites, mitochondrial injury or other idiosyncratic processes. Risk increases with polypharmacy, multimorbidity, older age, impaired renal or hepatic function, pregnancy, genetic variation, previous drug reactions and fragmented medication records. Clinical assessment requires a complete medication history, a plausible time relationship, evaluation of alternative causes, appropriate laboratory or imaging investigations, and structured causality assessment. Management prioritises stabilisation, withdrawal or dose adjustment of the suspected agent when clinically appropriate, treatment of the affected organ system, documentation and reporting. Prevention relies on medication reconciliation, individualised prescribing, targeted monitoring, patient education, interprofessional communication and pharmacovigilance. ADRs cannot be eliminated completely, but coordinated safety practices can reduce avoidable harm and improve the benefit-risk balance of commonly prescribed medicines.

Keywords:

Adverse drug reaction; pharmacovigilance; medication safety; drug interactions; polypharmacy; patient monitoring; preventable harm.

1. Introduction:

Medicines are central to the prevention and treatment of acute and chronic illness, but every pharmacological intervention carries a possibility of harm. An adverse drug reaction is generally understood as a noxious and unintended response occurring at doses normally used for prevention, diagnosis or treatment. The term is narrower than adverse drug event, which may also include harm caused by medication errors, overdose, misuse or exposure during inappropriate use. Edwards and Aronson (2000) emphasised that an ADR is clinically

important when it predicts risk on future exposure and may require treatment, dose modification or withdrawal of the medicine.

The burden is clinically meaningful across inpatient and outpatient settings. A meta-analysis of prospective hospital studies found that serious and fatal ADRs contribute to hospital morbidity, although estimates differ according to study design, definitions and surveillance methods (Lazarou et al., 1998). In a prospective UK study of 18,820 admissions, Pirmohamed et al. (2004) identified ADRs as an important cause of hospital admission, with many reactions judged potentially avoidable. Medication-related harm is not restricted to rare or newly marketed agents: widely used anticoagulants, glucose-lowering medicines, analgesics, antibiotics and cardiovascular drugs can all cause clinically significant reactions.

The increasing use of multiple medicines, longer life expectancy and treatment of multimorbidity make medication safety a shared responsibility. The World Health Organization (WHO) has highlighted polypharmacy, transitions of care and high-risk situations as priorities for reducing avoidable medication-related harm (World Health Organization, 2017; World Health Organization, 2019). The purpose of this review is to provide an integrated clinical overview that can support rational prescribing, early recognition and safer management.

Review approach and scope:

This is a narrative review synthesising foundational ADR literature, peer-reviewed clinical studies, professional guidance and official pharmacovigilance resources. The discussion focuses on medicines commonly encountered in general practice and hospital care, including non-steroidal anti-inflammatory drugs (NSAIDs), anticoagulants, antidiabetic agents, antihypertensives, antimicrobials, lipid-lowering medicines, opioids, psychotropic medicines and systemic corticosteroids. It is not a systematic review or a drug-by-drug prescribing guideline. Individual product information, local formularies and current national recommendations should be consulted for medicine-specific decisions.

2. Definitions and classification of adverse drug reactions:

2.1. Adverse event, adverse drug reaction and medication error:

An adverse event is an untoward medical occurrence following exposure to a medicine, whether or not the medicine caused it. An ADR implies a suspected or established causal relationship and occurs at a dose normally used. A medication error is a preventable event that may lead to inappropriate medication use or harm while the medicine is under the control of a healthcare professional, patient or consumer. An error may occur without injury; conversely, an ADR may occur despite correct prescribing and administration. This distinction matters because the investigation and prevention strategy differs: an ADR may require pharmacological risk assessment, while an error also requires analysis of the process that allowed it to occur (Edwards and Aronson, 2000; World Health Organization, 2002).

2.2. Type A to Type F classification:

The traditional Type A and Type B classification remains useful at the bedside. Type A (augmented) reactions are dose-related, predictable from the pharmacology of the medicine and often more frequent. Examples include hypoglycaemia with insulin, bleeding with anticoagulants, and hypotension with antihypertensives and gastric injury with NSAIDs. They may often be reduced by dose adjustment, monitoring or avoidance of interacting medicines. Type B (bizarre) reactions are generally unpredictable, less clearly dose-related and may involve immune or idiosyncratic mechanisms, such as anaphylaxis or severe cutaneous reactions. They are less common but can be life-threatening.

The expanded Type A–F framework describes additional patterns: Type C (chronic) reactions are associated with prolonged use or cumulative exposure; Type D (delayed) reactions become apparent after a delay; Type E (end-of-use) reactions follow withdrawal; and Type F (failure) refers to unexpected failure of therapy, sometimes because of interactions, resistance, poor absorption or non-adherence. These categories are descriptive rather than mutually exclusive, and a reaction may have more than one contributing mechanism (Edwards and Aronson, 2000).

