

[HOSPITAL / HEALTH AUTHORITY NAME]

POWER, OXYGEN, INFORMATION-SYSTEM, LABORATORY, IMAGING, AND EQUIPMENT DOWNTIME

Protocol 57: Essential Utility Failure; Clinical Command; Manual Workflows; Diagnostic Degradation; Equipment Substitution; Cybersecurity; Restoration; Reconciliation; and Quality Governance

DRAFT FOR EMERGENCY MEDICINE, NURSING, HOSPITAL EXECUTIVE / INCIDENT COMMAND, FACILITIES / ESTATES, BIOMEDICAL ENGINEERING, MEDICAL GAS SERVICES, INFORMATION TECHNOLOGY / CYBERSECURITY, LABORATORY / BLOOD BANK, IMAGING, PHARMACY, ANAESTHESIA, CRITICAL CARE, PAEDIATRICS, OBSTETRICS, AMBULANCE / TRANSPORT, SECURITY, QUALITY, AND CLINICAL GOVERNANCE

STATUS: This is a draft clinical-governance and business-continuity document. It does not replace electrical, medical-gas, cyber, laboratory, imaging, equipment, fire-safety, disaster, evacuation or manufacturer procedures. All contacts, technical limits, reserve calculations, legal duties and restoration tests must be locally validated before approval.

CORE RULE: Treat loss or degradation of power, medical oxygen, communications, information systems, diagnostics or critical equipment as a clinical incident. Activate early, identify the affected dependency chain, protect life-support capacity, simplify care safely, and escalate before reserve systems are exhausted.

LIFE-SUPPORT OVERRIDE: Actual or threatened loss of oxygen, ventilation, suction, monitoring, infusion, essential electrical supply or environmental support for a critically ill patient requires immediate bedside action, senior clinical command, facilities / engineering response and early relocation or transfer. Do not wait for total failure.

IDENTITY / RESULTS OVERRIDE: Downtime never suspends patient-identification standards. Every patient, specimen, order, medicine, image, result, transfer and later electronic entry must remain traceable through one approved manual workflow with closed-loop acknowledgement and post-restoration reconciliation.

| Document control | Details |
|------------------------------|--|
| Document owner | Emergency Department / Hospital Emergency Management Committee / Medical Services Directorate / Nursing Directorate |
| Clinical and technical leads | Emergency Medicine; Nursing; Facilities / Estates; Biomedical Engineering; Medical Gas Services; Information Technology / Cybersecurity; Laboratory / Blood Bank; Imaging; Pharmacy; Anaesthesia / Critical Care; Quality and Patient Safety |
| Applies to | All emergency-department staff and all hospital services supporting emergency care during planned or unplanned service degradation |
| Related protocols | Protocols 1-6, 10, 17, 27-30, 41, 47-50, 53-56, 58 and 59; hospital fire, evacuation, cyber, disaster, oxygen, generator, medical-device, laboratory, imaging, blood-bank and business-continuity plans |
| Version / status | Draft 1.0 for multidisciplinary review and local configuration |
| Approval authority | _____ |
| Effective date | _____ |
| Review date | _____ or after any activation, near miss, major system change or relevant external alert |
| 24-hour escalation contact | Incident command / administrator on call: _____ Facilities: _____ IT: _____ |

1. Purpose

To provide a practical, auditable framework for maintaining safe emergency care when essential utilities, information systems, diagnostic services or medical equipment are unavailable or operating below normal capability. The protocol establishes early recognition, clinical command, manual fallback workflows, minimum operating capability, transfer thresholds, staged restoration and reconciliation so that infrastructure failure does not become hidden clinical harm.

2. Core principles

- Downtime is a patient-safety incident, not merely a technical inconvenience. Clinical and operational leaders share responsibility from recognition through recovery.
- Activate on credible risk and predicted reserve depletion, not only after complete failure. A slow oxygen-pressure decline, unstable generator, intermittent network, analyser fault or repeated device alarm can justify escalation.
- Protect the functions that prevent death or irreversible disability: airway and ventilation, oxygenation, haemorrhage control, essential medicines and infusions, neonatal thermal support, resuscitation, time-critical diagnostics, blood provision and safe transfer.
- Use one incident structure, one verified status picture and one approved downtime workflow. Parallel unofficial workarounds create duplicate orders, mismatched identities, missed results and unsafe restoration.
- Maintain two patient identifiers whenever available. When identity is unknown, use one unique temporary identifier consistently across wristband, paper record, specimens, images, medicines, blood and transfer documents.
- Reduce demand before reserve systems are exhausted. Defer non-urgent activity, consolidate patients into supported areas, close unsafe spaces and transfer early when local capability cannot be sustained.
- Do not improvise electrical connections, oxygen splitters, medical-device modifications, unvalidated software or unapproved substitutes. A technically possible workaround is not automatically clinically safe.
- When diagnostics are degraded, make the limitation explicit in every decision. Use clinical assessment, bedside tools and referral pathways, but do not allow false reassurance from incomplete testing.
- Restoration is complete only after technical verification, clinical validation and reconciliation of identities, records, medicines, orders, specimens, images and results generated during downtime.
- Preserve equitable access. Children, pregnant patients, people with disability, patients requiring oxygen or electrically powered devices, and those with communication or safeguarding needs must be explicitly included in continuity plans.

