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Implementation of a renal pharmacist consultant service — Information sharing in paper versus digital form

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Abstract

What is known and objective: Renal impairment (RI) and renal drug-related problems (rDRP) often remain unrecognized in the community setting. A "renal pharmacist consultant service" (RPCS) at hospital admission can support patient safety by detecting rDRP. However, the efficient information sharing from pharmacists to physicians is still discussed. The aim of the study was to test the implementation of a RPCS and its effectiveness on prescription changes and to evaluate two ways of written information sharing with physicians.

Methods: Urological patients with $eGFR_{non\text{-}indexed}$ of 15-59 ml/min and ≥1 drug were reviewed for manifest and potential rDRP at admission by a pharmacist. Written recommendations for dose or drug adaptation were forwarded to physicians comparing two routes: July-September 2017 paper form in handwritten chart; November 2017-January 2018 digital PDF document in the electronic patient information system and e-mail alert. Prescription changes regarding manifest rDRP were evaluated and compared with a previous retrospective study without RPCS.

Results and discussion: The RPCS detected rDRP in 63 of 234 (26.9%) patients and prepared written recommendations (median 1 rDRP (1-5) per patient) concerning 110 of 538 (20.5%) drugs at admission. For manifest rDRP, acceptance rates of recommendations were 62.5% (paper) vs 42.9% (digital) ($P = 0.16$). Compared with the retrospective study without RPCS (prescription changes in 21/76 rDRP; 27.6%), correct prescribing concerning manifest rDRP significantly increased by 27.1%.

What is new and conclusion: A RPCS identifies patients at risk for rDRP and significantly increases appropriate prescribing by physicians. In our hospital (no electronic order entry, electronic chart or ward pharmacists), consultations in paper form seem to be superior to a digital PDF document.

Parts of the study have been presented as poster at the 45. Scientific Congress of the German Association of Hospital Pharmacists ADKA e.V. (due the COVID-19-pandemic the presentation was online in November 2020) and will be presented as poster at the 46. Scientific Congress of the German Association of Hospital Pharmacists ADKA e.V. 2021.

KEYWORDS
pharmacist intervention, renal drug-related problems, renal impairment, renal pharmacist, renal risk drugs

1 | INTRODUCTION

Renal impairment (RI) is a common risk factor for patient safety, leading to renal drug-related problems (rDRP), which increase the risk for adverse drug reactions (ADR), prolonged hospital stay, and mortality.[1-5] Around 2%-7% of the German adult population suffers from RI with an estimated glomerular filtration rate (eGFR) of <60 ml/min/1.73 m^2, but about 70% are unaware of their organ impairment.[6,7] Thus, RI often remains unrecognized in the community setting and drug therapy is not adjusted appropriately. In a previous study, we revealed that around 22% of hospitalized urological patients show an $eGFR_{indexed}$ of <60 ml/min/1.73 m^2 at hospital admission and adequate drug and dosage adjustments is often neglected, leading to rDRP in 61% of the patients with $eGFR_{non\text{-}indexed}$ 15-59 ml/min and ≥1 drug.[8]

Essential for the detection of rDRP is the correct determination of patient's renal function. The Kidney Disease Improving Global Outcomes Initiative (KDIGO) recommends reporting eGFR in adults using the 2009 Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) creatinine equation, which refers to a body surface area (BSA) of 1.73 m^2 ($eGFR_{indexed}$ with the units ml/min/1.73 m^2).[9] However, for drug dosing purposes, the $eGFR_{indexed}$ should be converted to $eGFR_{non\text{-}indexed}$ with the units ml/min, especially for patients with considerable deviation of BSA.[9-11] Interestingly, we previously found that the majority of patients admitted to the department of urology had a BSA considerably higher than 1.73 m^2.[8] Thus, after conversion to $eGFR_{non\text{-}indexed}$ 5.1% of the patients fell outside the eGFR-range <60 ml/min.[8]

