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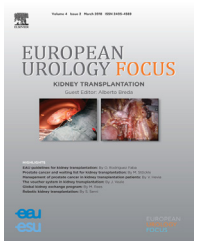

Statistics in Urology

Unwarranted Between-hospital Variation in Mortality, Readmission, and Length of Stay of Urological Admissions: An Important Trigger for Prioritising Quality Targets

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Abstract

Background: Unwarranted between-hospital variation is a persistent health care quality issue. It is unknown whether urology patients are prone to this variation.
Objective: To examine between-hospital variation in mortality, readmission, and length of stay for all 22 urological All Patient Refined Diagnosis Related Groups (APR-DRGs).
Design, setting, and participants: This study included administrative data from 320 640 urological admissions in 99 (98%) Belgian acute-care hospitals between 2016 and 2018.
Outcome measurements and statistical analysis: We used hierarchical mixed-effect logistic regression models to estimate hospital-specific and APR-DRG–specific risk-standardised rates for in-hospital mortality, 30-d readmission, and length of stay above the APR-DRG–specific 90th percentile. Between-hospital variation was assessed based on the estimated variance components. Associations of outcomes with patient and hospital characteristics and time trends were examined.
Results and limitations: Our analysis revealed important between-hospital variation in mortality, readmission, and length of stay for urological pathologies, particularly for medical diagnoses. Significant variation was shown in all three outcomes for kidney and urinary tract infections; other kidney and urinary tract diagnoses, signs, and symptoms; urinary stones and acquired upper urinary tract obstruction; and kidney and urinary tract procedures for nonmalignancy. Lowering of mortality rates in upper-quartile hospitals to the median could potentially save 41.5% of deaths in these hospitals, with the largest absolute gain for kidney and urinary tract infections and kidney and urinary tract malignancy. Limitations included a likely underestimation of readmission rates.

Abbreviations: LOS, length-of-stay; APR-DRG, All Patient Refined Diagnosis Related Group; QI, quality improvement; MOR, Median Odds Ratio; ICD-9-CM, International Classification of Diseases 9-Clinical Modification.

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Conclusions: Urological patient outcomes are characterised by unwarranted between-hospital variation. We recommend improvement initiatives to prioritise kidney and urinary tract infections because of significant variation across the three outcomes and the largest potential gain in lives saved.
Patient summary: We found notable between-hospital variation in mortality, readmission, and length of stay for urological hospital admissions in Belgium. As much as 41.5% of deaths could potentially be avoided if underperforming hospitals improved. Targeting kidney and urinary tract infections could help reduce variation.

1. Introduction

The concept of unwarranted health care variation was first described more than 80 yr ago [1], yet today numerous studies continue to suggest that outcomes vary between hospitals [2–10]. Between-hospital variation in patient outcomes has been documented to correlate with numerous hospital factors, such as volume [5,8], teaching status [11,12], nurse staffing levels [9,10], and geographic region [6,8]. Further monitoring and understanding sources of variation are key steps in supporting effective policies to reduce unwarranted variation, increase health outcomes, and reduce expenditures [6]. Subsequently, there is a need to prioritise interventions with the largest potential to reduce variation in patient outcomes [13]. Mortality, readmissions, and length of stay (LOS) are often considered the "vital few" patient outcomes among the "trivial many" to be monitored. Despite their acknowledged importance, not many studies exist where all three outcomes are studied simultaneously [14], with the majority of studies remaining limited to only one [2,7] or two [3,4,15] outcomes and restricted to a select number of diagnoses or procedures [2–4,7,14,15]. We hypothesised that between-hospital variation in quality of care for urological pathologies is substantial; yet today, little is known about the topic [16–18], with no overarching research conducted to our knowledge. In order to determine priorities for future quality improvement (QI) initiatives, we examined between-hospital variation in mortality, readmission, and LOS rates across Belgian acute-care hospitals for all urological All Patient Refined Diagnosis Related Groups (APR-DRGs). We also assessed associations between outcomes and patient and hospital characteristics. Finally, we considered whether the number of lives potentially saved, if mortality were to improve, is sizable. As a secondary aim, we looked at trends in urological mortality, readmission, and LOS rates over time.

2. Patient and methods

2.1. Data source and study population

We obtained the Belgian Hospital Discharge Set on all inpatient hospitalisations from all 103 Belgian acute-care hospitals for the years 2012–2018, excluding psychiatric stays and 1-d clinics. The dataset was provided by the federal health authorities and contains patient demographics, hospital stay characteristics, and clinical data, that is, primary and secondary diagnoses and diagnostic and therapeutic procedures according to International Classification of Diseases 9-Clinical Modification (ICD-9-CM) up to 2014 and ICD-10-CM from 2016 onwards. In 2015, registration of diagnoses using ICD was not mandatory in Belgium. We excluded data from two hospitals with exclusive specialist care, and data from two hospital mergers during the study period were combined; thus, our final sample included 99 hospitals.

The APR-DRG 31.0 (3M) grouping system was used to select all 22 urological pathologies (Table 1), which fall within Major Diagnostic Categories 11 (kidney and urinary tract) and 12 (male reproductive system). Of these, 13 are surgical procedures, while nine involve medical diagnoses. An overview of the majority of diagnoses and procedures that fall under one particular APR-DRG is provided in Supplementary Table 1. We used the three available years with ICD-10-CM data (2016–2018) as the main study period, including 320 640 hospital stays. For the assessment of trends over time, we included all 296 766 urological hospital stays registered in the period 2012–2014.

2.2. Outcomes and patient and hospital characteristics

We investigated three outcomes: all-cause in-hospital mortality, 30-d readmission, and LOS above the APR-DRG–specific 90th percentile, hereafter referred to as upper-decile LOS. We opted for the latter as the overall urological 90th percentile was set at 13 d, a patient stay generally accepted as long [19]. A readmission was defined as an all-cause, nonelective admission to the same hospital within 30 d of discharge following the index admission. Readmissions remained limited to those within hospital, as patient identifiers are specific for each hospital, thus preventing research of between-hospital readmissions. The index admission was used as the unit of analysis, so each readmission of a patient is again an index admission for a subsequent readmission. Transfers, discharges against medical advice, and admissions ending with the patient's death were not considered as index admissions. As anonymised patient identifiers are changed each calendar year, readmissions occurring in the next calendar year could not be identified, so all admissions in the month of December were excluded as index admissions.