2.3. Severity, seriousness and preventability:

Severity describes the intensity of the clinical symptoms, often graded as mild, moderate or severe. Seriousness is a regulatory concept based on the outcome or required intervention. A reaction is generally considered serious if it results in death, is life-threatening, requires or prolongs hospitalisation, causes persistent or significant disability, produces a congenital anomaly, or is otherwise medically important. A severe symptom

is not automatically a serious adverse reaction, and a reaction with initially modest symptoms may be serious if it signals a life-threatening condition. Preventability is a separate dimension: a reaction may be preventable when safer prescribing, suitable dose adjustment, monitoring, counselling or follow-up could reasonably have avoided it (Schumock and Thornton, 1992; Hakkarainen et al., 2012).

3. Mechanisms underlying adverse drug reactions:

3.1. Dose-related pharmacological effects:

Most predictable ADRs arise when the intended pharmacological action becomes excessive in a particular patient or at a particular exposure. Excess anticoagulation may cause bleeding; excessive insulin or sulfonylurea activity may cause hypoglycaemia; opioids may suppress respiratory drive; and antihypertensive medicines may cause symptomatic hypotension. The reaction may reflect an excessive dose, reduced clearance, increased sensitivity at the receptor or organ level, or a drug interaction. The same dose can therefore be safe for one patient and harmful for another.

3.2. Altered pharmacokinetics and drug exposure:

Pharmacokinetic mechanisms involve absorption, distribution, metabolism or elimination. Reduced kidney function can cause accumulation of renally cleared medicines or active metabolites, increasing toxicity. Hepatic impairment may reduce metabolism, alter protein binding or impair biliary elimination. Changes in gastric pH, intestinal motility, food intake and absorption can modify exposure. Enzyme inhibition may raise concentrations of a substrate medicine, whereas enzyme induction may reduce concentrations and contribute to treatment failure. Interactions can also occur through transporters, protein binding, renal tubular secretion and additive pharmacodynamic effects.

3.3. Immune-mediated hypersensitivity:

Immune-mediated reactions occur when a drug or drug-protein complex triggers an immune response. Immediate reactions may involve immunoglobulin E and mast-cell mediator release, producing urticaria, angioedema, bronchospasm and anaphylaxis. Other reactions are delayed and may be mediated by T cells, producing maculopapular eruptions, drug reaction with eosinophilia and systemic symptoms (DRESS), or severe cutaneous adverse reactions such as Stevens–Johnson syndrome and toxic epidermal necrolysis. A previous reaction, cross-reactivity within selected drug groups and the timing of exposure can inform risk, but allergy labels should be clinically reviewed rather than assumed to be accurate.

3.4. Idiosyncratic and organ-specific injury:

Idiosyncratic ADRs are not readily predicted from the usual pharmacological action and may depend on genetic susceptibility, reactive metabolites, immune activation, mitochondrial dysfunction or interactions between host and environmental factors. Drug-induced liver injury (DILI), for example, may present with hepatocellular, cholestatic or mixed biochemical patterns. Some medicines cause predictable injury at high exposure, while others produce rare and unpredictable injury at therapeutic doses. Evaluation requires a careful chronology, exclusion of competing causes and attention to all prescription, non-prescription, herbal and dietary products (Andrade et al., 2019; Fontana et al., 2023).

3.5. Pharmacogenetic susceptibility:

Inherited variation in drug-metabolising enzymes, transporters, receptors and immune-related genes can alter efficacy or toxicity. Examples include variation in CYP enzymes affecting exposure, HLA alleles associated with selected severe cutaneous reactions, and TPMT or NUDT15 variants influencing thiopurine-related myelosuppression. Pharmacogenomic testing is most useful when a validated gene–drug association has a clear prescribing action and the result is available before treatment. It does not replace clinical monitoring because age, organ function, interactions and adherence remain important determinants of response (Relling and Evans, 2015).

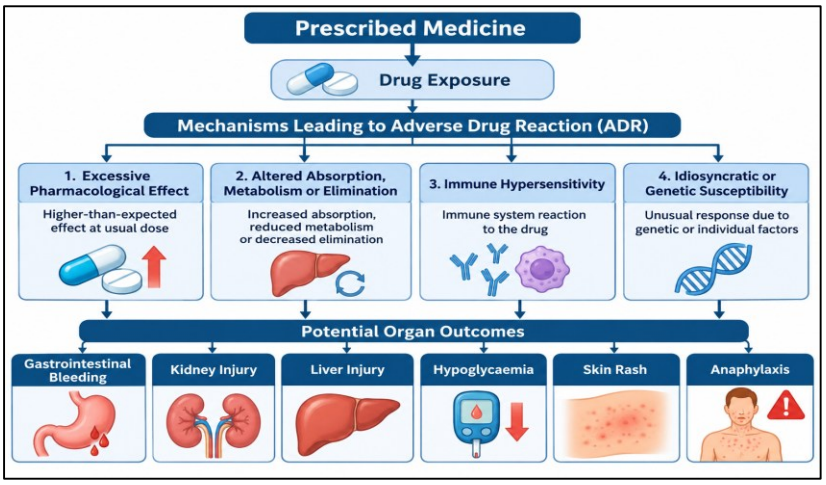


Figure. 1: Mechanisms of Adverse Drug Reactions (ADRs) and Their Potential Organ Effects

4. Risk factors for adverse drug reactions:

ADRs usually arise from an interaction between the medicine, the patient and the healthcare system. Identifying risk factors before and during treatment allows monitoring to be targeted rather than applied uniformly to every patient.