However, beside correct determination of renal function, rDRP must be detected and handled appropriately at hospital admission. Pharmacist can help in these tasks and the collaboration of pharmacist and physician can optimize safe drug prescribing in CKD patients.[12,13] To effectively implement a collaboration, an appropriate information sharing to the attending physicians is important. For prescription changes, the information needs to be noticed by physicians and the phrasing must be clear. A review by Tesfaye et al. indicates that the most effective way to reduce inappropriate prescribing is immediate concurrent feedback to the physicians by pharmacists.[4] Unfortunately, this way of information transfer cannot be realized in most German hospitals, as permanent ward pharmacists are not yet established. In addition, only few hospitals already use electronic prescribing and unit dose drug distribution. Moreover, physicians in surgical departments, like urology, are mostly not present on the ward throughout the day, thus, complicating effective information sharing. For these reasons, starting with a pharmacist-led medication reconciliation (PhMR) at hospital admission and forwarding identified drug-related problems to responsible physicians may be a promising approach. However, an obstacle hampering the detection of RI as risk factor are missing laboratory data at the time of PhMR, which are often only available several hours after admission and cannot be taken into account in centralized, not ward-based PhMR, like in our hospital. To overcome this issue, a "renal pharmacist consultant service" (RPCS) operating independently from PhMR might be an option.

The goal of our study was to test the implementation of a RPCS in addition to PhMR at a tertiary teaching hospital, managing inappropriate drug use in patients with RI at hospital admission. We evaluated two ways of written information sharing (paper vs digital) to physicians in a surgical department. Furthermore, we compared the prescription changes with a retrospective phase to assess the effectiveness of the implementation.

2 | MATERIALS AND METHODS

Between July 2017 and January 2018, we conducted a study to evaluate a "renal pharmacist consultant service" (RPCS) for patients with renal impairment (RI) at a tertiary teaching hospital. During weekdays, a pharmacist collected the eGFR-values (CKD-EPI equation; ml/min/1.73 m^2) of all patients ≥18 years, who were admitted to one of three urological wards and received a pharmacist-led medication reconciliation (PhMR) before entering the ward. All patients with an $eGFR_{non\text{-}indexed}$ (CKD-EPI) of 15–59 ml/min and ≥1 drug at admission were included. Patients with an $eGFR_{non\text{-}indexed}$ >60 ml/min were not further analysed as adaption of medication is usually not necessary, and thus, patients have a relative low risk for rDRP. Patients with $eGFR_{non\text{-}indexed}$ <15 ml/min were excluded, because they routinely receive specialized care of a nephrologist. Readmitted patients were included, since renal function can change over time.

2.1 | Ethical approval

The study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the ethics committee at Ludwig-Maximilians-University Munich, registration number 778-16.

2.2 | Data collection

The pharmacist collected eGFR by CKD-EPI equation [ml/min/1.73 m^2], weight, height, age, sex and drugs at admission from patients' medical records (SAP-i.s.h.med, Cerner Corporation, North Kansas City, USA), laboratory records and medication plans from PhMR. The indexed eGFR [ml/min/1.73 m^2] was recalculated to the non-indexed eGFR [ml/min] with patient's

BSA ($eGFR_{non\text{-}indexed}$ [ml/min] = $eGFR_{indexed}$ [ml/min/1.73 m^2] / 1.73 m^2 x BSA).[11] BSA was calculated by the Mosteller's equation[14] using weight and height of each individual (self-declared).

2.3 | Renal drug-related problems (rDRP)

The pharmacist reviewed the medication at admission for "renal risk drugs" (RRD) and renal drug-related problems (rDRP) according to the recommendations given by the German SPC (www.fachinfo.de) and the drug information database AiDKlinik®, which refers to the renal dose recommendation portal Dosing® (www.dosing.de). If data were not clear, The Renal Drug Handbook by Ashley was consulted.[15] For analysis, the identified rDRP were categorized in consensus decision by three clinical experienced pharmacists as described previously.[8] In brief, it was distinguished between potential (rDRP possible, if eGFR decreases; until +15 ml/min) and manifest (problem exists with current eGFR) rDRP concerning treatment safety or treatment effectiveness. The rDRP were categorized in one main cause and may lead to one or more interventions. One drug might as well cause a potential and a manifest rDRP, depending on the drug and the patient's renal function. Drugs with a drug interaction potentially decreasing renal function (three drugs per interaction; "Triple Whammy") were counted seperately.