3. Scope and definitions

| Term | Working definition |
|--|---|
| Downtime | A planned or unplanned period when an essential service, system or device is unavailable, unreliable, inaccessible or unsafe for normal use. |
| Degraded operation | A state in which care continues with reduced capacity, slower workflows, restricted functions, alternative equipment or increased clinical risk. |
| Critical infrastructure failure | Loss or threatened loss of a utility or service whose failure can directly compromise life support, diagnosis, treatment, infection control, security or safe evacuation. |
| Business continuity | The capability to continue prioritized services at an acceptable predefined level during disruption. |
| Disaster recovery | Technical restoration of systems, data, infrastructure or services after disruption. It does not by itself confirm clinical safety. |
| Maximum tolerable downtime | The longest period a service can be unavailable before unacceptable harm or operational failure is expected. |
| Recovery time objective (RTO) | The target time to restore a service or an agreed minimum function. |
| Recovery point objective (RPO) | The maximum acceptable period of data loss measured backward from the incident. |
| Essential electrical supply | The generator-, UPS- or other backup-supported electrical circuits designated for critical clinical, safety and infrastructure functions. |
| Oxygen reserve | The usable duration of approved backup oxygen at the current or forecast total demand, after applying the local safety reserve. |
| Manual downtime workflow | The pre-approved paper, label, communication and tracking process used when electronic or automated systems are unavailable. |
| Reconciliation | The structured comparison and completion of paper and electronic records after restoration to identify missing, duplicate, delayed or conflicting information. |
| Safe state | A verified condition in which a system or device is isolated, shut down, transferred to backup or otherwise controlled so that it does not create further risk. |

4. Governance and baseline preparedness

- The hospital emergency-management and business-continuity programme must maintain a current business impact analysis identifying critical ED functions, dependencies, maximum tolerable downtime, RTO, RPO, minimum staffing, minimum equipment and acceptable degraded modes.
- Map interdependencies. Electricity may support oxygen concentrators, pipeline alarms, suction, ventilation, refrigeration, laboratory analysers, imaging, doors, lifts, lighting, communications, water pumps, HVAC, fire systems and network infrastructure. Plans must account for cascading failure.
- Name a 24-hour activation authority and backups. The ED senior clinician or nurse in charge may initiate clinical downtime measures immediately while technical confirmation and executive command are being established.
- Maintain tested emergency electrical supply, UPS protection for designated devices, fuel arrangements, generator load priorities, connection diagrams, authorized switching procedures and a process for prolonged outage or generator failure.
- Maintain a medical-gas operational policy with alarm response, responsible persons, source and manifold status, reserve calculations, cylinder inventory, regulators, trolleys, keys, transfer routes and emergency isolation procedures.

- Maintain approved downtime packs at defined locations. Packs should contain patient identifiers, wristbands, registration forms, clinical notes, medication and transfusion charts, order forms, specimen labels, result logs, radiology requests, transfer forms, prescription forms, incident logs and reconciliation checklists.
- Provide secure emergency access to essential clinical information appropriate to local systems, such as allergies, medicines, problem lists, resuscitation decisions, recent results and contact details. Test read-only, replicated or offline access without assuming the main network is available.
- Laboratory, blood bank and imaging services must define a restricted emergency test / imaging menu, point-of-care capability, manual accession and reporting, external referral arrangements, courier options, backup equipment and time-critical transfer thresholds.
- Biomedical engineering must maintain a risk-based device inventory, preventive maintenance, battery-replacement programme, approved substitutes, spare equipment, service contacts, quarantine labels and processes for manufacturer safety alerts and incident reporting.
- Cybersecurity plans must include containment, safe communication channels, network segmentation, backup validation, privileged-access control, vendor contact, evidence preservation and rules prohibiting staff from reconnecting or using suspect devices without authorization.
- Train all relevant staff in manual workflows and conduct at least annual exercises covering combined failures, after-hours staffing and prolonged outage. Include restoration and reconciliation, not only the first response.
- Review plans after every activation, near miss, failed test, infrastructure change, software upgrade, new device deployment, service relocation and change in regional transfer capability.

5. Recognition, classification and activation

ACTIVATION PRINCIPLE: Classify by clinical consequence, affected area, expected duration, reserve status and availability of a safe alternative. A localized failure can be Level 3 if it removes the only capability required for a time-critical patient.

| Level | Typical triggers | Minimum response |
|---|---|--|
| Level 1 - Localized / short | Single device, room, workstation or limited service affected; safe alternative immediately available; no current patient harm; restoration expected promptly. | Local lead notified; isolate failed item; use approved backup; document incident; monitor for spread; prepare escalation. |
| Level 2 - Major degraded operation | Multiple devices / rooms, essential diagnostic function, network segment, generator-supported area or medical-gas zone affected; delays or constrained capacity; uncertain restoration. | Activate departmental or hospital continuity plan; appoint incident lead; restrict activity; begin manual workflow; calculate reserves; notify receiving / referral services; review at set intervals. |
| Level 3 - Critical failure | Loss or imminent loss of life-support utility; hospital-wide IT / communications failure; cyberattack; no safe diagnostic alternative for time-critical care; reserve below transfer threshold; cascading infrastructure failure. | Full incident command; immediate clinical stabilization and relocation; suspend unsafe activity; external emergency / utility support; regional coordination; evacuation or transfer as indicated; frequent situation reports. |

- Immediate Level 3 triggers include: total or unstable essential power in resuscitation / critical care; loss of piped oxygen pressure without adequate backup; inability to ventilate or suction safely; fire, smoke, flooding or overheating affecting critical systems; uncontained cyber incident; inability to identify patients; loss of blood-bank compatibility function; loss of all time-critical imaging; repeated device failures suggesting a common cause.
- The initial alert should state: affected service and location, time recognized, current patient impact, safety hazards, backup in use, estimated duration if known, reserve / battery / cylinder status, actions taken, support required and next update time.
- Use plain language. Avoid declaring a system restored based only on a vendor or technical message; clinical validation is required before normal workflows resume.

6. Command, communication and the first 15 minutes

| Role | Initial responsibilities |
|--|--|
| Incident commander / administrator on call | Set incident level and objectives; obtain external support; authorize service restriction, transfer or evacuation; coordinate executive, legal and public communication. |
| ED clinical lead | Prioritize patients and clinical functions; define minimum safe capability; approve degraded pathways; trigger transfer; communicate risks to clinicians and patients. |
| ED nurse lead | Account for patients and staff; deploy downtime packs; assign safety checks and runners; protect medicines, equipment, oxygen and documentation. |
| Facilities / estates lead | Assess electrical, generator, fuel, HVAC, water, medical-gas and building risks; isolate hazards; provide verified technical status and restoration plan. |
| Medical-gas authorized person / designated lead | Assess source, pipeline pressure, alarms and reserve; arrange cylinders / alternative supply; control isolation and restoration; liaise with clinical teams. |
| IT / cybersecurity lead | Assess scope and cause; contain cyber risk; support approved fallback; provide restoration estimates cautiously; preserve logs and validate interfaces. |
| Biomedical engineering lead | Inspect failed devices; deploy approved substitutes; manage batteries, spares, quarantine and repair; verify devices before return to service. |
| Laboratory / blood-bank lead | Activate restricted test menu and manual accession / reporting; protect specimen traceability; arrange referral testing and blood continuity. |
| Imaging lead | Activate manual requesting / reporting; prioritize modalities; arrange alternative imaging / transfer; validate PACS / RIS and modality reconciliation. |
| Safety / quality scribe | Maintain incident log, decisions, risks, patient impacts, status board, action owners, review times and reconciliation plan. |

1. Identify immediate threats at the bedside. Confirm which patients depend on oxygen, ventilation, suction, continuous infusion, monitoring, warming, refrigeration or time-critical diagnostics.
2. Call the approved alert. Name the incident lead and technical leads; open an incident log and record the exact time of failure and last known normal operation.