Patient demographics included sex, age, number of comorbidities, place before admission, and admission type. Age was categorised into 10-yr age groups, which were, for each APR-DRG and outcome combination, grouped to contain at least ten cases in each category. We used the R-package "comorbidity" [20] to obtain the (unweighted) number of Elixhauser comorbidities, categorised as zero,

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Table 1 – Overview of the included urological All Patient Refined-Diagnosis Related Groups (APR-DRGs)

APR-DRG	Diagnosis description	Abbreviation	Type
440	Kidney transplant	KTr	Surgical
441	Major bladder procedures	MBP	Surgical
442	Kidney and urinary tract procedures for malignancy	UTM	Surgical
443	Kidney and urinary tract procedures for nonmalignancy	UTNM	Surgical
444	Renal dialysis access device procedure only	DIAL	Surgical
445	Other bladder procedures	OBl	Surgical
446	Urethral and transurethral procedures	TUP	Surgical
447	Other kidney, urinary tract, and related procedures	OUT	Surgical
460	Renal failure	RF	Medical
461	Kidney and urinary tract malignancy	UTMD	Medical
462	Nephritis and nephrosis	NEPH	Medical
463	Kidney and urinary tract infections	UTI	Medical
465	Urinary stones and acquired upper urinary tract obstruction	USO	Medical
466	Malfunction, reaction, and complication of genitourinary device or procedure	DEV	Medical
468	Other kidney and urinary tract diagnoses, signs, and symptoms	OUTD	Medical
480	Major male pelvic procedures	MMPP	Surgical
481	Penis procedures	PENP	Surgical
482	Transurethral prostatectomy	TURP	Surgical
483	Testes and scrotal procedures	TSP	Surgical
484	Other male reproductive system and related procedures	OMRP	Surgical
500	Malignancy, male reproductive system	MMRSD	Medical
501	Male reproductive system diagnoses except malignancy	MRSD	Medical

one to four, and five or more comorbidities. Place before admission was defined as home, other hospital or nursing home, and on the road or other. Admission type was categorised as elective or emergency. Hospital characteristics included region (Flanders, Wallonia, and Brussels), hospital type (academic or general), and urological volume. Urological volume was calculated for each hospital as the average annual number of admissions for the 22 selected APR-DRGs and was categorised into tertiles: <700 admissions (low volume), 700–1100 admissions (medium volume), and ≥1100 admissions (high volume).

2.3. Statistical analyses

Using the SAS-GLIMMIX procedure, we fitted logistic hierarchical linear models with a random intercept for each hospital to account for hospital-level clustering. APR-DRG–specific models were run for each of the three binary outcomes. In a first set of models, only patient characteristics were included as fixed effects, whereas a second set of models also included hospital characteristics. For each APR-DRG, hospital-specific risk-standardised mortality rates were calculated as the ratio of predicted and expected deaths (estimated by the model including only patient characteristics), multiplied by the overall crude mortality rate for that APR-DRG. The predicted number of deaths was obtained as the hospital-specific prediction from the logistic hierarchical linear model including both the fixed effects and the hospital-specific random intercept (ie, the best linear unbiased predictor), whereas the expected number of deaths is the prediction including only the fixed effects. Hospitals for which the random intercept estimate was significantly higher (or lower) than zero were identified as hospitals with significantly higher (or lower) than expected mortality. Significance of the between-hospital variation in mortality risk was based on a Wald test for the random hospital effect, and the variation was quantified by means of the median odds ratio (MOR) [21]. If one were to repeatedly sample at random two patients with the same covariates (ie, same fixed effects) from different hospitals, then the MOR is the median odds of mortality for the patient in the high-risk hospital compared with the patient in the low-risk hospital. The same methods were used for readmission and upper-decile LOS.

3. Results

3.1. Descriptives

Of the 99 hospitals included, 52 are located in Flanders, 36 in Wallonia, and 11 in Brussels. Seven hospitals are academic. The majority of included APR-DRGs occurred in all included hospitals (Table 2), while kidney transplant (KTr) occurs in only seven hospitals, as this procedure occurred exclusively in academic centres. The most frequent APR-DRG was kidney and urinary tract infections (UTIs), representing nearly 20% of all urological hospital admissions, whereas KTr was least frequent (0.5% of admissions). The highest mortality rates were observed in two cancer APR-DRGs, that is, malignancy of the male reproductive system (MMRSD) and kidney and urinary tract malignancy (UTMD; 21.9% and 17.1% mortality, respectively). Readmission rates ranged from 2.6% (testes and scrotal procedures) to 12.6% (major bladder procedures). The latter also caused the longest LOS, with 10% of patients staying for 28 d or longer.

3.2. Between-hospital variation in patient outcomes

Fig. 1 shows that, after adjusting for patient characteristics, significant variation in between-hospital risk for all three outcomes was observed for three medical APR-DRGs (UTIs; other kidney and urinary tract diagnoses, signs, and symptoms [OUTD]; and urinary stones and acquired upper urinary tract obstruction [USO]) and one surgical APR-DRG (kidney and urinary tract procedures for nonmalignancy [UTNM]). Significant variation in the risk for two out of three outcomes was found for MMRSD, renal failure (RF), kidney and urinary tract procedures for malignancy, and malfunction, reaction, and complication of genitourinary device or procedure (DEV; mortality and upper-decile LOS), and for major male pelvic procedures (MMPPs), urethral and transurethral procedures, male reproductive system diagnoses except malignancy (MRSD), and transurethral prostatectomy (readmission and upper-decile LOS). UTIs ranked highest based on significance of the variation in risk ($p < 0.001$ for the three outcomes). For mortality, the MOR was nearly twofold higher (Supplementary Table 2) for UTMD at a high-risk hospital than that at a low-risk hospital. Additionally, six hospitals had signif-

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Table 2 – Characteristics of urological hospital admissions in Belgium, 2016–2018