2.4 | Pharmacist's intervention—two-way approach for information sharing

The identified rDRP as well as recommendations for dose or drug adaptations were shared with the responsible physician in two different written ways. For route I, over a period of 3 months, information was given in paper form (yellow colour) as inlay in patient's paper chart. In route II, over a period of 3 months, information was deposited as a digital PDF file in the electronic patient information system (SAP--i.s.h.med) accompanied by an e-mail alert sent to the responsible physicians. The two routes were separated by a one-month break. Prior to the start of each route, the concepts of information delivery were introduced at the physician's meeting. Acceptance rates of RPCS recommendations regarding manifest rDRP were evaluated as number of changed prescriptions in patient's handwritten chart. Manifest rDRP with "monitoring" as only intervention were not included in the analysis of the acceptance rates. The effect of the two ways of information sharing was analysed by comparing acceptance rates achieved in both routes (route I vs. route II).

2.5 | Evaluation of the impact of a "renal pharmacist consultant service" on prescription changes

Additionally, the six-month period with RPCS was compared with changes of prescriptions regarding manifest rDRP of a six-month retrospective analysis one year before, without RPCS (July-December 2016). This study included patients from the same urological wards.[8]

2.6 | Statistical analysis

Descriptive statistics were used to characterize the patient population. Qualitative variables are expressed with their frequency distribution. Quantitative variables are presented as mean and standard deviation (SD) or as median and interquartile range. As test for normality in frequency, the Shapiro-Wilk test was used. For comparison between groups, chi-square test was used for categorical variables and Student's *t* test (normal distribution)/Mann-Whitney *U* test (without normal distribution) for continuous variables. Statistical significance was accepted as $P < 0.05$. Data analyses and figures were performed with Microsoft Excel® 2016 (Seattle, WA, USA) and IBM SPSS Statistics® version 25.0 (Armonk, NY, USA).

3 | RESULTS

3.1 | Patients´ characteristics

During the study periods of route I (written report on paper) and II (written report in digital form), a total number of 1648 patients were screened for RI and 318 (19.3%) presented with an $eGFR_{indexed}$ of 15-59 ml/min/1.73 m^2 (route I: 157; route II: 161). After readjustment for individual BSA, 246 (14.9%) patients showed an $eGFR_{non\text{-}indexed}$ of 15-59 ml/min (route I: 118; route II 128). Of these, 234 (14.2%) used ≥1 drugs at admission and their medication was checked for rDRP (route I: 111; route II: 123). Detailed information on patient's eGFR-categories in route I and route II is presented in Figure 1. Comparing the included patients for route I (n = 111) and route II (n = 123), there were no significant differences in sex ($P = 0.45$), age ($P = 0.64$), BSA ($P = 0.08$) and body mass index (BMI; $P = 0.19$) but differences in incidences of RI and number of drugs. However, the baseline characteristics of the patients with rDRP were similar for route I and route II (Table 1). Comparing patients with and without rDRP for each route, patients with rDRP were significantly on more drugs and eGFR-values were significantly lower, whereas there was no significant difference regarding age, BSA, BMI and sex (Table 1).

3.2 | Identification of patients with renal drug-related problems (rDRP) by a "renal pharmacist consultant service"

In total, 63 (26.9%) of the 234 included patients had one or more rDRP. We identified 105 rDRP, affecting 110 (20.5%) of 538 drugs at admission (more drugs than rDRP because drug interactions involve several drugs) (Tables 1 and 2). Of all 105 rDRP, 59 (56.2%) were manifest and 46 (43.8%) potential depending on the individual's $eGFR_{non\text{-}indexed}$. Most rDRP concerned treatment safety (84.8%). The