3. Determine scope: one device, one room, one circuit, one gas zone, one interface, one diagnostic service, the whole ED or the whole hospital. Look for a common cause.
4. Place affected systems or equipment in a safe state. Stop unsafe use, disconnect only when clinically and technically appropriate, label / isolate hazards and prevent unauthorized reconnection.
5. Switch to approved backup: essential outlet / UPS, generator, cylinder oxygen, portable suction, manual documentation, point-of-care testing, alternate modality or spare device.
6. Calculate and display the limiting reserve: generator fuel, UPS / device battery, cylinder oxygen, reagents, paper forms, communications, blood stock, staffing or external transport time.
7. Prioritize patients and protect one functioning resuscitation pathway. Consolidate critical patients into supported locations when movement is safer than remaining in place.
8. Suspend or redirect non-urgent activity before reserves become critical. Notify ambulance services and referral partners if receiving capability is reduced.
9. Deploy manual identity, order, medication, specimen, image, result and transfer workflows. Assign a single downtime numbering process and result log.
10. Establish primary and backup communication methods and update intervals. Use radios, approved mobile phones, landlines, public address, secure messaging or runners according to the incident.
11. Identify patients requiring early transfer or evacuation. Begin transport arrangements while backup systems are still functioning; do not wait for reserve exhaustion.
12. Set a review time based on the fastest-changing risk, usually every 10-15 minutes for critical utility loss and every 30-60 minutes for stable degraded operation.

7. Electrical power failure and electrical safety

- Confirm whether the failure affects normal supply, essential / generator circuits, UPS, a distribution board, one room or individual outlets. Facilities staff control switching, generator operation and electrical isolation.
- Use only designated essential outlets and approved cables. Do not overload circuits, daisy-chain extension leads, bypass protective devices, use domestic generators indoors or connect improvised power sources.
- Check each critical device for battery status and realistic runtime under clinical load. Manufacturer display estimates may change rapidly with alarms, pumps, heaters, wireless modules or degraded batteries.
- Prioritize power for ventilation, oxygen production / alarms, suction, monitoring, defibrillation, infusion of time-critical medicines, neonatal warming, blood / medicine refrigeration, communications, emergency lighting and essential diagnostics.
- For a ventilated patient, place a self-inflating bag with oxygen reservoir and appropriate airway equipment immediately available. If ventilation becomes manual, assign a trained clinician, use capnography / pulse oximetry where available, rotate staff and transfer urgently; prolonged manual ventilation is not a sustainable continuity plan.
- Convert non-critical powered functions to safe manual alternatives only through approved procedures. Never assume a gravity infusion, manual calculation or consumer device is equivalent to a validated pump or monitor.
- Check lighting, powered doors, access control, fire alarm, lifts, water pressure, HVAC, refrigeration, temperature-sensitive medicines, laboratory and imaging cooling. A power outage may require closure or evacuation even when bedside devices remain on battery.
- Use torches or approved emergency lighting, not candles or open flames. Restrict lifts until facilities confirms safety; protect stairways and manual evacuation routes.
- If a device emits smoke, heat, sparks, unusual smell or repeated fault alarms, stop use if this can be done safely, disconnect power when authorized, move the patient to a safe substitute and activate fire / electrical response.
- Document any patient exposed to interruption, unmonitored interval, delayed treatment or equipment malfunction and arrange clinical review even if no immediate harm is apparent.

8. Oxygen, medical air, suction and vacuum failure

OXYGEN RULE: Medical oxygen is an essential medicine with no equivalent substitute. A falling pressure alarm, depleted source, concentrator power failure, frozen / damaged manifold, pipeline leak or unexpectedly rising demand requires immediate clinical and technical escalation.

- Confirm the affected gas and extent: one outlet, one zone, pipeline, manifold, bulk source, PSA / concentrator plant, cylinder bank, medical air, vacuum or suction. Do not silence or reset alarms without identifying the cause.
- Immediately ensure each oxygen-dependent patient has a functioning independent supply. Move to a tested outlet or approved cylinder and verify flow at the patient, not only at the source.
- Use the correct medical-gas cylinder, regulator, connector and trolley. Secure cylinders upright or in an approved carrier; keep valves free of oil / grease; protect from heat, impact and unauthorized handling; open and close according to local policy.
- Display total cylinder inventory, location, estimated usable contents, flow demand and projected depletion time. Recalculate after every patient movement, treatment change, delivery or cylinder exchange.
- Preserve clinically appropriate oxygen targets. Do not respond to shortage by indiscriminately stopping oxygen or lowering targets without senior review. Reduce waste through leak checks, correct interfaces and prompt discontinuation where oxygen is no longer clinically indicated.
- Do not use improvised multi-patient splitters, unapproved adapters or non-medical oxygen. Devices such as ventilators, HFNO, CPAP, anaesthetic machines and blenders may consume more gas than the displayed patient flow and must be included in reserve calculations using manufacturer / engineering data.
- If medical air fails, identify devices that depend on it and switch only to an approved alternative configuration. High oxygen concentrations may alter delivered FiO₂ and fire risk; respiratory / anaesthetic expertise is required.
- If central suction / vacuum fails, deploy approved portable electric or manual suction, confirm canister and tubing function, and prioritize airway, major secretion, chest-drain and procedural needs. Battery and waste capacity must be monitored.
- Escalate early to supplier, neighboring hospitals, ambulance, national emergency management and regional transfer services. Concentrate oxygen-dependent patients in areas with verified supply only when safe movement and infection-control requirements can be maintained.
- Begin transfer before the locally approved reserve threshold is reached. Consider journey oxygen, loading delays, cylinder changes, receiving-site capacity and the possibility that the outage will outlast the initial estimate.
- Only an authorized technical process may isolate or restore a medical-gas zone. Clinical teams must identify all affected patients before isolation, and every outlet used after restoration must be verified according to local engineering policy.