APR-DRG	No. of hosp.	Admissions		Mort. (%)	Readm. (%)	LOS P90	Age, mean ± SD	Sex	No. of comorbidit		Place before admission		Type of admission
		Total (*N*)	Yearly *N* per hospital, median (IQR)					Male (%)	1–4 (%)	≥5 (%)	Other hospital or nursing home (%)	Other (%)	Emergency (%)
Total	99	320 64	1271 (874–1967)	2.2	7.8	13	63 ± 21	66.8	41.5	8.1	5.5	1.7	50.7
440—Kidney transplant	7	1468	63 (51–89)	0.3	9.3	24	53 ± 14	64.2	79.6	8.4	0.7	0.4	72.5
441—Major bladder procedures	99	4743	12 (6–21)	2.4	12.6	28	67 ± 16	71.1	57.5	8.3	1.7	0.6	9.6
442—Kidney and urinary tract procedures for malignancy	99	6553	16 (9–32)	1.7	6.8	13	67 ± 13	66.2	56.9	6.6	0.9	0.2	6.3
443—Kidney and urinary tract procedures for nonmalignancy	99	25 496	61 (34–107)	0.8	7.6	10	57 ± 20	57.1	36.8	4.0	2.4	1.2	31.2
444—Renal dialysis access device procedures only	82	2881	10 (4–18)	0.3	6.4	4	66 ± 15	64.8	76.3	11.3	1.1	0.5	5.8
445—Other bladder procedures	99	4234	10 (5–17)	0.6	6.4	9	67 ± 17	66.1	38.7	4.6	3.4	0.6	24.2
446—Urethral and transurethral procedures	99	41 197	115 (70–185)	0.3	6.6	4	64 ± 17	73.6	32.4	2.2	1.0	1.0	26.1
447—Other kidney, urinary tract, and related procedures	96	2180	6 (3–11)	4.6	6.6	25	65 ± 17	55.1	57.1	16.7	4.5	1.4	26.2
460—Renal failure	99	12 773	38 (19–58)	11.0	9.4	24	72 ± 17	54.3	58.8	32.9	12.5	2.4	71.0
461—Kidney and urinary tract malignancy	99	5747	16 (10–26)	17.1	10.0	19	73 ± 14	71.4	61.1	12.5	6.4	1.1	40.0
462—Nephritis and nephrosis	99	2480	6 (2–13)	1.5	6.3	13	45 ± 27	59.3	46.9	9.0	5.0	1.4	41.4
463—Kidney and urinary tract infections	99	62 464	182 (133–274)	3.0	8.0	18	61 ± 29	30.0	47.5	13.8	14.9	2.3	90.6
465—Urinary stones and acquired upper UT obstruction	99	35 260	106 (73–153)	0.1	8.9	3	51 ± 17	68.5	21.4	0.9	1.1	3.3	81.7
466—Malfunction, reaction, compl. of genitourinary device or proc.	99	7650	17 (10–32)	2.1	11.5	14	66 ± 19	67.0	55.0	13.7	11.0	2.5	72.2
468—Other kidney and UT diagnoses, signs, and symptoms	99	34 281	86 (61–140)	2.2	9.2	13	69 ± 18	66.7	49.8	13.4	6.5	2.4	56.6
480—Major male pelvic procedures	97	12 158	22 (10–53)	0.2	5.4	8	66 ± 7	100.0	43.2	1.2	0.3	0.1	0.9
481—Penis procedures	98	3335	5 (2–12)	0.0	3.3	5	42 ± 28	100.0	21.6	1.0	1.2	0.6	9.8
482—Transurethral prostatectomy	99	24 337	63 (37–100)	0.2	8.1	6	71 ± 9	100.0	37.2	2.3	0.7	0.2	4.3
483—Testes and scrotal procedures	99	6483	18 (9–31)	0.1	2.6	2	41 ± 24	100.0	21.5	1.1	0.8	2.0	26.8
484—Other male reproductive system and related proc.	99	5747	13 (7–28)	0.4	6.6	9	70 ± 10	100.0	37.4	2.4	0.6	0.4	6.3
500—Malignancy, male reproductive system	99	3899	11 (6–18)	21.9	11.3	23	75 ± 13	100.0	66.1	14.2	8.0	1.3	48.7
501—Male reproductive system diagnoses except malignancy	99	15 274	43 (27–66)	0.7	6.0	10	64 ± 20	100.0	37.7	6.3	4.3	2.7	77.8

APR-DRG = All Patient Refined Diagnosis Related Groups; compl. =, complication; hosp. = hospitals; IQR = interquartile range; LOS = length of stay; Mort. = mortality; Readm. = readmission; P90 = 90th percentile; proc. = procedure; SD = standard deviation; UT = urinary tract.
Grey indicates a surgical APR-DRG.

icantly worse and 16 significantly better mortality than expected for this APR-DRG. For both readmission and upper-decile LOS, MMPPs showed the highest MORs (1.67 and 3.08, respectively).

3.3. Associations with patient and hospital characteristics

In general, odds of mortality and readmission were higher for men than for women (Supplementary Table 3), whereas odds of upper-decile LOS were lower for men. For the three outcomes, odds were higher for a higher number of comorbidities and for emergency admissions. Patients admitted from nursing homes or other hospitals often had higher odds of mortality and upper-decile LOS than patients admitted from home. In most APR-DRGs, the risk of mortality and readmission was not significantly associated with the year of discharge, but the odds of upper-decile LOS decreased significantly over time.

Overall, a higher number of significant associations with hospital characteristics (Table 3) was observed in medical (14 significant associations for mortality, five for readmissions, and 19 for upper-decile LOS) compared with surgical APR-DRGs (five, five, and 13 significant associations for mortality, readmissions, and upper-decile LOS, respectively). Flanders showed significantly higher odds of readmission compared with Brussels or Wallonia for six APR-DRGs. For upper-decile LOS, however, Flanders often outperformed Brussels (12 APR-DRGs) or Wallonia (eight APR-DRGs). Significant associations of hospital type with mortality, readmission, and upper-decile LOS were observed for seven, one, and eight APR-DRGs, respectively, with odds always being lower for academic hospitals, except for the readmission association. Low urological volume was associated with lower mortality for five APR-DRGs, of which four are medical (RF, UTMD, UTIs, and DEV), and with higher mortality for other kidney, urinary tract, and related procedures (OUT). For readmission (n = 1) and upper-decile LOS (n = 3), significant odds ratios showed worse outcomes for low volume.

3.4. Potential lives saved

If APR-DRG–specific risk-standardised mortality rates in upper-quartile hospitals would be reduced to the median values, a total of 412 urological deaths per year, or 41.5% of observed urological deaths in those hospitals, could be avoided (Fig. 2). The largest absolute gain was observed for UTIs and UTMD (92 and 73 lives saved, respectively), and the largest relative gain was observed for USO and nephritis and nephrosis (67.3% and 66.5% of observed deaths, respectively).