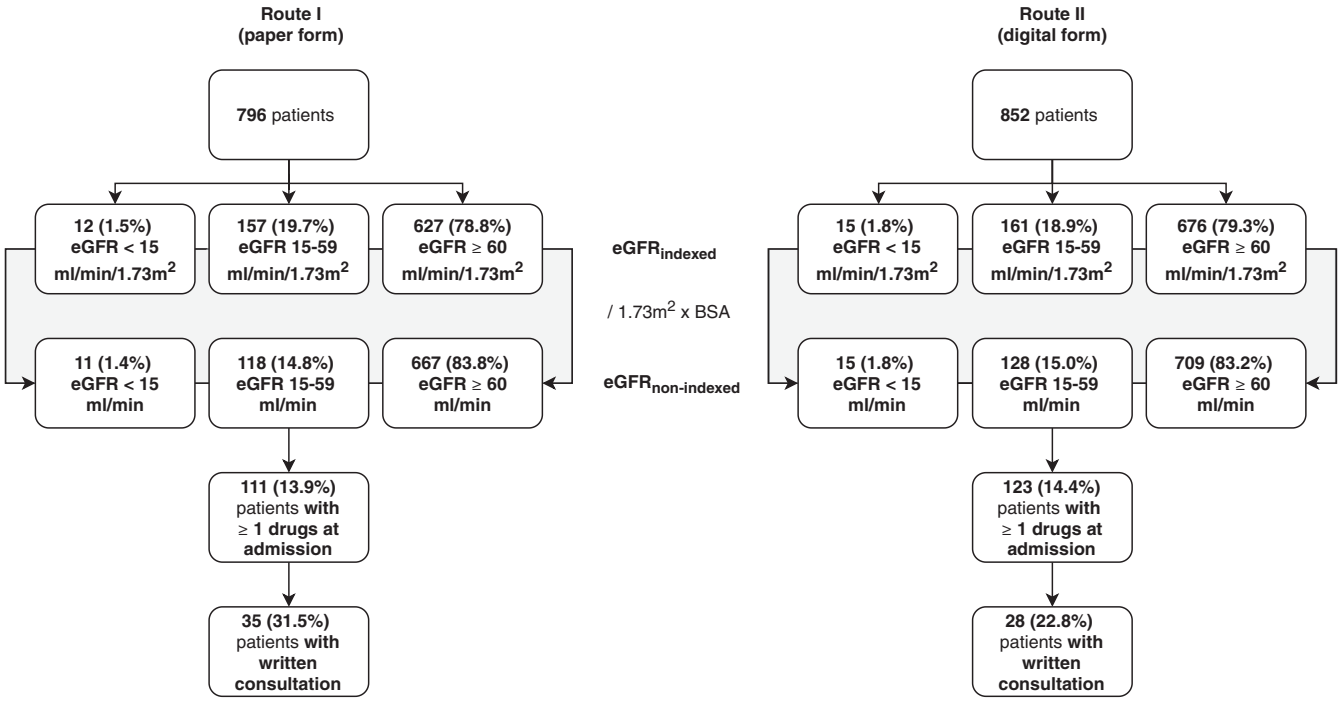

FIGURE 1 Patient flow chart of route I (paper form, 3 months) and route II (digital form, 3 months)

main causes of rDRP were "drug dose too high" (37.1%), "suboptimal drug" (23.8%) and "drug contraindicated" (18.1%). In total, 150 interventions were proposed to prescribers with the major recommendation "change/stop drug" (36.0%), "change dosage" (29.3%) and "monitoring of serum blood levels or ADR" (26.0%). Additionally, 2 (4.3%) potential and 6 (10.2%) manifest rDRP had "monitoring" as only intervention (potential rDRP: route I n = 2 (8.7%), route II n = 0; manifest rDRP: route I n = 5 (13.5%), route II n = 1 (4.5%)). The detected rDRP in route I and II are characterized in Table 2.

3.3 | "Renal Risk Drugs" (RRD) with drug-related problems (rDRP)

The 105 detected rDRP concerned 38 different substances. The drug classes (according to the Anatomic Therapeutic Classification System) most often associated with rDRP were antiinflammatory and antirheumatic drugs (n = 18, 16.7%), diuretics (n = 15, 13.9%), blood glucose lowering drugs, excl. Insulins (n = 12, 11.1%), lipid modifying agents (n = 12, 11.1%), vitamin D and analogues (n = 10, 9.3%), antithrombotic agents (n = 9, 8.3%) and mineral supplements (n = 6, 5.6%) (Figure S1).

3.4 | Evaluation of the two-way approach of information sharing between pharmacist and physician

In route I, 35 (55.6%) written reports and in route II, 28 (44.4%) digital forms with in total 105 rDRP were prepared. Of these, 59 concerned manifest rDRP and acceptance rate of recommendations was evaluated in 53 cases, excluding the six cases with "monitoring" as only intervention (Table 2). In total, 29 of 53 recommendations (54.7%) were implemented by the responsible physicians. In route I (written report on paper), 20/32 (62.5%) changes of patients´ prescriptions were found, whereas in route II (digital form) 9/21 (42.9%) prescription changes according to renal pharmacist´s recommendations were detected (Figure 2). Although numerically different, there was no statistical significance (P = 0.16) between the two routes found, probably due to the small sample size.