9. Information-system, telecommunications and cyber downtime

- Activate the manual workflow when registration, EHR, medication administration, order entry, results, e-prescribing, patient tracking, telephony or network access is unreliable - not only when completely unavailable.
- If ransomware, malware, unauthorized access, unusual encryption, mass login failure or suspicious device behavior is possible, stop non-essential interaction, notify cybersecurity immediately and follow containment instructions. Do not connect personal storage, unapproved hotspots or previously isolated devices.
- Use one downtime identifier process. Apply wristband / label at first contact; verify two identifiers before medicine, procedure, specimen, image, blood or transfer. Temporary identifiers must never be reused.
- Maintain one paper clinical record with arrival time, allergies, medicines, resuscitation status, assessment, observations, orders, administration times, procedures, consultations, results, disposition and responsible clinician.
- Use pre-numbered order and result forms when available. Record request time, urgency, specimen / examination, requester, destination, person receiving, result time, critical result read-back and action taken.
- For medicines, use an approved paper prescription / administration record. Avoid verbal orders except where locally permitted and clinically necessary; read back, document immediately and obtain countersignature according to policy.
- Use approved read-only or replicated data sources only when their time stamp and completeness are understood. Clearly mark information that may be stale. Ask the patient / family and check paper or pharmacy sources where important discrepancies remain.
- Establish a downtime status board without displaying unnecessary personal information. Track all patients, transfers, pending consultations, pending tests and results requiring follow-up.
- Use primary and backup communications. If telephones fail, deploy radios, secure mobile devices, runners and written situation reports. Protect confidential information and authenticate extraordinary instructions through a known callback or face-to-face confirmation.
- At discharge, provide a legible written summary, medicines, follow-up, pending-result plan and contact route. Record how the patient will be contacted if electronic messaging is unavailable.
- Do not mass-enter data during restoration without prioritization and quality checks. High-risk medicines, allergies, blood products, procedures, imaging, critical results, disposition and outstanding actions require first reconciliation.

10. Laboratory and blood-bank downtime

| Domain | Minimum safe downtime control |
|-----------------------------|--|
| Patient / specimen identity | Two identifiers or one unique emergency identifier on patient, form and specimen; label at bedside; date / time and collector identity; no unlabeled or ambiguously relabeled specimens except under an approved exceptional process. |
| Emergency test menu | Locally defined tests that materially change immediate resuscitation or disposition. Restrict low-value repeat testing and batch non-urgent requests. |
| Point-of-care testing | Use only approved devices, trained operators, in-date consumables and quality-control processes. Record device ID, operator, patient ID, time and result; confirm unexpected or critical values when feasible. |
| Manual accession / tracking | Unique specimen number, requested test, priority, collection / receipt times, destination, status and final result. Protect chain of custody and temperature requirements. |
| Critical results | Direct verbal communication to a named clinician with read-back, time, sender, receiver and documented action. A result left on an unattended phone or paper tray is not closed-loop communication. |
| Referral testing | Pre-arranged receiving laboratory, courier, packaging, acceptance criteria, turnaround time, result route, billing / authorization and escalation if transport fails. |
| Blood provision | Activate blood-bank continuity plan. Preserve positive patient identification, sample validity rules, compatibility testing, emergency-release authorization, product traceability, temperature control and transfusion documentation. |
| Restoration backlog | Prioritize unprocessed specimens by stability and clinical need; identify expired / compromised specimens; prevent duplicate testing; reconcile every request and critical result with the patient record. |

- When analyser results are delayed, clinicians must be told what is unavailable, what alternative is being used, expected turnaround and how results will be communicated. Do not display an unverified restoration estimate as a promise.
- For severe metabolic disturbance, poisoning, sepsis, major haemorrhage, neonatal illness, pregnancy emergency or other laboratory-dependent care, obtain referral testing or transfer when the required decision cannot be made safely within the necessary time.
- Refrigerators, freezers, blood storage and temperature logs require immediate assessment during power failure. Quarantine products or specimens when temperature integrity is uncertain until the responsible service authorizes use.

11. Imaging downtime

- Determine whether the problem affects modality hardware, power, cooling, injector, RIS, PACS, image transfer, reporting workstation, network, archive or radiologist access. A modality may acquire images that cannot be identified, viewed, reported or safely retained.
- Activate a restricted emergency imaging pathway agreed by ED and imaging leads. Prioritize examinations that immediately affect haemorrhage control, surgery, stroke / thrombectomy, major trauma, ectopic pregnancy, torsion, obstruction, critical respiratory disease, line / tube position or other time-critical decisions.
- Use bedside ultrasound or portable radiography only when the operator, equipment and clinical question are appropriate. A limited bedside examination does not automatically exclude disease that normally requires CT, formal ultrasound or specialist interpretation.
- Use a manual request with patient identifier, clinical question, urgency, pregnancy status where relevant, requester and callback. Imaging staff must verify the patient and examination before exposure.
- When PACS / RIS is unavailable, use the approved local storage, worklist and labeling process. Prevent images from being assigned to the wrong patient or overwritten. Record where the image is stored and who has reviewed it.
- Communicate urgent or preliminary findings directly to a named clinician with read-back and documentation. State limitations and whether a formal report remains outstanding.

- If required imaging cannot be performed or safely interpreted within the clinical window, arrange transfer to a capable site while continuing stabilization. Do not delay transfer solely in hope of uncertain restoration.
- If equipment malfunctions during exposure or patient movement, stop when safe, protect the patient, follow radiation / MRI / equipment contingency procedures, quarantine the equipment and report the incident.
- After restoration, reconcile all manual requests, acquired images, preliminary opinions and final reports. Identify examinations not completed, images not archived, reports not delivered and patients requiring amended advice or recall.