4.1. Patient-related factors:

Older adults are at increased risk because ageing may reduce renal and hepatic clearance, alter body composition, increase pharmacodynamic sensitivity and coexist with frailty, falls and multiple chronic illnesses. The number of medicines and the presence of potentially inappropriate combinations are especially important. A systematic review of older adults in acute-care settings identified ADRs as a substantial clinical concern and described multiple contributing risk factors (Alhawassi et al., 2014). The 2023 American Geriatrics Society Beers Criteria provide a structured aid for identifying medicines that may be inappropriate or require caution in adults aged 65 years and older; they support, rather than replace, individual clinical judgement (American Geriatrics Society 2023 Beers Criteria Update Expert Panel, 2023).

Renal or hepatic impairment can substantially change medicine exposure. Other relevant conditions include heart failure, diabetes, electrolyte disturbances, dehydration, malnutrition, cognitive impairment and a history of falls. Pregnancy and breastfeeding require attention to gestational timing, placental transfer, fetal development and infant exposure. Previous ADRs, documented allergies and family history may also influence selection. Children require weight- and age-appropriate dosing because organ maturation and body composition change rapidly during development.

4.2. Medicine- and treatment-related factors:

Polypharmacy increases the possibility of drug–drug interactions, duplicate therapy, complex schedules and adherence difficulties. Risk is not determined by medicine count alone: the combination, dose, duration, and therapeutic index and patient characteristics matter. High-risk medicines include anticoagulants, insulin and other glucose-lowering agents, opioids, selected sedatives, immunosuppressants and medicines requiring concentration or laboratory monitoring. Rapid dose escalation, prolonged treatment, high cumulative exposure, multiple prescribers and use of over-the-counter or complementary products may add risk. The WHO recommends person-centred medication review and coordinated management in polypharmacy (World Health Organization, 2019b).

4.3. Healthcare-system and behavioural factors:

Incomplete medication histories, poor transfer of information, unclear prescriptions, look-alike or sound-alike product names, inadequate counselling, and limited follow-up and insufficient laboratory monitoring can contribute to medication-related harm. Patients may unintentionally take duplicate ingredients in combination products or use medicines differently from the instructions because of cost, literacy, beliefs or adverse symptoms. Use of herbal products and dietary supplements should be asked about respectfully and documented with the same care as prescription medicines. Transitions between community care, emergency departments, hospitals and long-term care are particularly vulnerable to discrepancies (World Health Organization, 2019c).

4.4. Commonly prescribed medication groups and representative adverse reactions:

The following table summarises selected, clinically important reactions. It is not an exhaustive list, and risks vary with the individual agent, dose, duration, comorbidity and co-prescribed medicines. A possible association should prompt assessment rather than automatic discontinuation of an essential treatment.

Table. 1: Commonly prescribed medication groups and representative adverse reactions

Medication group	Representative adverse reactions	Practical safety considerations
NSAIDs (e.g., ibuprofen, diclofenac, naproxen)	Dyspepsia, peptic ulceration and gastrointestinal bleeding; fluid retention, worsening blood pressure, acute kidney injury and cardiovascular risk in susceptible patients.	Assess GI, renal and cardiovascular risk; use the lowest effective dose for the shortest appropriate duration; consider gastroprotection when indicated.
Anticoagulants and antiplatelets	Bleeding, bruising, gastrointestinal or intracranial haemorrhage; warfarin interactions and excessive anticoagulation.	Review indication, dose, renal function and interactions; monitor INR for warfarin; counsel on bleeding signs and adherence.
Insulin and sulfonylureas	Hypoglycaemia, confusion, sweating, tremor, seizures or loss of consciousness; weight gain may occur with some agents.	Individualise targets and doses; coordinate meals and activity; teach glucose monitoring and hypoglycaemia response.
Antihypertensives and diuretics	Dizziness, postural hypotension, bradycardia, electrolyte disturbance, kidney function changes; ACE inhibitors may cause cough or angioedema.	Check blood pressure, pulse, renal function and electrolytes after initiation or dose changes; review symptoms and combinations.
Antibiotics and other antimicrobials	Rash, immediate allergy, diarrhoea, antibiotic-associated colitis, QT prolongation or agent-specific renal, hepatic, auditory or neurological toxicity.	Confirm indication, allergy history, dose and duration; adjust for renal function; assess severe rash, breathing difficulty or persistent diarrhoea urgently.
Statins and other lipid-lowering medicines	Myalgia or muscle weakness; rare myopathy/rhabdomyolysis; occasional liver enzyme abnormalities.	Review symptoms, interacting medicines and risk factors; measure creatine kinase or liver tests when clinically indicated.
Opioids and sedatives	Drowsiness, constipation, falls, delirium and respiratory depression; risk rises with alcohol or other central nervous system depressants.	Use a clear indication and review duration; assess sedation, breathing, constipation and concurrent sedatives; avoid unsafe combinations.
Antidepressants and antipsychotics	Gastrointestinal symptoms, sexual dysfunction, hyponatraemia, bleeding risk, movement disorders, sedation, metabolic effects or QT prolongation, depending on agent.	Review early tolerability, mood and suicidality where relevant, sodium in at-risk patients, movement symptoms and metabolic measures.
Systemic corticosteroids	Hyperglycaemia, fluid retention, mood or sleep changes, infection risk, osteoporosis, adrenal suppression and gastrointestinal complications.	Use the lowest effective dose and appropriate duration; review infection, glucose, bone protection and tapering needs after prolonged use.
Antiepileptic medicines	Dizziness, ataxia, sedation, cognitive effects, rash, hyponatraemia, liver injury or blood dyscrasias, depending on the medicine.	Check interactions, pregnancy considerations and agent-specific laboratory monitoring; urgent assessment for severe rash or systemic symptoms.