3.5 | Impact of the implementation of a "renal pharmacist consultant service" on prescription changes

To evaluate the impact of the RPCS, prescription changes regarding rDRP without RPCS were analysed for patients admitted to the hospital from a six-month period one year earlier.[8] In this control group of 1320 patients, 190 had an $eGFR_{non\text{-}indexed}$ of 15-59 ml/min and used ≥1 drugs at admission.[8] In retrospective analysis, 152 manifest rDRP were detected with 57 concerning only monitoring as clinical action. Thus, 95 manifest rDRP were eligible for analysis of prescription changes initiated by the physicians on ward. The change of 19 rDRP could not be determined because of missing documentation and was excluded from the analysis. 55 of 76 rDRP (72.4%) were not identified by physicians on ward and prescriptions remained unchanged. For 21 of 76 rDRP (27.6%), the prescriptions were changed but 13 rDRP (17.1%) of these had already been communicated by pharmacists on medication plans during standard PhMR resulting in

TABLE 1 Baseline characteristics of all included patients ($eGFR_{non\text{-}indexed}$ 15-59 ml/min, ≥1 drug) in route I and II, and comparison of patients with potential and manifest renal drug-related problems (rDRP) in route I vs. route II. Data are quoted as the mean ± SD, the median (interquartile range) or n (%). BSA: body surface area, BMI: body mass index

Route I	Overall	Patients with rDRP	Patients without rDRP	*P*-values
Total	111 (100.0)	35 (31.5)	76 (68.5)	
Males	86 (77.5)	28 (80.0)	58 (76.3)	0.666[a]
Age [y]	75 (28-92)	74 (28-87)	75 (30-92)	0.523[b]
BSA [m^2]	1.88 ± 0.2	1.94 ± 0.3	1.85 ± 0.2	0.066[c]
BMI [kg/m^2]	24.8 (14.8-68.8)	26.0 (18.4-68.8)	24.5 (14.8-40.8)	0.081[b]
Renal impairment				
15-29 ml/min	14 (12.6)	5 (14.3)	9 (11.8)	<0.020[a]
30-44 ml/min	34 (30.6)	19 (54.3)	15 (19.7)	
45-59 ml/min	63 (56.8)	11 (31.4)	52 (68.4)	
No. of drugs	785 (100.0)	298 (38.0)	487 (62.0)	
per patient	6 (1-18)	9 (1-18)	6 (1-17)	0.015[b]
Route II	**Overall**	**Patients with rDRP**	**Patients without rDRP**	***P*-values**
Total	123 (100.0)	28 (22.8)	95 (77.2)	
Males	76 (61.8)	18 (64.3)	58 (61.1)	0.757[a]
Age [y]	76 (30-94)	78 (30-94)	76 (32-94)	0.146[b]
BSA [m^2]	1.85 ± 0.3	1.88 ± 0.3	1.84 ± 0.2	0.549[c]
BMI [kg/m^2]	25.2 (15.6-69.1)	25.4 (16.8-69.1)	24.7 (15.6-46.7)	0.921[b]
Renal impairment				
15-29 ml/min	15 (12.2)	6 (21.4)	9 (9.5)	0.042[a]
30-44 ml/min	49 (39.8)	14 (50.0)	35 (36.8)	
45-59 ml/min	59 (48.0)	8 (28.6)	51 (53.7)	
No. of drugs	855 (100.0)	240 (28.1)	615 (71.9)	
per patient	7 (1-20)	9 (2-17)	6 (1-20)	0.026[b]
Patients with rDRP	**Overall**	**Patients with rDRP Route I**	**Patients with rDRP Route II**	***P*-values**
Total	63 (26.9)	35 (55.6)	28 (44.4)	
Males	46 (73.0)	28 (80.0)	18 (64.3)	0.163[a]
Age [y]	76 (28-94)	74 (28-87)	78 (30-94)	0.131[b]
BSA [m^2]	1.91 ± 0.3	1.94 ± 0.3	1.88 ± 0.3	0.470[c]
BMI [kg/m^2]	25.6 (16.8-69.1)	26.0 (18.4-68.8)	25.4 (16.8-69.1)	0.439[b]
Renal impairment				
15-29 ml/min	11 (17.5)	5 (14.3)	6 (21.4)	0.759[a]
30-44 ml/min	33 (52.4)	19 (54.3)	14 (50.0)	
45-59 ml/min	19 (30.2)	11 (31.4)	8 (28.6)	
No. of drugs	538	298	240	
per patient	9 (1-18)	9 (1-18)	9 (2-17)	0.983[b]
No. of drugs with rDRP	110[d] (20.5)	64[d] (21.5)	46[d] (19.2)	
No. of rDRP	105 (100.0)	60 (57.1)	45 (42.9)	
per patient	1 (1-5)	1 (1-5)	1 (1-5)	

[a]Chi-square test (categorical variables).