12. Medical-equipment failure and approved substitution

- If a device fails while attached to a patient, support the patient first using an approved backup or manual rescue method; then isolate the device. Do not allow troubleshooting to delay airway, breathing, circulation or transfer.
- Remove a failed device from service, attach a clear quarantine label, retain disposables / logs when relevant, record asset number and settings, and notify biomedical engineering. Preserve the device and evidence after a serious incident unless immediate safety requires otherwise.
- Use only an approved substitute for the intended patient and environment. Confirm staff competence, accessories, consumables, electrical / gas compatibility, alarm limits, calibration, infection control and manufacturer instructions.
- For infusion-pump failure, identify all infusions, drug concentrations, remaining volume and clinical priority. Transfer high-risk medicines to a functioning pump whenever possible. A gravity or manual method requires an explicit approved protocol, independent calculation / check and close observation.
- For monitor failure, replace the monitor or move the patient to a staffed area with equivalent observation. Intermittent manual observations are not equivalent for a patient requiring continuous rhythm, saturation, invasive pressure or capnography monitoring.
- For defibrillator failure, bring a verified replacement immediately and maintain manual CPR / clinical care. Check pads, cables, battery and self-test status; do not rely on a device that repeatedly resets or shows unexplained error messages.
- For neonatal incubator / warmer failure, provide approved thermal support and continuous temperature assessment; avoid unregulated heat sources and arrange urgent relocation.
- Manage battery pools actively: charge rotation, compatibility, age, load testing, storage, transport and replacement. A fully charged indicator does not prove acceptable runtime if battery health is poor.
- Report patient injury, near miss, interrupted treatment or incorrect diagnosis associated with a device through local patient-safety and regulatory channels. Manufacturer repair does not replace clinical incident review.
- Return equipment to service only after authorized inspection / repair, functional testing, cleaning, configuration and user verification. Remove temporary warning labels only by the designated service.

13. Clinical prioritization during degraded capability

| Patient / function | Minimum continuity capability | Transfer / escalation threshold |
|--|--|---|
| Mechanically ventilated / difficult airway | Independent ventilation method, oxygen, suction, monitoring, trained staff and transport plan. | Any uncertainty that ventilation, oxygen or monitoring can be sustained through restoration plus transfer time. |
| HFNO / NIV / high oxygen demand | Verified oxygen source and device power; reserve calculation includes actual device consumption. | Reserve below local threshold, unstable patient, or no safe alternative respiratory support. |
| Major haemorrhage / emergency surgery | Blood continuity, warming, power, suction, theatre / transfer capability and essential laboratory support. | Definitive haemorrhage control or compatible blood cannot be provided within the required window. |
| Stroke, STEMI, major trauma, vascular or obstetric emergency | One time-critical diagnostic and referral pathway with direct specialist communication. | Required imaging / intervention unavailable or restoration time is uncertain beyond the therapeutic window. |
| Neonate / child dependent on warming or equipment | Age-appropriate oxygen, ventilation, monitoring, thermal support, dosing aids and trained escort. | Backup cannot maintain temperature, oxygenation, ventilation, monitoring or safe transfer readiness. |
| Dialysis / severe electrolyte or toxicological emergency | Essential laboratory / ECG / antidote support and confirmed dialysis or referral capability. | Decision-critical testing or dialysis cannot occur safely in time. |
| Patient using implanted / home-powered device | Identify device and dependency; maintain power / oxygen and contact specialist or supplier. | Battery / supply cannot outlast incident and transfer; device malfunction or unfamiliar alarm. |
| Infectious / isolation patient | Continuity of isolation, ventilation, PPE, waste and communication while relocating. | Required environmental controls fail and no safe cohort / transfer option exists locally. |

When several patients compete for limited reserve, decisions should be based on immediate clinical need, likelihood of benefit, time sensitivity and resource consumption under an approved ethical and command framework. Do not prioritize according to social status, disability, wealth, nationality or perceived worth. Reassess as capacity and patient condition change.

14. Patient movement, transfer and evacuation

- Choose the safest location by comparing the risk of movement with the risk of remaining. A room with functioning outlets may still be unsafe because of heat, smoke, water, gas leak, structural risk, failed fire systems or inaccessible evacuation route.
- Before movement, identify required oxygen, battery, monitoring, infusions, airway equipment, staff, route, lift / stair status, isolation precautions and destination acceptance. Carry a manual record and transfer checklist.
- For inter-facility transfer, include credible reserve for preparation, loading, travel, delays and handover. Verify receiving-site capability, transport device compatibility and return / replacement of cylinders and equipment.
- Evacuation order and destination should follow the hospital emergency plan. Prioritize patients according to immediate environmental threat, mobility, life-support dependency and route feasibility; maintain identity and tracking at every handover.
- Notify families or representatives when feasible, but do not delay life-saving relocation. Protect unaccompanied children and vulnerable adults through approved safeguarding and identification processes.

15. Recovery, restoration and reconciliation

RESTORATION RULE: Technical availability is not the same as safe clinical restoration. Bring services back in a controlled sequence, validate critical functions and interfaces, reconcile all downtime work, and retain the original paper record.

1. The incident commander authorizes staged recovery after advice from clinical and technical leads. Maintain fallback until the restored service has passed required checks.
2. Validate infrastructure at the point of care: power stability, correct outlets, gas identity / pressure, alarm function, suction, network access, device operation, environmental controls and communications.

3. Validate digital functions using test patients or approved checks: identity, allergies, medicines, order routing, label printing, interfaces, results, imaging worklists, report delivery, prescribing and audit trails.
4. Prioritize electronic entry of high-risk information. Mark entries as transcribed from downtime documentation with original event time, transcription time and responsible person; retain the source record according to policy.
5. Reconcile every patient against the downtime tracker: registration, location, disposition, consultations, medicines, blood, procedures, specimens, imaging, results, referrals, discharge information and outstanding actions.
6. Identify duplicates, missing requests, conflicting results, delayed reports, unacknowledged critical values, unrecorded administrations, unresolved allergies and patients discharged before final information became available.
7. Contact patients promptly when new or corrected information changes treatment, follow-up or safety advice. Document attempts, communication and escalation for those not reached.
8. Restock and reseal downtime packs; recharge / replace batteries; refill oxygen and fuel; service failed equipment; restore forms and labels; replenish reagents and consumables; update reserve calculations.
9. Record actual and potential patient harm, staff injury, data loss, security exposure, equipment damage and service delays through the patient-safety / regulatory system.
10. Conduct an immediate operational debrief, followed by a multidisciplinary after-action review. Assign actions, owners, deadlines and executive oversight; update dependency maps, thresholds, training and mutual-aid arrangements.