3.5. Trends over time

For APR-DRGs that allowed a comparison between the main study period (2016–2018) and the 3 yr prior (2012–2014),

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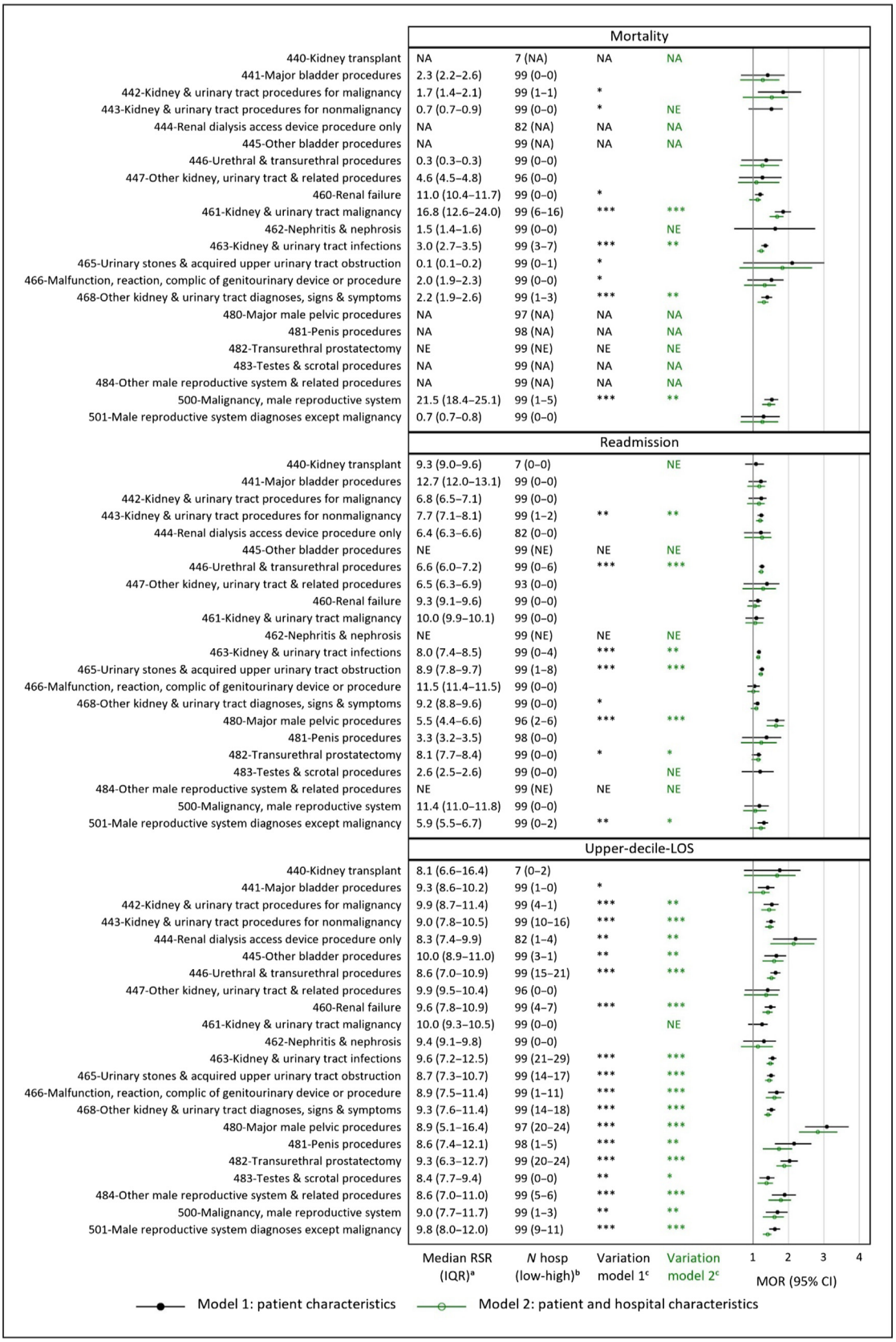

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mortality rates decreased over time by one-third or more for UTNM, UTMD, and USO (Fig. 3). The largest (absolute) decrease in mortality (from 24.3% to 16.8%) was observed for UTMD. UTIs, DEV, and OUT demonstrated increasing mortality rates, with a remarkable surge in OUT (25% increase). Upper-decile LOS rates decreased for most APR-DRGs (except for OUTD, DEV, MRSD, other bladder procedures, and OUT), with approximately a halving of rates observed for UTNM and MMPPs. Readmission rates, however, increased for 16 out of 19 comparable APR-DRGs.

As for the main study period, UTIs ranked highest based on significance of risk variation across the three outcomes ($p < 0.01$). The mortality variation for USO, UTNM, and DEV was significant in the main study period, but not in earlier years, with a remarkable increase in MOR for USO, which also showed an increase in readmission variation over time. The significant variation in readmission in the main study period for UTNM and MRSD was not significant for 2012–2014. A remarkable increase in readmission MOR was observed for MMPPs, for which the (already high) MOR for upper-decile LOS also increased. Contrastingly, the significance of readmission variation for DEV, penis procedures, and renal dialysis access device procedure only disappeared over time. For upper-decile LOS, variation for the APR-DRGs UTMD and OUT was significant in 2012–2014, but not in 2016–2018.

4. Discussion

Significant between-hospital variation in at least two of three measured outcomes was observed for seven out of nine medical and five out of 13 surgical APR-DRGs, suggesting larger inequalities in urological quality of care for medical than for surgical admissions. This might be related to past QI initiatives having mainly been directed towards surgical patients, with, for example, implementation of safe surgery checklists [22,23] and technological advances such as robotics [24]. The European Association of Urology has invested significantly in the development of guidelines and standards [25] for urological care since many years, with high acceptance among the urological community. These guidelines are produced after a rigorous methodological process using analysis of all published clinical trials, with expert opinion avoided as much as possible. Adherence to guidelines might be higher for oncology because clinical practice guidelines are based on a large amount of clinical trials, whereas the limited number of trials for nononcological diseases could represent a problem for obtaining high-quality recommendations [26].

With significant variation in each of the three outcomes, and representing nearly 20% of urological hospital admissions, our research revealed that UTIs should become a priority for future QI interventions. Improvement in mortality in bottom-performing hospitals could potentially save 92 patients annually for this APR-DRG, a substantial amount considering its relatively low, yet increasing, mortality rate. The observation of a high number of lives potentially saved (73 per annum) was also made for UTMD, which also showed the highest significant mortality variation (based on the MOR). The highest relative gain in lives saved (67.3%) and the highest MOR for mortality (2.11), although not significant, were observed for USO. MORs for APR-DRGs with significant between-hospital variation were often higher than odds ratios for hospital characteristics, indicating that between-hospital variation exceeds variation explained by hospital characteristics. With 41.5% of deaths potentially being avoided in bottom-performing hospitals if they were to improve to the median, reducing variation would be highly beneficial for urological patients.