[b]Mann-Whitney *U* text (continuous variables).

[c]Student's *t* test (continuous variables).

[d]Drugs were counted separately, when there was a drug interaction potentially decreasing renal function (three drugs per interaction); one drug might have a potential and a manifest rDRP.

TABLE 2 Renal drug-related problems (rDRP) and pharmacist's interventions. Data are quoted as n (%). rDRP: renal drug-related problems

Renal drug-related problem (rDRP)	Overall	Route I	Route II
rDRP	105 (100.0)	60 (57.1)	45 (42.9)
Potential[a]	46 (43.8)	23 (38.3)	23 (51.1)
Manifest[b]	59 (56.2)	37 (61.7)	22 (48.9)
Treatment safety	89 (84.8)	46 (76.7)	43 (95.6)
Treatment effectiveness	16 (15.2)	14 (23.3)	2 (4.4)
Cause of rDRP			
Drug contraindicated	19 (18.1)	8 (13.3)	11 (24.4)
Drug dose too high	39 (37.1)	20 (33.3)	19 (42.2)
Dosage regime wrong	1 (1.0)	1 (1.7)	0 (0.0)
Suboptimal drug	25 (23.8)	20 (33.3)	5 (11.1)
Additional decrease of renal function possible	18 (17.1)	9 (15.0)	9 (20.0)
Inappropriate combination	3 (2.9)	2 (3.3)	1 (2.2)
Recommended intervention[c]	150 (100.0)	90 (60.0)	60 (40.0)
Drug change/drug stop	54 (36.0)	31 (34.4)	23 (38.3)
Dosage change	44 (29.3)	23 (25.6)	21 (35.0)
Dosage regimen change	3 (2.0)	3 (3.3)	0 (0.0)
New drug start	10 (6.7)	8 (8.9)	2 (3.3)
Monitoring[d]	39 (26.0)	25 (27.8)	14 (23.3)
Change of prescription for manifest rDRP[e]	29/53 (54.7)	20/32 (62.5)	9/21 (42.9)

[a]eGFR must be monitored, DRP possible, if eGFR changes (+/− 15 ml/min).

[b]rDRP is currently present with the current eGFR.

[c]More than one intervention might be necessary to solve rDRP.

[d]"Monitoring" means that serum blood value. (eg electrolytes) or adverse drug reaction must be monitored.

[e]Manifest rDRP with monitoring as only intervention not included in analysis.

8 rDRP (10.5%) that were changed on ward without pharmacist´s advice. Comparing the two periods with and without a consultant service, the implementation of the RPCS resulted in a significant improvement of 27.1% ($P < 0.01$) in prescription changes considering the manifest rDRP (Figure 2).

4 | DISCUSSION

In this study, we were able to prove the benefit of a "renal pharmacist consultant service" (RPCS), screening medication for rDRP in patients with RI and forwarding this information to physicians on ward. Our results suggest that consultations in paper form still seem to be superior to digital information sharing in a hospital with paper charts and without routinely used digital support systems. Importantly, by implementing a RPCS significantly more prescription changes regarding manifest rDRP were made than in a retrospective phase without RPCS. The implementation of a centralized RPCS in addition to the pharmacist-led medication reconciliation at hospital admission was feasible and helped to improve in-patient medication safety.