16. Special populations and safeguards

| Population | Required safeguards |
|---|--|
| Children and neonates | Weight-based equipment / medicines, paediatric identifiers, thermal support, age-specific monitoring, family communication and early paediatric transfer threshold. |
| Pregnancy / postpartum | Protect maternal resuscitation, fetal assessment when appropriate, emergency blood and obstetric imaging / theatre pathways; do not delay maternal treatment for unavailable fetal monitoring. |
| Older adults / frailty | Prevent delirium, falls, pressure injury, missed medicines, hearing / vision barriers and prolonged unmonitored waiting during relocation or manual workflows. |
| Disability / communication need | Maintain communication aids, interpreters, carers, mobility equipment and accessible evacuation. Never mistake communication difficulty for lack of capacity. |
| Mental-health / behavioural emergency | Maintain observation, ligature / elopement safeguards, medication records, legal status and therapeutic communication despite electronic or security-system failure. |
| Home oxygen / ventilator / implanted device | Identify model, settings, battery / oxygen dependency and specialist contact. Use the patient device only when safe, compatible and supported by local policy. |
| Infection / isolation | Maintain source control, ventilation / room controls, PPE, cleaning and specimen pathways. Relocation must not spread contamination. |
| Safeguarding / unidentified patient | Preserve unique identity, protected location, authorized information sharing and safe handover. Downtime must not weaken child or adult safeguarding controls. |

17. Responsibilities

| Role / service | Ongoing responsibilities |
|---------------------------------------|--|
| Hospital executive / incident command | Maintain continuity governance, resources, mutual aid, decision authority, communication and recovery oversight. |
| ED medical and nursing leads | Recognize risk, activate fallback, prioritize patients, define safe capability, protect documentation and initiate transfer. |
| Facilities / estates | Maintain and test power, generators, fuel, medical gases, HVAC, water, alarms and building systems; provide authorized isolation and restoration. |
| IT / cybersecurity | Maintain resilience, backups, downtime access, containment, recovery and interface validation; communicate technical uncertainty honestly. |
| Biomedical engineering | Maintain device inventory, servicing, batteries, spares, substitutes, quarantine, repair, return-to-use checks and incident support. |
| Laboratory / blood bank | Maintain restricted service, manual tracking, referral arrangements, critical-result communication, temperature integrity and reconciliation. |
| Imaging | Maintain priority imaging, manual identity / requests / reports, alternative sites, equipment safety and image / report reconciliation. |
| Pharmacy | Support paper prescribing, high-risk medicine continuity, refrigeration assessment, stock alternatives, infusion safety and medicine reconciliation. |
| Security / communications / transport | Control access, support runners and radios, protect equipment / cylinders, maintain routes and assist transfer / evacuation. |
| Quality / patient safety | Support incident reporting, harm review, regulatory notification, audit, simulation and corrective-action tracking. |
| All staff | Use only approved workflows and substitutes; report failure early; verify identity; document clearly; escalate uncertainty and participate in recovery checks. |

18. Quality indicators and review

| Measure | Suggested review |
|-------------------|--|
| Preparedness | Current business impact analysis; dependency map; named leads; tested call lists; stocked downtime packs; validated reserve and transfer thresholds. |
| Power / utilities | Generator and UPS test completion; fuel readiness; time to technical assessment; number of unsupported critical devices; unplanned interruptions. |

| Measure | Suggested review |
|----------------------|--|
| Oxygen | Time from alarm to clinical escalation; reserve calculation documented; cylinder exchange failures; patients transferred before critical reserve. |
| Digital downtime | Time to manual workflow; two-identifier compliance; duplicate / missing registrations; unresolved paper records; restoration validation completed. |
| Laboratory / imaging | Turnaround for restricted emergency service; critical-result closed-loop rate; specimens / images lost or mismatched; transfers caused by unavailable diagnostics. |
| Equipment | Time to approved replacement; battery failures; devices quarantined correctly; patient incidents and regulatory reports; repeat faults. |
| Clinical outcomes | Delayed treatment, unmonitored intervals, medication omissions / duplication, missed results, unplanned ICU transfer, morbidity or death related to downtime. |
| Recovery | Time to reconciliation completion; number of outstanding results / reports; patients recalled; backlog duration; action plan completion. |
| Training | Proportion of staff trained; frequency and findings of planned / unannounced exercises; after-hours performance. |
| Equity / experience | Impact on children, disability, language access, mental health and vulnerable patients; complaints and communication quality. |

19. Evidence base and source framework

| Source | Key use in this protocol |
|--|---|
| World Health Organization. Health service continuity planning for public health emergencies; Hospital emergency response checklist; resilient-hospital and health-facility guidance. | Business impact analysis, continuity of essential services, incident command, critical infrastructure, backup systems, exercises and recovery. |
| World Health Organization. Medical use of oxygen resources; National medical oxygen scale-up plan; oxygen-system and device technical resources. | Oxygen as an essential medicine; source-distribution-delivery chain; power and maintenance dependencies; backup and system planning. |
| NHS England. Core Standards for Emergency Preparedness, Resilience and Response; Business Continuity Management resources. | Governance, assurance, business continuity, incident response, exercising, mutual aid and recovery. |
| NHS England / Department of Health. HTM 06-01 Electrical services supply and distribution; HTM 02-01 Medical gas pipeline systems. | Healthcare electrical resilience, essential supply, operational medical-gas management, alarms, responsible persons and maintenance. |
| US Office of the National Coordinator for Health Information Technology. 2025 SAFER Guides: Contingency Planning, System Management, Test Results Reporting and Follow-Up. | Planned / unplanned EHR unavailability, safe manual workflows, technical resilience, result tracking, recovery and organizational responsibility. |
| World Health Organization. Laboratory Quality Management System handbook and implementation tools. | Equipment management, patient / specimen identifiers, information management, referral laboratories, quality control and records. |
| Medicines and Healthcare products Regulatory Agency. Managing Medical Devices; reporting medical-device adverse incidents and current post-market safety resources. | Device inventory, training, maintenance, repair, quarantine, incident reporting and safe return to use. |
| Relevant national radiological, imaging, cybersecurity, fire, occupational safety, blood, pharmacy, privacy and emergency-management requirements. | Local legal duties, reporting thresholds, technical restrictions, records, data protection and professional responsibilities. |

This protocol should be reviewed against the current versions of cited sources, manufacturer instructions and locally approved technical plans at each formal review. Technical parameters, electrical switching, medical-gas isolation, cyber containment, radiation procedures, blood-bank rules and restoration tests remain the responsibility of appropriately authorized personnel.