To mitigate this unwarranted variation, we encourage urological associations to further invest into the development and implementation of clinical guidelines and standardisation. While surgical and oncological standards have received abundant attention in the past [25,27], it is now time to switch focus to medical conditions such as antibiotic stewardship [28] for urological infections. Secondly, systematic collation and benchmarking of outcomes and variation on national and international levels are required to ensure future focus on the right priorities [13]. Thirdly, collaborative learning on a local level has shown promise to improve patient outcomes [29] and should be expanded from existing initiatives [30].

In line with previous work [2–4], we found certain hospital characteristics, for example, region or teaching status, are associated with mortality, readmission, and LOS. Remarkably, our study discovered that medical diagnoses with low admission volume are often associated with a lower risk of mortality, which seems contradictive of the existing evidence base on surgical volume [5]. The mechanism behind this finding is currently uncertain and therefore requires further research. Inclusion of hospital factors into the statistical model only minimally helped explain between-hospital variation, suggesting the need for additional research on hospital contextual factors contributing to this variation. Strategies for improving hospital performance should be customised based on key hospital attributes as well as on individual performance profiles.

In this study, we formally evaluated between-hospital variation in patient outcomes at APR-DRG-level. The methods presented in this paper are easily transferrable to other disease groups besides urology, allowing priority setting across the health care spectrum. However, several study limitations merit attention. Firstly, we were unable to

Fig. 1 – Hospital variation in APR-DRG–specific urological in-hospital mortality, 30-d readmissions, and upper-decile LOS, with the median odds ratio representing the odds for a randomly chosen patient in a high-risk hospital compared with a similar patient (ie, with the same fixed effects) in a low-risk hospital. APR-DRGs are ordered by decreasing variation (based on the significance of the variation in model 1) across the three outcomes. Results are not presented for models with <30 cases (indicated as NA) and for models in which the random hospital effect was estimated to be zero (indicated as NE). APR-DRG = All Patient Refined Diagnosis Related Group; CI = confidence interval; complic = complications; hosp = hospital; IQR = interquartile range; LOS = length of stay; MOR = median odds ratio; NA = not applicable; NE = not estimable; RSR = risk-standardised rate. [a] Based on the model including only patient characteristics (model 1). [a] Total number of hospitals (number with RSR significantly lower than expected – number with RSR significantly higher than expected), based on model 1. [c] Significance of the variation in risk across hospitals (testing whether the random hospital effect differs from zero): * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

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Table 3 – Adjusted odds ratios (95% confidence intervals) for hospital characteristics from hierarchical logistic regression analyses of in-hospital mortality, 30-d readmission, and upper-decile LOS [a]