Anticoagulants and glucose-lowering medicines deserve particular attention in older adults because preventable dosing problems and interactions may result in emergency care. In a US surveillance study of older adults, warfarin, insulin, oral antiplatelet agents and oral hypoglycaemic medicines accounted for a large proportion of estimated emergency hospitalisations for adverse drug events (Budnitz et al., 2011). This finding

illustrates why medication safety should focus on actual exposure, monitoring and patient circumstances rather than relying only on lists of medicines labelled high-risk.

4.5. Clinical manifestations and warning signs:

ADRs can affect any organ system and may resemble the disease being treated or an unrelated acute illness. The pattern, onset, duration and relationship to starting, stopping or changing a medicine are central clues. Some reactions appear within minutes or hours, whereas others develop after days, weeks or months of exposure. Delayed effects may also occur after a medicine has been discontinued.

4.6. Gastrointestinal and hepatic manifestations:

Nausea, vomiting, diarrhoea, constipation, abdominal discomfort and dyspepsia are common but should not automatically be dismissed as minor. Gastrointestinal bleeding may present with haematemesis, melaena, fresh rectal bleeding, unexplained anaemia, dizziness or shock. Hepatic injury may produce fatigue, anorexia, nausea, right upper-quadrant discomfort, dark urine, pale stools, pruritus or jaundice. Laboratory assessment commonly includes alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase and bilirubin, interpreted with the clinical history. DILI remains a diagnosis requiring exclusion of competing causes (European Association for the Study of the liver, 2019; Fontana et al., 2023).

4.7. Renal, cardiovascular and haematological manifestations:

Renal ADRs may present as a rise in serum creatinine, reduced urine output, fluid imbalance or electrolyte disturbance. Cardiovascular effects include hypotension, syncope, bradycardia, tachycardia, QT prolongation, arrhythmia, oedema and worsening heart failure. Haematological reactions include thrombocytopenia, neutropenia, agranulocytosis, haemolytic anaemia and bleeding. Unexplained fever, sore throat, bruising, pallor or recurrent infection in a patient taking a medicine associated with marrow suppression warrants prompt clinical review.

4.8. Neurological, respiratory and dermatological manifestations:

Neurological reactions include headache, dizziness, confusion, delirium, tremor, seizures, extrapyramidal symptoms and peripheral neuropathy. Respiratory reactions may include bronchospasm, cough, interstitial lung injury or respiratory depression. Skin manifestations range from mild itching and uncomplicated rashes to angioedema, blistering, mucosal lesions and systemic hypersensitivity. A rapidly spreading rash, skin pain, blistering, mucosal involvement, facial swelling or breathing difficulty must be treated as a warning sign rather than a routine minor side effect.

4.9. Emergency warning signs:

Immediate emergency assessment is required for suspected anaphylaxis, airway swelling, and severe breathing difficulty, and collapse, chest pain suggestive of a cardiac event, major bleeding, seizure, severe hypoglycaemia, rapidly progressive neurological impairment, extensive blistering rash or signs of acute organ failure. Anaphylaxis is a time-critical emergency; intramuscular adrenaline (epinephrine) is the first-line treatment, alongside emergency support and airway, breathing and circulation assessment (Cardona et al., 2020).

5. Clinical assessment and causality evaluation:

5.1. Structured medication history:

The assessment should begin with a complete and time-specific medication history. Record generic and brand names where relevant, strength, dose, route, frequency, indication, start and stop dates, recent dose changes and the last dose taken. Include prescribed medicines, over-the-counter products, topical preparations, inhalers, injections, vitamins, herbal medicines, supplements, alcohol and recreational substances when relevant. Confirm actual use with the patient or caregiver rather than relying solely on the medication list. Ask about previous reactions, allergies, adherence, recent hospital visits and medicines prescribed by other clinicians.

