Introduction
The effect of Acute Kidney Injury (AKI) on patient outcomes and health care systems has been demonstrated internationally (1). In the past two decades, Ireland has documented a rising incidence of AKI, particularly among hospitalized patients and the elderly (2). When compared with other OECD countries, Ireland has a high health expenditure but a relatively low number of hospital beds per capita (3). AKI places further demands on a hospital system that is already pressurized. Northern Ireland, as part of the United Kingdom, is subject to a different governance and health care system. This article describes the experience with AKI for the island of Ireland in its entirety, including comments on clinical practice differences between the Republic of Ireland (RoI) and Northern Ireland (NI) where relevant.

Epidemiology of AKI in Ireland
Ireland does not have a national surveillance or audit system for AKI cases, and hence epidemiologic data are limited. One retrospective study using regional laboratory data reported an AKI incidence of 12% per 100 patient-years in 2014 (2). These data were predominantly gathered from the mid-west and northwest of Ireland. As the east of the country is the most populous region, these data may not be generalizable. However, this AKI incidence is comparable with the pooled incidence rate of 15% reported for Northern Europe in a meta-analysis of worldwide AKI rates (4). The majority of captured AKI cases in Ireland are diagnosed in a hospital context (inpatient, emergency department attendance, or outpatient clinic), with approximately 10% of cases diagnosed from samples requested from primary care practices (2). The authors are of the opinion that the effect of community-diagnosed AKI may be under-represented in published data.

Patients admitted to the intensive care unit (ICU) in Ireland have high illness severity on admission compared with international data, as evidenced by high Acute Physiology, Age, Chronic Health Evaluation 2 scores and the relatively high proportion of patients receiving advanced respiratory support (5–7). According to data published by the National Office of Clinical Audit (NOCA), 52% of patients admitted to the ICU in the RoI developed AKI (stages 1–3) within 24 hours of admission to the ICU (5,8). Comparable data from NI reported an incidence of 36% (8). These rates are similar to those documented for other European countries but exceed incidence rates reported in the United States, Asia, Australia, and New Zealand (9). Approximately 10% of AKI cases in the ICU receive RRT (both intermittent and continuous modalities).

Methodology of AKI Diagnosis
Trends in the diagnosis of AKI in Ireland have followed the evolution of standardized diagnostic criteria. The Kidney Diseases Improving Global Outcomes classification system is currently in widespread use (10). In recent years, this has been increasingly utilized in clinical practice and in AKI research. NI developed and adopted a national algorithm for the management of AKI (11). It has been incorporated into the regional laboratory system, triggering an alert, prompting earlier recognition of AKI. A similar national algorithm has not been implemented in the RoI, but local data would suggest that there is an appetite for implementing such a framework (12).

There is limited use of kidney injury biomarkers in a clinical context. However, some nephrologists have recently begun to use neutrophil gelatinase-associated lipocalin (NGAL) to improve diagnostic discrimination and aid management of AKI in routine clinical practice (13). Cote et al. reported on the use of plasma and urinary NGAL in a heterogeneous cohort of AKI patients in their institution. In their experience, prospectively measured urinary NGAL helped differentiate between transient (functional) AKI and persistent AKI. These results may prompt a shift in attitude and practice patterns in other centers in Ireland. The furosemide stress test can aid the prediction of AKI progression and renal recovery after RRT (14–16). The furosemide stress test is gaining acceptance among many nephrologists in Ireland as an easily conducted and cost-effective diagnostic tool in the management of AKI. It has been more widely incorporated into clinical nephrology practice than the use of plasma or urinary AKI biomarkers.

Prophylactic Prevention of AKI in High-Risk Patients
Factors such as major surgery and exposure to nephrotoxic drugs confer an increased risk of AKI.

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development, providing an opportunity for risk stratification and AKI prophylaxis. Data from Irish hospital admissions report an incidence of postoperative AKI in the range of 14%–19% and 20%–30% for noncardiac surgery and cardiac surgery patients, respectively (17–21). Preoperative renal risk prediction includes the measurement of serum creatinine and calculation of eGFR and, less frequently, detection and quantification of albuminuria. Risk stratification models are not routinely used in preoperative assessment, but some nephrologists utilize the Cleveland Clinic (Dialysis Risk after Cardiac Surgery) Score (22). In our experience, those with underlying CKD are often prioritized for preprocedure nephrology assessment to aid in medication reconciliation, hemodynamic optimization, and close postoperative monitoring. Such strategies are often omitted in those with a normal preprocedure creatinine, despite the possibility of a low renal reserve. Kidney injury biomarkers are not routinely utilized to risk stratify patients undergoing cardiothoracic surgery or prior to any other anticipated renal threat (toxic or hemodynamic). In particular, Nephrocheck, which measures the urinary concentrations of [TIMP-2]×[IGFBP-7], has not been adopted in clinical practice in Ireland.