APR-DRG [b]	Mortality					Readmission					Upper-decile LOS				
	Region (reference = Flanders)		Hospital type	Annual volume (reference = high)		Region (reference = Flanders)		Hospital type	Annual volume (reference = high)		Region (reference = Flanders)		Hospital type	Annual volume (reference = high)	
	Brussels	Wallonia	Academic	Low	Medium	Brussels	Wallonia	Academic	Low	Medium	Brussels	Wallonia	Academic	Low	Medium
KTr						0.77 (0.51–1.15)	0.55 (0.27–1.11)				0.93 (0.34–2.53)	0.50 (0.11–2.18)			
MBP	1.14 (0.57–2.29)	1.07 (0.68–1.68)	0.76 (0.39–1.48)	1.46 (0.83–2.58)	0.84 (0.50–1.44)	1.07 (0.78–1.49)	0.82 (0.65–1.04)	0.83 (0.60–1.15)	0.95 (0.69–1.31)	0.91 (0.70–1.18)	**1.53 (1.05–2.24)**	0.84 (0.63–1.11)	**0.60 (0.40–0.90)**	1.13 (0.79–1.61)	0.82 (0.60–1.11)
UTM	**2.67 (1.33–5.34)**	1.19 (0.72–1.97)	**0.41 (0.18–0.91)**	1.49 (0.84–2.64)	**0.52 (0.29–0.94)**	1.20 (0.82–1.76)	1.15 (0.90–1.48)	0.76 (0.53–1.08)	1.26 (0.90–1.76)	0.98 (0.74–1.29)	**1.57 (1.03–2.40)**	1.12 (0.84–1.49)	0.88 (0.55–1.40)	**1.53 (1.08–2.18)**	1.09 (0.80–1.51)
UTNM	1.31 (0.84–2.04)	0.79 (0.57–1.11)	**0.39 (0.24–0.62)**	0.85 (0.55–1.32)	0.78 (0.53–1.14)	0.83 (0.66–1.04)	0.87 (0.75–1.02)	0.96 (0.76–1.20)	0.96 (0.79–1.16)	0.93 (0.79–1.11)	1.07 (0.77–1.50)	0.81 (0.65–1.01)	1.05 (0.72–1.54)	0.89 (0.68–1.16)	0.91 (0.70–1.17)
DIAL						0.84 (0.48–1.48)	1.21 (0.81–1.81)	1.38 (0.77–2.49)	0.78 (0.42–1.43)	0.87 (0.57–1.35)	0.64 (0.27–1.54)	0.87 (0.47–1.60)	1.53 (0.61–3.86)	0.77 (0.34–1.78)	1.12 (0.57–2.21)
OBI						0.81 (0.51–1.30)	0.81 (0.58–1.12)	0.73 (0.47–1.13)	1.07 (0.71–1.62)	1.13 (0.81–1.56)	1.17 (0.68–2.02)	1.29 (0.88–1.89)	0.59 (0.32–1.10)	0.97 (0.61–1.55)	0.82 (0.54–1.24)
TUP	0.46 (0.20–1.08)	0.97 (0.62–1.52)	1.30 (0.64–2.63)	1.24 (0.74–2.10)	1.25 (0.77–2.02)	0.89 (0.71–1.11)	**0.79 (0.68–0.92)**	0.97 (0.76–1.25)	1.06 (0.90–1.26)	0.90 (0.77–1.06)	**2.11 (1.51–2.94)**	**1.53 (1.23–1.90)**	0.80 (0.53–1.20)	1.03 (0.80–1.32)	0.89 (0.69–1.14)
OUT	1.61 (0.84–3.11)	1.07 (0.65–1.77)		**1.89 (1.02–3.48)**	0.74 (0.41–1.31)	0.77 (0.38–1.54)	0.65 (0.40–1.04)	0.98 (0.52–1.84)	1.05 (0.53–2.08)	1.08 (0.64–1.80)	0.77 (0.38–1.54)	1.18 (0.77–1.80)	0.96 (0.52–1.78)	1.33 (0.73–2.40)	0.89 (0.54–1.46)
RF	1.02 (0.82–1.26)	0.91 (0.78–1.05)	**0.67 (0.52–0.85)**	1.02 (0.86–1.22)	**0.83 (0.70–0.97)**	0.91 (0.73–1.12)	**0.81 (0.69–0.94)**	1.16 (0.95–1.42)			**1.62 (1.16–2.26)**	1.14 (0.91–1.42)	0.73 (0.49–1.10)	**1.31 (1.00–1.71)**	0.98 (0.75–1.26)
UTMD	0.88 (0.56–1.38)	**0.62 (0.46–0.84)**	**0.35 (0.20–0.62)**	**0.69 (0.48–0.99)**	0.73 (0.52–1.03)	1.14 (0.84–1.53)	1.04 (0.82–1.31)	1.16 (0.87–1.54)			**1.32 (1.02–1.73)**	**0.76 (0.62–0.95)**	**0.57 (0.41–0.78)**	1.09 (0.85–1.40)	0.88 (0.70–1.10)
NEPH	0.85 (0.27–2.71)	1.65 (0.78–3.47)	1.15 (0.47–2.82)	1.20 (0.40–3.55)	0.81 (0.33–1.96)	0.91 (0.51–1.65)	1.11 (0.74–1.67)	0.62 (0.37–1.03)	0.58 (0.26–1.25)	1.00 (0.65–1.56)	1.38 (0.84–2.27)	**1.46 (1.02–2.10)**	0.96 (0.61–1.50)	1.23 (0.71–2.14)	1.06 (0.70–1.59)
UTI	**1.41 (1.12–1.78)**	**1.41 (1.22–1.64)**	**0.69 (0.52–0.91)**	**0.79 (0.66–0.95)**	**0.81 (0.68–0.96)**	0.86 (0.74–1.00)	0.95 (0.86–1.05)	**1.23 (1.04–1.45)**	0.97 (0.86–1.09)	0.98 (0.88–1.10)	**1.47 (1.08–2.00)**	1.15 (0.95–1.40)	**0.53 (0.36–0.79)**	1.04 (0.83–1.31)	1.08 (0.86–1.36)
USO	2.22 (0.79–6.23)	1.09 (0.52–2.29)	0.34 (0.08–1.49)	1.04 (0.42–2.58)	0.98 (0.44–2.20)	0.82 (0.66–1.02)	**0.87 (0.76–0.99)**	1.06 (0.83–1.36)	1.16 (0.99–1.36)	1.06 (0.91–1.23)	**1.48 (1.09–2.02)**	**1.32 (1.09–1.61)**	0.86 (0.59–1.26)	1.25 (1.00–1.58)	1.03 (0.82–1.30)
DEV	0.63 (0.35–1.14)	0.86 (0.57–1.30)	**0.51 (0.28–0.92)**	**0.54 (0.30–0.97)**	0.93 (0.60–1.45)	0.93 (0.72–1.19)	0.92 (0.76–1.11)	1.02 (0.83–1.27)	0.91 (0.71–1.16)	0.86 (0.69–1.06)	**1.64 (1.05–2.57)**	**1.38 (1.01–1.90)**	0.97 (0.59–1.58)	0.82 (0.55–1.21)	0.81 (0.56–1.16)
OUTD	1.02 (0.72–1.44)	1.03 (0.83–1.28)	**0.54 (0.36–0.81)**	1.10 (0.85–1.43)	1.16 (0.91–1.47)	**0.82 (0.70–0.96)**	0.93 (0.84–1.03)	1.05 (0.91–1.23)	0.96 (0.84–1.09)	0.94 (0.84–1.06)	**1.58 (1.18–2.11)**	1.15 (0.95–1.39)	**0.57 (0.40–0.81)**	**1.30 (1.04–1.62)**	1.07 (0.86–1.33)
MMPP						1.36 (0.81–2.29)	1.10 (0.77–1.55)	1.06 (0.62–1.83)	0.89 (0.57–1.41)	1.02 (0.69–1.49)	2.20 (0.98–4.95)	**1.71 (1.01–2.89)**	0.61 (0.23–1.64)	1.52 (0.81–2.86)	0.87 (0.47–1.60)
PENP						0.57 (0.28–1.16)	0.77 (0.46–1.30)	0.90 (0.55–1.49)			**3.03 (1.62–5.66)**	**2.68 (1.64–4.36)**	0.97 (0.50–1.87)	0.92 (0.47–1.80)	1.16 (0.69–1.98)
TURP	2.23 (0.89–5.57)	0.80 (0.34–1.88)	0.44 (0.09–2.04)	1.09 (0.49–2.40)	0.54 (0.22–1.32)	0.86 (0.70–1.06)	0.90 (0.78–1.03)	1.08 (0.85–1.38)	0.96 (0.82–1.12)	0.98 (0.85–1.14)	**2.09 (1.28–3.42)**	**1.76 (1.28–2.43)**	**0.53 (0.28–1.00)**	1.00 (0.69–1.45)	0.99 (0.68–1.43)
TSP						**0.49 (0.28–0.87)**	**0.63 (0.43–0.91)**	1.34 (0.77–2.31)	**1.70 (1.07–2.70)**	1.44 (0.95–2.20)	1.27 (0.85–1.89)	0.89 (0.67–1.18)	**0.57 (0.36–0.90)**	0.81 (0.57–1.14)	0.79 (0.58–1.08)
OMRP						0.99 (0.68–1.44)	**1.29 (1.00–1.66)**	1.18 (0.78–1.78)	0.98 (0.71–1.36)	0.88 (0.67–1.16)	1.20 (0.67–2.16)	1.25 (0.85–1.84)	0.60 (0.28–1.26)	1.33 (0.85–2.09)	0.87 (0.56–1.35)
MMRSD	0.75 (0.51–1.11)	**0.74 (0.57–0.97)**	0.65 (0.41–1.04)	0.91 (0.67–1.25)	0.86 (0.64–1.16)	1.07 (0.75–1.54)	0.89 (0.66–1.19)	1.00 (0.65–1.53)	1.27 (0.91–1.78)	1.32 (0.97–1.80)	0.91 (0.54–1.53)	0.91 (0.64–1.30)	**0.46 (0.24–0.90)**	1.06 (0.71–1.59)	0.91 (0.61–1.36)
MRSD	0.63 (0.31–1.28)	1.02 (0.66–1.58)	1.19 (0.61–2.31)	0.99 (0.55–1.79)	1.33 (0.82–2.15)	1.10 (0.83–1.45)	**0.72 (0.59–0.88)**	0.87 (0.64–1.20)	1.16 (0.92–1.46)	1.10 (0.89–1.36)	**2.56 (1.86–3.52)**	**1.65 (1.33–2.05)**	**0.55 (0.37–0.82)**	1.09 (0.84–1.42)	1.03 (0.81–1.32)

APR-DRG = All Patient Refined Diagnosis Related Groups; LOS = length of stay.