5.2. Clinical timeline and differential diagnosis:

Construct a timeline linking medicine exposure to symptom onset, progression, dose changes and withdrawal. Consider whether the onset is biologically plausible for the suspected mechanism and whether the reaction is consistent with the known profile of the medicine. Examine alternative explanations, including progression of

the underlying disease, infection, dehydration, metabolic disturbance, a new illness, another medicine or an interaction. Review vital signs and perform a focused examination guided by the affected organ system.

5.3. Investigations and causality tools:

Investigations should be selected according to the suspected reaction rather than ordered as a fixed panel for every patient. Examples include full blood count for cytopenias or bleeding, renal function and electrolytes for kidney injury or diuretic effects, liver biochemistry for suspected DILI, glucose for hypoglycaemia, coagulation testing for selected anticoagulant-related concerns, electrocardiography for rhythm or QT-related symptoms, and creatine kinase for suspected significant muscle injury. Drug concentrations may be useful for selected medicines with established therapeutic monitoring. A normal test does not exclude an ADR if the reaction is intermittent or primarily clinical.

The Naranjo algorithm provides a structured set of questions to estimate the probability that a medicine caused an event, using factors such as timing, dechallenge, rechallenge, alternative causes, drug concentrations and previous reports (Naranjo et al., 1981). It can improve consistency but should not replace clinical judgement. Rechallenge may provide evidence in selected non-serious circumstances, but it is generally inappropriate after anaphylaxis, severe cutaneous reactions, serious organ injury or other life-threatening events. Causality assessment should also consider the strength of evidence, competing diagnoses and the limitations of available records.

6. Management strategies:

6.1. Immediate stabilisation and triage:

The first priority is the patient's safety, not the completion of a causality score. Assess airway, breathing, circulation, mental status and vital signs; identify shock, respiratory compromise, severe bleeding, altered consciousness or rapidly evolving organ injury. Activate emergency or specialist support when indicated. In suspected anaphylaxis, stop exposure to the trigger, call for emergency assistance and administer intramuscular adrenaline according to current emergency protocols; antihistamines and corticosteroids must not delay adrenaline (Cardona et al., 2020).

6.2. Review, hold, withdraw or adjust the suspected medicine:

The suspected medicine should be reviewed promptly. Depending on the reaction and the clinical importance of treatment, the appropriate action may be immediate discontinuation, temporary withholding, dose reduction, and slower titration, substitution with an alternative or continuation with closer monitoring. For a suspected life-threatening reaction, exposure should be stopped while emergency care is arranged. For medicines where abrupt withdrawal can cause harm, such as some corticosteroids, antiepileptics or long-term psychotropic agents, a clinician-directed plan is needed unless the immediate danger requires emergency withdrawal. Do not stop essential prescription treatment solely on the basis of a mild symptom without professional review.

6.3. Treat the clinical reaction:

Treatment is directed at the affected organ system and the severity of the reaction. It may include fluid resuscitation, correction of glucose or electrolyte abnormalities, and treatment of gastrointestinal bleeding, management of acute kidney injury, respiratory support, seizure management or specialist treatment of severe skin reactions. Specific antidotes or reversal agents are available for selected toxicities, but their use depends on the agent, timing, dose, clinical condition and local protocol. For drug-induced liver injury, withdrawal of the likely causative agent is central; further treatment and monitoring depend on severity, biochemical pattern and specialist assessment (Fontana et al., 2023).

6.4. Documentation, counselling and follow-up:

Document the suspected medicine, dose, route, reaction description, onset, clinical severity, seriousness, investigations, treatment, outcome and the clinician's assessment of causality. Update the medication and allergy records with sufficient detail to avoid both re-exposure and unnecessary broad allergy labels. Explain to the patient which symptoms require urgent care, which medicines should be avoided or reviewed, and whether an alternative treatment is planned. Arrange follow-up to confirm resolution, monitor organ recovery and reassess the continuing need for treatment. A suspected ADR should be communicated to relevant prescribers and pharmacists, particularly when the patient receives care from multiple services.