Annex A. First 15-minute downtime checklist

| Priority | Action / record |
|------------------------|---|
| Alert | Time _____ Service / location _____ Recognized by _____ Level 1 / 2 / 3 Incident lead _____ |
| Immediate patient risk | <input type="checkbox"/> Ventilation <input type="checkbox"/> Oxygen <input type="checkbox"/> Suction <input type="checkbox"/> Infusion <input type="checkbox"/> Monitoring <input type="checkbox"/> Warming <input type="checkbox"/> Blood <input type="checkbox"/> Time-critical test / imaging |
| Scope / common cause | <input type="checkbox"/> One device <input type="checkbox"/> One room / circuit / zone <input type="checkbox"/> Department <input type="checkbox"/> Hospital <input type="checkbox"/> External utility <input type="checkbox"/> Cyber suspected |
| Safe state | Failed system / device isolated or controlled: _____ Authorized by _____ |
| Backup active | <input type="checkbox"/> Essential power / UPS <input type="checkbox"/> Cylinder oxygen <input type="checkbox"/> Portable suction <input type="checkbox"/> Paper workflow <input type="checkbox"/> POCT <input type="checkbox"/> Alternate imaging <input type="checkbox"/> Spare device |
| Limiting reserve | Resource _____ Quantity / runtime _____ Safety threshold _____ Recheck time _____ |
| Patients prioritized | Critical patients / location / dependency: _____ |
| Demand reduction | <input type="checkbox"/> Non-urgent activity stopped <input type="checkbox"/> Ambulance diversion / notice <input type="checkbox"/> Patients consolidated <input type="checkbox"/> Early discharge / transfer reviewed |
| Communications | Primary _____ Backup _____ Next status update _____ External notification _____ |
| Transfer / evacuation | Patients requiring early movement: _____ Destination / transport _____ |
| Manual tracking | Downtime number range _____ Tracker owner _____ Result log owner _____ Forms / labels issued _____ |
| Next command review | Time _____ Priority risks / actions _____ |

Annex B. Downtime level and action matrix

| Scenario | Immediate actions | Escalation threshold |
|-----------------------------------|---|---|
| Localized device / workstation | Use approved spare; quarantine failure; maintain patient care; report and monitor for common cause. | Escalate if no substitute, repeated faults, critical patient affected or repair estimate exceeds clinical window. |
| Departmental power / gas zone | Consolidate patients into supported areas; verify backup; calculate reserve; restrict activity; facilities / gas lead on scene. | Full command if essential supply unstable, reserve declining, fire / building risk or movement required. |
| Hospital-wide IT / communications | Manual registration, notes, orders, medicines, specimens, images, results and tracker; cyber assessment; runners / radios. | Full command for cyber suspicion, identity failure, prolonged outage, loss of results / prescribing or regional effect. |
| Laboratory / blood bank | Restricted menu, POCT, manual accession / critical results, referral testing, blood continuity. | Transfer / mutual aid if decision-critical testing or compatible blood cannot be supplied in time. |
| Imaging / PACS / modality | Restricted imaging pathway, manual requests, bedside alternatives, direct reporting, local image storage. | Transfer if time-critical imaging / intervention unavailable or equipment safety uncertain. |
| Multiple cascading failures | Assume Level 3; protect resuscitation, activate hospital command, external support, transfer / evacuation planning. | Escalation remains until technical and clinical stability plus adequate reserve are verified. |

Annex C. Manual patient, order and result tracking template

| Field | Record |
|---------------------------|---|
| Downtime patient identity | Temporary / hospital ID _____ Name _____ DOB / estimated age _____ Sex _____ Wristband applied <input type="checkbox"/> |
| Arrival / location | Arrival date / time _____ Arrival route _____ Current location _____ Responsible clinician / nurse _____ |
| Critical information | Allergies _____ Medicines / anticoagulants _____ Resuscitation / escalation plan _____ |
| Order / request | Sequence no. _____ Date / time _____ Test / image / consultation / medicine _____ Priority _____ Requester _____ |
| Specimen / examination | Collected / performed time _____ Collector / operator _____ Destination / modality _____ Identifier verified <input type="checkbox"/> |
| Acknowledgement | Received by _____ Time _____ Status / expected completion _____ |
| Result / response | Result / advice _____ |
| Critical-result loop | Communicated by _____ to _____ at _____ Read-back <input type="checkbox"/> Action / time _____ |
| Disposition / follow-up | Admit / transfer / discharge / remain _____ Pending items _____ Contact plan _____ |
| Electronic reconciliation | Entered / scanned by _____ at _____ Original event time preserved <input type="checkbox"/> Checked by _____ Outstanding action _____ |

Annex D. Oxygen reserve quick guide - local validation required

| Step | Action |
|--------------------------------|--|
| 1. Identify every consumer | Record patient interface / device, source, current flow or manufacturer-specified gas consumption, and whether medical air is also required. |
| 2. Determine usable contents | Prefer the cylinder / manifold contents displayed by the approved local system. If estimating from pressure and cylinder water capacity, use the locally validated conversion and units. |
| 3. Apply safety reserve | Subtract the approved reserve; never plan to empty a cylinder completely. Include exchange time, transport delay and inaccessible stock. |
| 4. Calculate duration | Approximate duration (minutes) = usable oxygen contents (litres) divided by total oxygen consumption (litres per minute). Recalculate whenever demand changes. |
| 5. Account for device behavior | Ventilators, HFNO, CPAP / NIV, blenders and anaesthetic systems may consume substantially more than a simple displayed patient flow. Use manufacturer / engineering data. |
| 6. Trigger action early | Transfer / resupply threshold must exceed preparation plus travel plus expected delay. Do not use uncertain restoration time to justify waiting. |
| Safety prohibitions | No improvised splitters, non-medical oxygen, oil / grease on fittings, unsecured cylinders, unapproved adapters or unauthorized pipeline isolation. |