Prophylactic strategies are evidence based and reserved for selective patient populations. Prophylactic strategies in routine clinic use in Ireland include pre- and postinsult volume expansion for those receiving cisplatin-based chemotherapy, early fluid resuscitation in cases of rhabdomyolysis, intravenous hydration and hypouricemic agents in tumor lysis syndrome, and therapeutic drug monitoring for potentially nephrotoxic antimicrobial agents. In terms of the prevention of contrast-associated AKI, clinical practice has followed international trends. In the RoI, pre- and postcontrast volume expansion strategies are generally reserved for patients with an eGFR <30 ml/min per 1.73 m² for computed tomography, with a higher eGFR threshold generally used for those undergoing angiography (<45 ml/min per 1.73 m² or <60 ml/min per 1.73 m²). The Northern Ireland Guidelines for AKI recommend adequate volume expansion for those receiving radiologic contrast media with an eGFR <30 ml/min per 1.73 m² (or <60 ml/min per 1.73 m² with additional AKI risk factors) (11). The choices of fluid preparation, volume, and rate and route of administration vary, depending on physician and department preference. N-acetylcysteine is no longer in routine use as part of these regimens.

Organizational Structure and RRT Management

The availability of RRT varies according to the hospital level. Renal units are primarily located in larger tertiary referral centers (see Figure 1), with some smaller regional hospitals also providing intermittent hemodialysis (23). In larger centers, both intermittent and continuous modalities

Figure 1. | Map of the major renal units in Ireland. The majority of these units are tertiary referral centers, with a smaller number of regional hospitals. These units have dialysis centers and access to specialist nephrology services.
are available. ICUs are a mix of open and closed units, and working relationships between nephrologists and intensivists are harmonious. Most nephrology consultants in Ireland are also general medical physicians and manage their own cohort of acute and chronic renal inpatients and general medical inpatients, in addition to providing advice and support to other specialties.

RRT prescribing is conducted by both specialties: nephrologists almost exclusively prescribe and monitor the use of intermittent modalities, whereas continuous modalities are prescribed and overseen by both critical care and nephrology physicians. As Ireland has a relatively low ICU bed capacity, available ICU beds are in high demand (3).

Most patients with sustained AKI are treated with a combination of continuous and intermittent modalities because their illness acuity changes. We do not have a documented national breakdown of the proportional use of each RRT modality, but the authors estimate an approximate 50:50 balance between continuous and intermittent modalities in the acute setting. The preferred intermittent modality is intermittent hemodialfiltration. Prolonged intermittent hemodialfiltration is used infrequently. Continuous RRT (predominantly continuous venovenous hemodiafiltration) is available solely in ICUs, and the decision to opt for this modality is dictated by the individual clinical circumstances and to a lesser degree by resource availability. RRT (both continuous and intermittent) is funded by the health service, and no patient in need of dialysis is denied it for financial reasons.

AKI Outcomes

Outcome data for AKI survivors are not nationally audited in Ireland. The data captured stem predominantly from ICU audit data, which are recorded by NOCA in the RoI and by the Intensive Care National Audit and Research Centre in NI. Data gathered from more than 22,000 ICU admissions in NI from 1999 to 2007 reported ICU and hospital mortality rates for those with early AKI of 30% and 41%, respectively (8). Data from the Dublin Acute Biomarker Group Evaluation (DAMAGE) Study, a prospective cohort study of critically ill patients, reported that 98 of 186 patients with early AKI progressed to death or RRT within 30 days of admission (24). Unpublished data from the DAMAGE study found that among critically ill patients with AKI who survived to hospital discharge, the 12-month mortality rate was 13%. This compared with a mortality rate of 7% for those who did not develop AKI. Stack et al. highlighted the importance of AKI as a risk factor for CKD (25). In their study of patients in RoI, the prevalence of CKD was almost 50% among patients with a past history of AKI. Unfortunately, long-term survival data and outcomes such as the progression or development of CKD and cardiovascular events are not audited or recorded nationally.

AKI Follow-Up

In Ireland, AKI clinical follow-up practices (criteria for nephrology outpatient follow-up, and timing and duration of follow-up) vary between departments, but there is a consensus among nephrologists that most AKI survivors require clinical follow-up. This takes place in nephrology outpatient clinics for those with prolonged or severe AKI (stage 2 and above), incomplete renal recovery, or proteinuria. Those with functional or prerenal AKI that resolves promptly are often followed up in primary care, with guidance from nephrology departments. The NI guidelines for AKI recommend that those patients who are still recovering from AKI at the time of hospital discharge require follow-up renal function tests to guide decisions regarding nephrology referral and to document recovery of baseline renal function.

Challenges and Conclusion

The effect of AKI on patient outcomes and hospital resources in Ireland mirrors that reported internationally. However, infrastructural limitations on the health care system pose additional challenges in the management of AKI. As previously mentioned, Ireland has a relatively low number of hospital beds and a shortage of ICU beds. Bed shortages often delay interhospital and ICU transfers, sometimes affecting the timing of RRT initiation. Consultant nephrology staffing levels are also low by international standards. In 2014, the RoI had 4.6 whole-time equivalent (WTE) nephrologists per million population (26). This figure is now closer to 8 WTE per million population. The authors estimate that NI has 13.8 WTE nephrologists per million population (27). This compares with 7.4 for the United Kingdom and 20.1 per million population for Europe (28). Hence, in reality, the timely and ongoing clinical follow-up of AKI survivors may be influenced by staffing and resource availability. An island-wide audit of AKI epidemiology and outcomes is warranted. There is a clear need for coordinated collation of AKI outcome data for Ireland, which could guide nephrology service planning and development nationally. Ultimately, this would improve the management and outcomes of this resource-intensive syndrome.

Disclosures

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Author Contributions

P. Murray was responsible for supervision; P. Murray and L. Redahan were responsible for conceptualization reviewed and
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