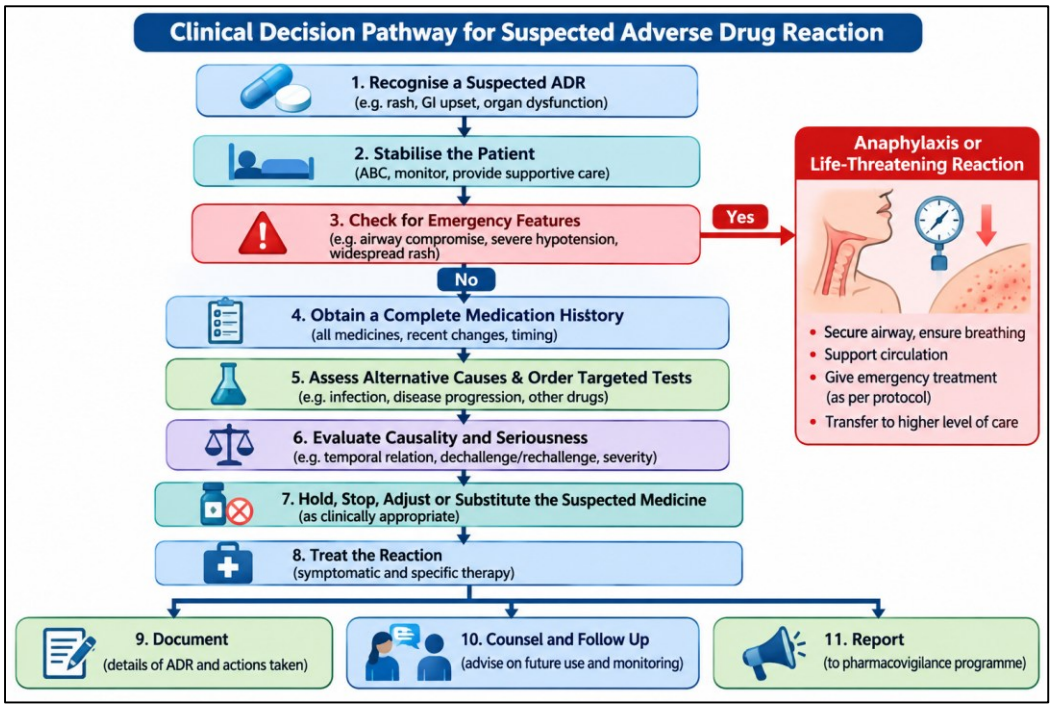


Figure. 2: Clinical Decision-Making Pathway for the Recognition, Assessment, Management and Reporting of Suspected Adverse Drug Reactions (ADRs)

7. Prevention and risk-reduction strategies:

7.1. Rational prescribing and individualised dosing:

Prescribing should begin with a clear indication and a defined therapeutic goal. Consider non-pharmacological options where appropriate, select the medicine with the most favourable benefit-risk profile, and use the lowest effective dose for the shortest suitable duration. Review allergies, prior ADRs, pregnancy or breastfeeding status, renal and hepatic function, age, frailty and relevant comorbidities. Adjust doses when required by organ function and use therapeutic drug monitoring for medicines where it is validated. Avoid unnecessary duplication and combinations with predictable additive toxicity.

7.2. Medication reconciliation and review:

Medication reconciliation should occur at admission, transfer between services and discharge. The process compares the medicines a patient is actually taking with new orders, identifies discrepancies and resolves unintended omissions, duplications or dose differences. Periodic structured medication review should assess indication, effectiveness, safety, adherence, interactions, monitoring needs and opportunities for deprescribing. Deprescribing should be planned and monitored, not carried out as an isolated instruction to stop multiple medicines. WHO guidance emphasises a person-centred, multidisciplinary approach to safer polypharmacy and transitions of care (World Health Organization, 2019b; World Health Organization, 2019c).

7.3. Monitoring and patient education:

Monitoring should be matched to the medicine and the patient. Examples include renal function and potassium after starting or increasing renin–angiotensin system medicines; glucose monitoring for insulin and sulfonylureas; INR monitoring for warfarin; blood counts for selected marrow-suppressing medicines; and liver tests when clinically indicated by the medicine or symptoms. Patients should receive practical information about expected effects, warning symptoms, missed doses, interactions and when to seek assistance. Use teach-back to confirm understanding, particularly when instructions are complex or the patient has limited health literacy.

7.4. High-alert medicines and system safeguards:

High-alert medicines require safeguards because errors involving them can produce serious harm. Strategies include standardised concentrations, clear dose units, and independent checks for selected high-risk processes, electronic prescribing support, barcode verification, secure storage and restricted access where appropriate. Alerts should be targeted and clinically meaningful to limit alert fatigue. The WHO framework for high-risk

situations recommends addressing medication-related risks at medicine, patient and system levels rather than relying only on individual vigilance (World Health Organization, 2019a).

7.5. Pharmacogenomics and precision risk reduction:

Where evidence-based pharmacogenetic recommendations are available, results may guide drug selection or starting dose and help prevent selected severe reactions. Testing should be implemented with clinical decision support, appropriate consent and interpretation, and systems for retaining results in the health record. It should not delay urgent treatment or be presented as a universal screen for all medicines. A negative genetic test does not guarantee freedom from ADRs (Relling and Evans, 2015).