[a]Adjusted for gender, age group, comorbidity index, place before admission, admission type, and year of discharge. Bold indicates significance $p < 0.05$; grey indicates a surgical APR-DRG.

[a]APR-DRG code abbreviations: KTr: 440—Kidney transplant; MBP: 441—Major bladder procedures; UTM: 442—Kidney and urinary tract procedures for malignancy; UTNM: 443—Kidney and urinary tract procedures for nonmalignancy; DIAL: 444—Renal dialysis access device procedure only; OBI: 445—Other bladder procedures; TUP: 446—Urethral and transurethral procedures; OUT: 447—Other kidney, urinary tract, and related procedures; RF: 460—Renal failure; UTMD: 461—Kidney and urinary tract malignancy; NEPH: 462—Nephritis and nephrosis; UTI: 463—Kidney and urinary tract infections; USO: 465—Urinary stones and acquired upper urinary tract obstruction; DEV: 466—Malfunction, reaction, and complication of genitourinary device or procedure; OUTD: 468—Other kidney and urinary tract diagnoses, signs, and symptoms; MMPP: 480—Major male pelvic procedures; PENP: 481—Penis procedures; TURP: 482—Transurethral prostatectomy; TSP: 483—Testes and scrotal procedures; OMRP: 484—Other male reproductive system and related procedures; MMRSD: 500—Malignancy, male reproductive system; MRSD: 501—Male reproductive system diagnoses except malignancy.

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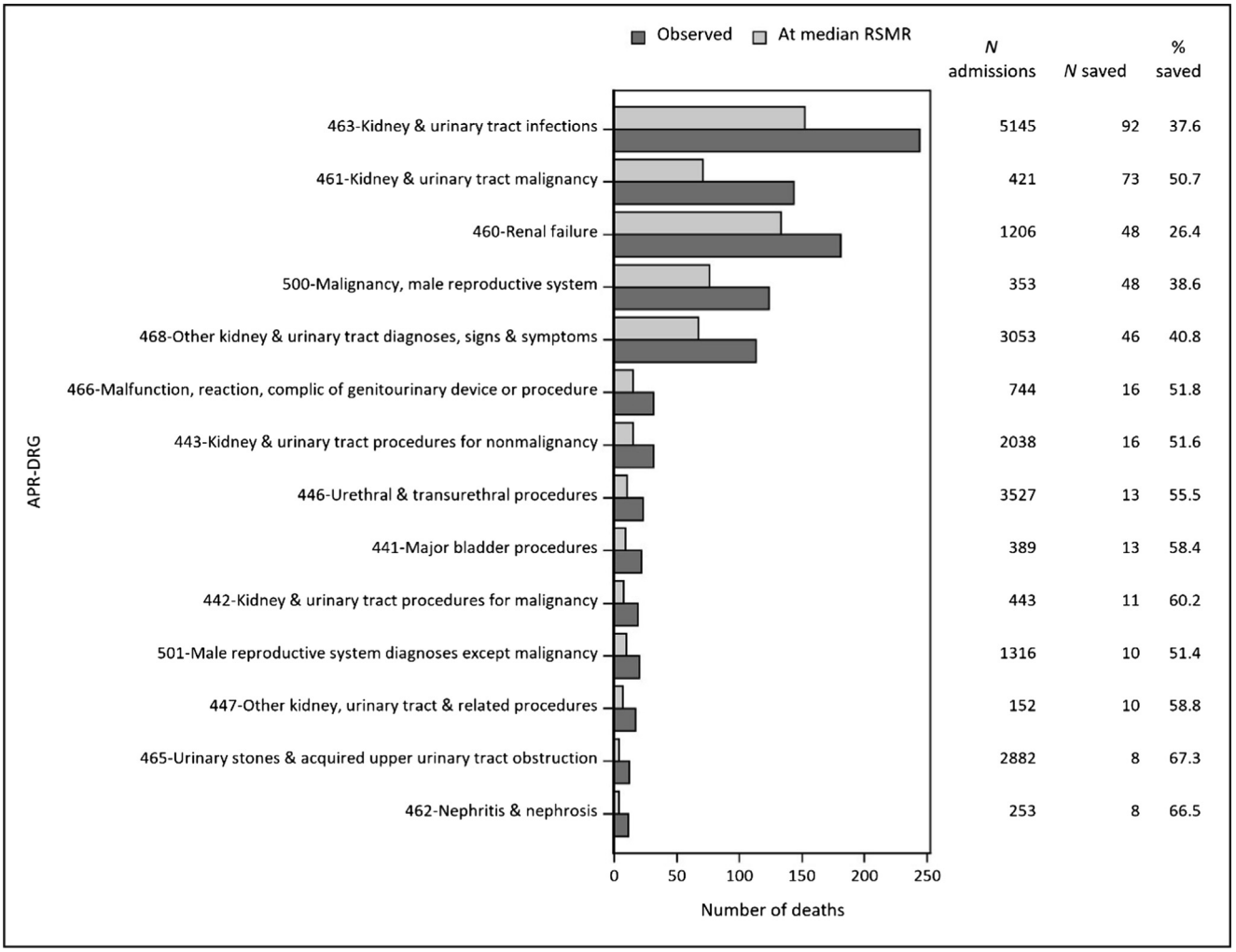

Fig. 2 – Annual number of observed deaths and estimated deaths among urological APR-DRGs if mortality in hospitals with risk-standardised mortality rates in the upper quartile would be reduced to the median value. Results are based on the risk-standardised mortality distribution estimated by the model including only patient characteristics. Numbers at the bottom of the figure represent the annual APR-DRG–specific number of admissions and lives saved in hospitals with risk-standardised mortality in the upper quartile. The percentage of lives saved is calculated relative to the number of observed deaths in those hospitals. Results are not presented for seven APR-DRGs with <30 deaths and for one APR-DRGs for which the random hospital effect was estimated to be zero. APR-DRG = All Patient Refined Diagnosis Related Group; complic = complications; RSMR = risk-standardised mortality rate.

include readmissions occurring in December or readmissions to other hospitals, so readmission rates are likely underestimated. Secondly, we did not obtain results for some combinations of outcomes and APR-DRGs because the random component was estimated to be zero, which could indicate low between-hospital variation, but could also result from a model misspecification, especially in case of low numbers. We did not encounter this problem for upper-decile LOS, probably because of the higher number of cases (10% by definition). This is also the outcome for which significant between-hospital variation was observed most often, suggesting a potential lack of power in some mortality and readmission models. Nevertheless, our study comprised the preponderance of the Belgian urological population and was able to identify urological APR-DRGs with important variation for mortality, readmission, and LOS.