Annex E. Minimum operating capability status board

| Domain | Rating | Current status / constraint / owner / next review |
|----------------------------------|---------------------|--|
| Essential power / generator | Green / Amber / Red | Status _____ Fuel / runtime _____ Unsupported areas _____ Owner _____ Recheck _____ |
| Oxygen / medical air / suction | Green / Amber / Red | Source _____ Reserve _____ Demand _____ Alarm / zone status _____ Owner _____ |
| EHR / registration / prescribing | Green / Amber / Red | Functions available _____ Manual workflow active <input type="checkbox"/> Cyber concern <input type="checkbox"/> Owner _____ |
| Communications | Green / Amber / Red | Landline _____ Mobile _____ Radio _____ Runner _____ Public address _____ |
| Laboratory / blood bank | Green / Amber / Red | Emergency menu _____ POCT _____ Blood status _____ Referral / courier _____ |
| Imaging | Green / Amber / Red | CT _____ X-ray _____ Ultrasound _____ PACS / reporting _____ Transfer site _____ |

| Domain | Rating | Current status / constraint / owner / next review |
|----------------------|---------------------|---|
| Critical equipment | Green / Amber / Red | Ventilators _____ Monitors _____ Pumps _____ Defibrillators _____ Warmers _____ |
| Environment / access | Green / Amber / Red | Lighting _____ HVAC _____ Fire systems _____ Doors / lifts _____ Water _____ |
| Clinical capacity | Green / Amber / Red | Resuscitation bays _____ Critical patients _____ Transfers pending _____ Diversion status _____ |

Annex F. Restoration and reconciliation checklist

| Check | Evidence |
|---------------------------|---|
| Authorization | <input type="checkbox"/> Technical lead confirms required repair / isolation / testing <input type="checkbox"/> Clinical lead approves staged return <input type="checkbox"/> Incident commander sets sequence |
| Infrastructure validation | <input type="checkbox"/> Power stable <input type="checkbox"/> Correct outlets <input type="checkbox"/> Gas / suction verified <input type="checkbox"/> Alarms <input type="checkbox"/> HVAC / temperature <input type="checkbox"/> Doors / lifts / fire systems |
| Digital validation | <input type="checkbox"/> Identity <input type="checkbox"/> Allergies <input type="checkbox"/> Medicines <input type="checkbox"/> Orders <input type="checkbox"/> Labels <input type="checkbox"/> Results <input type="checkbox"/> Imaging <input type="checkbox"/> Prescribing <input type="checkbox"/> Interfaces <input type="checkbox"/> Audit trail |
| Equipment return | <input type="checkbox"/> Authorized inspection / repair <input type="checkbox"/> Function test <input type="checkbox"/> Correct configuration <input type="checkbox"/> Cleaning <input type="checkbox"/> User check <input type="checkbox"/> Quarantine removed |
| Patient reconciliation | <input type="checkbox"/> Every patient on tracker located / disposed <input type="checkbox"/> Paper record retained <input type="checkbox"/> Allergies / medicines / procedures / blood entered |
| Orders / tests / images | <input type="checkbox"/> All requests matched <input type="checkbox"/> Duplicates stopped <input type="checkbox"/> Unprocessed items identified <input type="checkbox"/> Images archived <input type="checkbox"/> Reports delivered |
| Critical results | <input type="checkbox"/> All critical values acknowledged and acted on <input type="checkbox"/> Outstanding results assigned <input type="checkbox"/> Discharged patients contacted as needed |
| Backlog / staffing | <input type="checkbox"/> Priority sequence <input type="checkbox"/> Adequate staff / rest <input type="checkbox"/> No unsafe simultaneous catch-up <input type="checkbox"/> Next review time |
| Incident closure | <input type="checkbox"/> Harm / near miss reported <input type="checkbox"/> Equipment / data preserved <input type="checkbox"/> Stocks restored <input type="checkbox"/> Debrief <input type="checkbox"/> After-action review <input type="checkbox"/> Actions assigned |

Annex G. Local configuration and approval checklist

| Item | Approved local rule / contact / document location |
|---|---|
| 24-hour incident-command activation authority and backup | _____ |
| Electricity supplier, facilities, generator contractor and fuel contacts | _____ |
| Essential circuits / outlets, generator load priorities and UPS locations | _____ |
| Generator fuel capacity, refueling arrangements and prolonged-outage threshold | _____ |
| Medical-gas authorized persons, supplier, source / manifold and emergency contacts | _____ |
| Oxygen cylinder types, usable contents, regulators, trolleys, stores and reserve threshold | _____ |
| Approved oxygen, suction, ventilation and manual-rescue alternatives | _____ |
| IT / cybersecurity contacts, downtime declaration, communication and containment rules | _____ |
| Offline / read-only clinical information and downtime number process | _____ |
| Locations and contents of downtime packs; responsible person for checks | _____ |
| Laboratory emergency test menu, POCT, referral laboratory and courier | _____ |
| Blood-bank emergency-release and compatibility continuity procedures | _____ |
| Imaging restricted service, PACS / RIS fallback, alternative site and transport | _____ |
| Biomedical engineering contacts, critical spare equipment and battery programme | _____ |
| Approved substitutes / manual methods for monitors, pumps, suction, warming and ventilation | _____ |
| Regional hospitals, ambulance, air / sea transfer and acceptance contacts | _____ |
| Evacuation routes, powered doors / lifts, fire systems and security contingencies | _____ |
| Patient-safety, device, cyber, data-breach, radiation and statutory reporting routes | _____ |
| Training / exercise frequency and last completed exercise | _____ |
| Multidisciplinary approval signatures and date | _____ |