7.6. Interprofessional responsibilities:

Medication safety is most effective when physicians, pharmacists, nurses and patients contribute complementary information. Prescribers are responsible for selecting appropriate therapy, documenting indications and reviewing new symptoms. Pharmacists can identify interactions, duplicate treatment, dose problems, contraindications and monitoring gaps, and can support medication reconciliation and patient education. Nurses often observe the earliest changes after administration, assess vital signs and symptoms, verify medication orders, support administration safety and communicate concerns promptly. Patients and caregivers contribute knowledge about actual medicine use, previous reactions, non-prescription products and treatment priorities. A non-punitive safety culture encourages reporting and learning from both harmful events and near misses.

7.7. Pharmacovigilance and adverse reaction reporting:

Pharmacovigilance is the science and activities concerned with detecting, assessing, understanding and preventing adverse effects and other medicine-related problems. Spontaneous reports, active surveillance, electronic health records, prescription data, registries and clinical studies contribute different forms of safety evidence. Individual reports rarely prove causation, but well-documented reports can reveal uncommon reactions, interactions, product-quality problems or changes in the frequency and severity of known risks. Reporting should not be withheld merely because the causal relationship is uncertain (World Health Organization, 2002).

In India, the Pharmacovigilance Programme of India (PvPI), coordinated through the Indian Pharmacopoeia Commission, encourages healthcare professionals and patients to report suspected adverse events using designated reporting channels and forms. Reports should include identifiable patient and reporter information as required by the form, a clear description of the reaction, suspected product details, dates, relevant investigations, treatment and outcome. Reporting is a safety activity and does not replace immediate clinical management. Local reporting requirements and available channels should be checked at the time of submission (Indian Pharmacopoeia Commission, 2026).

7.8. Challenges and future directions:

Under-reporting, incomplete clinical records, inconsistent terminology, uncertainty about causality and limited follow-up continue to constrain pharmacovigilance. Spontaneous reporting is valuable for signal detection but cannot by itself provide reliable incidence rates because the number of exposed patients and the completeness of reporting are often unknown. Digital systems can support interaction screening, trigger-based laboratory alerts and longitudinal surveillance, but poorly designed alerts may create fatigue or encourage inappropriate discontinuation. Artificial intelligence may help identify patterns in large datasets, yet outputs require validation, transparency, privacy protection and clinical oversight.

Future improvement should combine better reporting with practical implementation research. Priorities include interoperable medication records, improved documentation of allergies and prior reactions, safer transitions of care, inclusion of herbal and non-prescription products in medication histories, and patient-centred deprescribing. Evaluation should measure patient outcomes, not merely the number of reports submitted. Health systems should also ensure that medication safety strategies are accessible to people with limited digital access, language barriers or complex social circumstances.

7.9. Clinical practice checklist:

1. Confirm the medicine, dose, route, start date, recent changes and actual use, including non-prescription and herbal products.
2. Identify emergency features first: airway or breathing difficulty, collapse, major bleeding, seizure, severe hypoglycaemia or extensive blistering rash.

3. Assess the timeline, alternative diagnoses, interactions and relevant renal, hepatic, haematological or metabolic investigations.
4. Decide whether the suspected medicine should be stopped, held, adjusted or replaced, considering withdrawal risks and the urgency of the reaction.
5. Treat the clinical problem, document the reaction precisely, communicate with the care team, arrange follow-up and submit a suspected ADR report.

Table. 2: Selected monitoring considerations

Medication group	Assessment before or at initiation	Follow-up considerations
ACE inhibitors, ARBs and diuretics	Blood pressure, renal function, potassium and sodium as appropriate.	Recheck blood pressure, renal function and electrolytes after initiation or dose change, guided by the medicine and patient risk.
Warfarin	Indication, bleeding history, baseline coagulation status and interaction review.	Monitor INR according to the anticoagulation plan; reassess after interacting medicines, illness or major dietary changes.
Insulin and sulfonylureas	Glucose pattern, meals, renal function, hypoglycaemia history and ability to self-manage.	Review glucose readings, hypoglycaemic episodes, dose timing and food intake after changes or intercurrent illness.
NSAIDs	Gastrointestinal bleeding history, renal function, blood pressure, cardiovascular risk and concurrent anticoagulants.	Review pain benefit, duration, blood pressure, oedema, renal function and signs of gastrointestinal bleeding in at-risk patients.
Statins	Medication interactions, muscle symptoms and relevant liver history.	Assess new muscle pain or weakness; obtain creatine kinase or liver tests when clinically indicated rather than as an automatic response to every symptom.
Medicines with marrow or immune toxicity	Baseline blood count and relevant renal or hepatic function; product-specific contraindications.	Use agent-specific blood counts, organ-function tests and drug concentrations where recommended; respond promptly to fever, bruising or infection.

8. Conclusion:

Adverse drug reactions are an important and partly preventable consequence of pharmacotherapy. They may arise from predictable pharmacological effects, altered drug exposure, interactions, immune hypersensitivity, idiosyncratic organ injury or genetic susceptibility. Older age, multimorbidity, polypharmacy, renal or hepatic impairment, previous reactions and fragmented care increase vulnerability. Early recognition depends on a complete medication history, a plausible clinical timeline, focused examination and targeted investigations. Management requires prompt stabilisation, careful decisions about the suspected medicine, treatment of the reaction, clear documentation, follow-up and reporting. Safe prescribing is therefore not a single action but a continuous process involving clinicians, pharmacists, nurses, patients and health systems. Consistent medication reconciliation, individualised dosing, appropriate monitoring, patient education and robust pharmacovigilance can reduce avoidable harm while preserving the benefits of commonly prescribed medicines.