In the community setting, RI often remains unrecognized[6] and adjustment of drug therapy is missing[4,5,16]. Moreover, as seen in the retrospective phase without RPCS, a notable number of rDRP remains unnoticed by physicians after admission to hospital. Despite ongoing efforts to integrate electronic systems, supporting safe prescribing of drugs, a considerable number of hospitals still lack on having computerized physician order entry systems automatically checking patients' renal function regarding drug dosage and drug selection. Thus, other ways to detect and solve rDRP have to be implemented. A first screening can be conducted by the pharmacist performing medication reconciliation at admission, but, renal function is often not known at this time point. As we show here, a RPCS can successfully be implemented on urological wards to screen all patients after hospital admission. This concerns a considerable number of patients with about 22%-25% presenting with an $eGFR_{indexed}$ <60 ml/min/1.73 m^2 or 17% with an $eGFR_{non\text{-}indexed}$ <60 ml/min at hospital admission.[8,17] A similar number of patients with RI was found in this study. Moreover, by comparing the number of rDRP detected and solved with and without a RPCS, we demonstrated that physicians on their own only care for a minor number (11%) of rDRP present in patients admitted to urological wards.

In addition, the RPCS can ensure correct use of the CKD-EPI equation for drug dosing purposes. Here, 15% from nearly 20% of all patients remained in the critical eGFR-range for drug adjustment after recalculation considering patients´ BSA. The adjustment to a patient's real BSA is often neglected, even in previous studies on RI in hospitalized patients,[17,18] possibly leading to unnecessary or incorrect prescription changes. A RPCS may indeed prevent this.

The success of clinical pharmacy services depends on their integration in clinical routines. Immediate concurrent feedback to the physician by pharmacists was demonstrated to be the most effective way to reduce inappropriate prescribing.[4] However, as permanent ward pharmacists are not yet established at our hospital and in Germany overall, different ways of communicating DRP effectively are necessary. Here, we compared written reports placed in the patient's paper chart to digital reports in the electronic patient information system including an e-mail alert to the responsible physicians. To evaluate which system was more effective, we retrospectively documented the number of prescription changes by the physicians upon notification of the problem and calculated the acceptance rate. In our setting, the acceptance rate of the written reports in the paper chart was higher than the digital report including an e-mail alert. Reasons for the lower acceptance of the digital information route may be lack of time to check the electronic patient information system (SAP-i.s.h.med) upon the e-mail alert and the fact that the physicians are still used to work with paper charts on the wards. In route I, the information was given as a yellow paper inlay in the patient's paper chart and we believe that this signal colour, discussed prior to usage with physicians, also contributed to the