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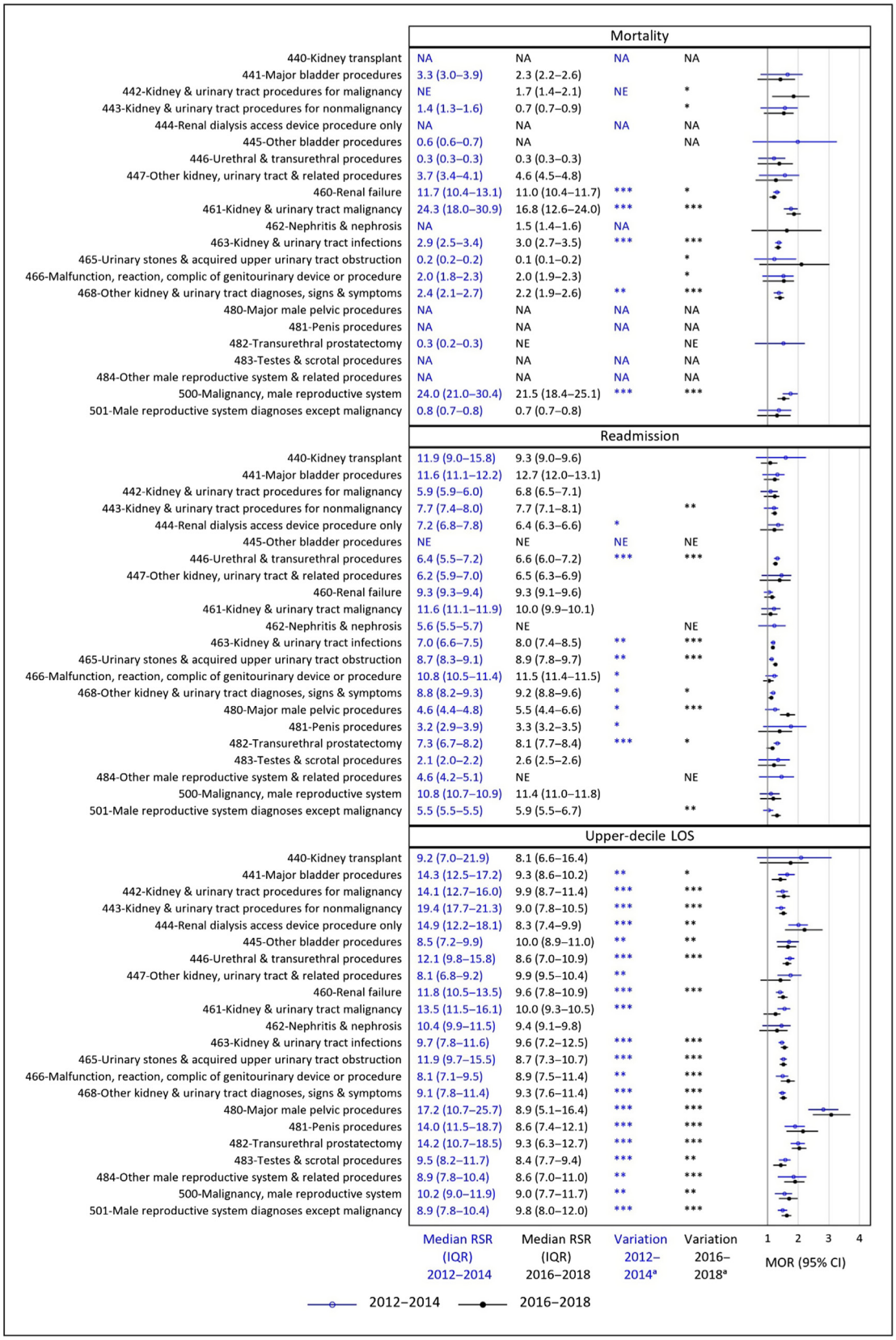

Fig. 3 – Comparison of hospital variation in APR-DRG–specific urological in-hospital mortality, 30-d readmissions, and upper-decile LOS between the main study period (2016–2018) and the 3 yr before it (2012–2014), with the median odds ratio representing the odds for a randomly chosen patient in a high-risk hospital compared with a similar patient (ie, with the same fixed effects) in a low-risk hospital. Results are based on models including only patient characteristics. APR-DRGs are ordered by decreasing variation (based on the significance of the variation in the model for 2016–2018) across the three outcomes. APR-DRG = All Patient Refined Diagnosis Related Group; CI = confidence interval; complic = complications; IQR = interquartile range; LOS = length of stay; MOR = median odds ratio; NA = not applicable; NE = not estimable; RSR = risk-standardised rate. [a] Significance of the variation in risk across hospitals (testing whether the random hospital effect differs from zero). * p < 0.05. ** p < 0.01. *** p < 0.001.

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5. Conclusions

Urological care is characterised by notable between-hospital variation in mortality, readmission, and LOS, in particular for medical pathologies. Future QI interventions could target this variation by prioritising kidney infections and UTIs, which were found to have significant variation in the three outcomes and could potentially save the largest number of lives if improvements were made.

Author contributions: Astrid Van Wilder had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Van Wilder, Cox, De Ridder, Vanhaecht.
Acquisition of data: Van Wilder, Vanhaecht.
Analysis and interpretation of data: Van Wilder, Cox.
Drafting of the manuscript: Van Wilder, Cox.
Critical revision of the manuscript for important intellectual content: Van Wilder, Cox, De Ridder, Vanhaecht, Bruyneel, Tambeur, Vanden Boer, Stijnen, Maertens, Brouwers, Claessens.
Statistical analysis: Cox.
Obtaining funding: Vanhaecht, De Ridder.
Administrative, technical, or material support: None.
Supervision: Vanhaecht, De Ridder, Bruyneel.
Other: None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.euf.2021.11.001.

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