9. References:

(1) Edwards IR, Aronson JK. Adverse drug reactions: definitions, diagnosis, and management. Lancet. 2000;356(9237):1255-9. doi:10.1016/S0140-6736(00)02799-9.
(2) Lazarou J, Pomeranz BH, Corey PN. Incidence of adverse drug reactions in hospitalized patients: a meta-analysis of prospective studies. JAMA. 1998;279(15):1200-5. doi:10.1001/jama.279.15.1200.
(3) Pirmohamed M, James S, Meakin S, Green C, Scott AK, Walley TJ, et al. Adverse drug reactions as cause of admission to hospital: prospective analysis of 18 820 patients. BMJ. 2004;329(7456):15-9. doi:10.1136/bmj.329.7456.15.
(4) Naranjo CA, Busto U, Sellers EM, Sandor P, Ruiz I, Roberts EA, et al. A method for estimating the probability of adverse drug reactions. Clin Pharmacol Ther. 1981;30(2):239-45. doi:10.1038/clpt.1981.154.

(5) Schumock GT, Thornton JP. Focusing on the preventability of adverse drug reactions. Hosp Pharm. 1992;27(6):538.
(6) Hakkarainen KM, Hedna K, Petzold M, Hägg S. Percentage of patients with preventable adverse drug reactions and preventability of adverse drug reactions: a meta-analysis. PLoS One. 2012;7(3):e33236. doi:10.1371/journal.pone.0033236.
(7) Budnitz DS, Lovegrove MC, Shehab N, Richards CL. Emergency hospitalizations for adverse drug events in older Americans. N Engl J Med. 2011;365(21):2002-12. doi:10.1056/NEJMsa1103053.
(8) Alhawassi TM, Krass I, Bajorek BV, Pont LG. A systematic review of the prevalence and risk factors for adverse drug reactions in the elderly in the acute care setting. Clin Interv Aging. 2014;9:2079-86. doi:10.2147/CIA.S71178.
(9) World Health Organization. The importance of pharmacovigilance: safety monitoring of medicinal products. Geneva: World Health Organization; 2002. ISBN:9241590157.
(10) Donaldson LJ, Kelley ET, Dhingra-Kumar N, Kieny MP, Sheikh A. Medication without harm: WHO's third global patient safety challenge. Lancet. 2017;389(10080):1680-1. doi:10.1016/S0140-6736(17)31047-4.
(11) World Health Organization. Medication safety in high-risk situations. Geneva: World Health Organization; 2019. WHO/UHC/SDS/2019.10.
(12) World Health Organization. Medication safety in polypharmacy: technical report. Geneva: World Health Organization; 2019. WHO/UHC/SDS/2019.11.
(13) World Health Organization. Medication safety in transitions of care. Geneva: World Health Organization; 2019. WHO/UHC/SDS/2019.9.
(14) American Geriatrics Society 2023 Beers Criteria Update Expert Panel. American Geriatrics Society 2023 updated AGS Beers Criteria® for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2023;71(7):2052-81. doi:10.1111/jgs.18372.
(15) Cardona V, Ansotegui IJ, Ebisawa M, El-Gamal Y, Fernandez Rivas M, Fineman S, et al. World Allergy Organization anaphylaxis guidance 2020. World Allergy Organ J. 2020;13(10):100472. doi:10.1016/j.waojou.2020.100472.
(16) Andrade RJ, Chalasani N, Björnsson ES, Suzuki A, Kullak-Ublick GA, Watkins PB, et al. Drug-induced liver injury. Nat Rev Dis Primers. 2019;5:58. doi:10.1038/s41572-019-0105-0.
(17) European Association for the Study of the Liver. EASL Clinical Practice Guidelines: drug-induced liver injury. J Hepatol. 2019;70(6):1222-61. doi:10.1016/j.jhep.2019.02.014.
(18) Fontana RJ, Liou I, Reuben A, Suzuki A, Fiel MI, Lee W, et al. AASLD practice guidance on drug, herbal, and dietary supplement-induced liver injury. Hepatology. 2023;77(3):1036-65. doi:10.1002/hep.32689.
(19) Relling MV, Evans WE. Pharmacogenomics in the clinic. Nature. 2015;526(7573):343-50. doi:10.1038/nature15817.
(20) Indian Pharmacopoeia Commission. Pharmacovigilance Programme of India: adverse drug reaction reporting [Internet]. Ghaziabad: Indian Pharmacopoeia Commission; [cited 2026 Oct 31]. Available from: https://ipc.gov.in/PvPI/adr.html.