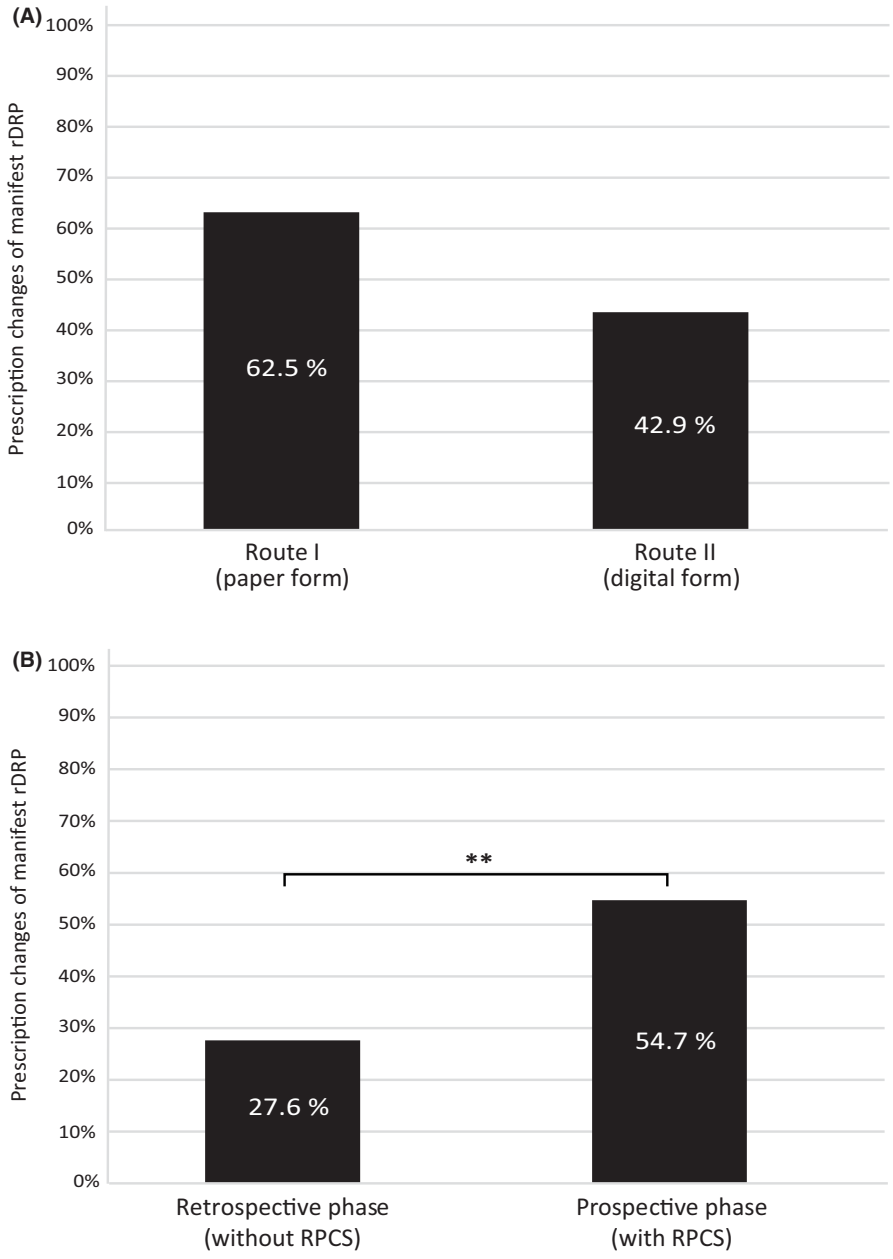

FIGURE 2 Prescription changes of manifest rDRP#. A, A higher number of prescription changes were made through route I (paper form, n = 20/32) than route II (digital form with e-mail alert, n = 9/21). B, The implementation of the "renal pharmacist consultant service" (RPCS) resulted in a significantly (**$P < 0.01$) higher number of prescription changes as seen when comparing the six months retrospective phase without RPCS (n = 21/76) to the six months prospective phase with RPCS (n = 29/53). #manifest rDRP with "monitoring" as only intervention are not included

higher notification. Additionally, with paper inlays in the paper charts the information was directly available for the physicians at the point of prescription. Although the acceptance rate of the written report in the paper charts (62.5%) was higher, there is still room for improvement. Where concurrent feedback to physicians from a ward pharmacist is yet not possible, as in our hospital, acceptance rates may be improved by calling the physician and personally discussing the issues.

In our study, it was not possible to distinguish whether the physicians consciously decided against pharmacist's recommendation due to sudden change of a patient's condition. The RPCS was centralized, and there was no ward pharmacist participating on the daily rounds. Therefore, the acceptance rate might have been higher when considering only relevant patients. This aspect should be addressed in further studies.

Since our study worked with a surgical department, where physicians are rarely present on the ward throughout the day, face-to-face discussions are often not feasible. Moreover, the hospital stay of urologic patients is typically short, sometimes only for one night after surgery, limiting the timeframe for the implementation of the recommendation by physicians. However, recommendations of the RPCS could be integrated in the discharge letter to the family physician. Future studies should cover this aspect. For digital information transfer, ways to improve the acceptance rate could include an automatic pop-up function marking important information to physicians, which should be mandatory to read.

5 | CONCLUSIONS

To improve drug safety for patients with renal impairment, a systematic screening by a "renal pharmacist consultant service" of the patient´s clinical parameters and drugs at hospital admission

identifies successfully potential and manifest rDRP. Although a "renal pharmacist consultant service" increases the amount of correct drug prescriptions, personal interaction with the responsible physicians, in addition to written paper or digital reports, may be necessary to further improve the acceptance of recommendations made by the consultant service in clinical routine.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

Sarah Seiberth participated in the design of the study, was responsible for acquisition of data, classification of rDRP, performed the analysis and drafted the manuscript. Dorothea Strobach made substantial contributions to the conception and the design of the study, classified rDRP and was involved in result interpretation and manuscript preparation. Dominik Bauer participated as a clinical pharmacist in the classification of the rDRP and critically reviewed the manuscript. Hanna Mannell helped with statistical questions, analysis of the data and revision of the manuscript. Joerg Hasford made substantial contributions to the conception and design of the study, including analyses, and manuscript preparation. Ulf Schönermarck made substantial contributions to the conception of the study, interpretation of results and critically reviewed the manuscript. Christian Stief critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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