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Acute kidney injury, the present on admission (POA) indicator and sex disparities: observational study of inpatient real-world data in a Swiss tertiary healthcare system. Explorative analysis

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ABSTRACT

Background Regarding kidney disease (KD), sex differences in epidemiology and clinical relevance have been reported. Related to absolute and relative changes of baseline creatinine, different criteria for staging may induce underdiagnosis or overdiagnosis related to sex. At the largest Swiss provider of inpatient acute healthcare, a clinic decision support algorithm ensures exact staging of KD (2012 KDIGO Kidney Disease Improving Global Outcomes Clinical Practice Guideline). Coding of the indicator 'Present On Admission' (POA) was introduced at this institution in 2018 to flag postadmission conditions.

Objective The explorative analysis aimed at differences in diagnosis groups. Defined indicators and the distribution of stages in acute kidney injury (AKI) were analysed using the POA flag. Sex differences were reported.

Methods Retrospective observational study. Explorative analysis. Routinely collected health data, 2019 and 2020 (121 757 cases) on the patient history and intensive care treatment duration, comorbidity levels, coded diagnoses, age and sex.

Software and statistic: program R, V.4.1.1, SD; median, IQR; prop.test; standardised mean difference.

Results The reporting of postadmission diagnoses showed more interhospital transfers, more intensive care stays, higher scores of severity and treatment intensity, more often mechanical ventilation, a higher age, a higher number of diagnoses, a higher complexity level of the related cases and mortality. This observation could be made to a lesser degree for the female population. However, for the female population mortality was higher (stage III AKI 41.6%).

Conclusion Using the POA flag, the results reflect the clinical situation of complications and comorbidities evolving unexpectedly. As our results show sex differences, that is, a lower morbidity of female patients for each stage, but a higher mortality, a deeper evaluation of the implied sex differences in staging of KD should follow.

The general results confirm the necessity of a diagnosis-onset reporting in health statistics.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Sex differences in kidney disease (KD) have been reported and former studies demonstrated an under-representation of female participants in research populations. Present On Admission (POA) reporting is used for flagging healthcare-associated diagnoses.

WHAT THIS STUDY ADDS

⇒ The study demonstrates a method to gain transparency for vulnerable inpatient groups (acute KD and stages; acute-on-chronic KD) by applying the POA indicator and stratifying for sex. It is the first study to use highly valid data of acute and acute-on-chronic KD (reliable and validated algorithm to calculate stages of KD) for POA reporting. Sex differences with regard to outcome could be reported.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study demonstrated the usability of POA reporting especially in combination with high-quality diagnosis and coding data. It enhances the introduction of additional indicators into local and national health statistics and underlines the need for transparency with regard to sex differences in routine data, process of diagnosis and research.

INTRODUCTION

In many studies, it is assumed that data obtained from research involving male participants could be extrapolated to women, although it could be demonstrated that sex "can account for high (50%–75%) inter-individual variability in pharmacological responses".[1–5] A recently published article could show a sex bias against female

participants in articles, being highest for studies on chronic kidney diseases (CKDs) compared with other diseases (global female prevalence of CKD 0.57, female participant fraction of the compared studies on CKD 0.40).[6] The sex bias is still present in the majority of research disciplines despite research policies.[6 7] Relevant under-representation of female participants could be made transparent by a recent study focussing on HIV/AIDS, CKD and cardiovascular diseases among others.[6] The under-representation of female sex applies not only for study population involving disease diagnosis but also for scoring systems, like severity and nursing scores for intensive care unit (ICU) treatment (Therapeutic Intervention Scoring System (TISS-28), Simplified Acute Physiology Score (SAPS), Nine Equivalents of Nursing Manpower Use Score (NEMS)).[8–10]

Moreover, the epidemiology and outcome of many diagnoses are related to biological sex.[11] The Global Burden of Disease Study estimated that CKD deaths among men of all ages were 14.5 per 100 000, whereas in women they were 12.14.[12] Sex has been shown to influence medical diagnoses.[7 13] Not only the biological but also other different determinants from social and economic to individual behaviours of patients and providers possibly contribute to the reported differences.[14]

Kidney disease (KD) is a particularly relevant disease with sex differences. There are more women with CKD, yet only 40% of patients receiving kidney replacement therapy are female.[12 15–17] In the dialysis population, the percentage of women is less than 50%, for both prevalent and incident patients.[12] When calculating the life expectancies of men and women (age 30–85 years), it could be shown that under the presumption that women generally live longer than men they actually lived 1–2 years less than men with both groups having CKD stage 5.[12] Disparities in access to care are also described for ICU admission, less aggressive medical care and later initiation of renal replacement therapy.[18–20] Even in high-income countries, the access to kidney transplantation seems to be limited for women and they receive less and donate more organs.[12 19] Globally, CKD stage 5 without renal replacement therapy was estimated to be present in the same number of women and men (3.2 million), but 1.3 million female and 1.7 million male patients were treated with dialysis and 0.3 million female versus 0.4 million male patients had a functioning kidney graft.[16] The lacking treatment corresponds to outcomes of CKD as well as of acute kidney injury (AKI).[11 16 17 19 21]

Biological sex is recognised as modulator of the course and progression of disease and management of CKD. This also has been examined in hospital-acquired AKI (HA-AKI).[16 22–24] The introduction of the KDIGO guidelines (2012 KDIGO Clinical Practice Guideline for AKI and the Clinical Practice Guideline for the Evaluation and Management of CKD[25 26]) to assess AKI and CKD raised questions concerning sex differences due to definition criteria.[23 24 27] Whatever the concluding discussion will convey in the future, there is no doubt that for both sex the prevalences are high, with AKI ranging from 10.7% to 31.3%,[15 28 29] that sex differences in epidemiology and the transition from AKI to CKD can be observed[22 30] and that HA-AKI is associated with increased mortality.[31–35] Moreover, for both sexes AKI, CKD and acute-on-chronic KD are very relevant as a comorbidity, intercurrent disease or complication.[28 36 37]

Indexing clinical information to diagnosis-timing, that is, using a present-on-admission flag for hospital admission is important in order to monitor complications and disease progression in CKD and AKI. The use of routinely collected health data of inpatient care for understanding patterns of different outcomes has been limited in Switzerland by the fact that pre-existing and postadmission conditions have been indistinguishable.

The use of a 'Present On Admission Indicator' (POA) allows to differentiate diagnoses arising during from those arising before an inpatient stay and therefore provides an important perspective on the quality of healthcare provided.

The POA indicator is dependent on the prevalence of the underlying diagnoses and the associated coding guidelines.[38 39] Therefore, we preferred a data-driven approach to assign diagnoses of AKI, CKD and acute-on-chronic KD with the help of a complex rule engine implementing the KDIGO criteria for diagnosis and staging.[25 26]

Since 2017, AKI and CKD have been coded according to the KDIGO guidelines in Switzerland,[39] but documentation of the exact KDIGO staging is often missing in the electronic health records and coding and documentation quality remains to be an issue.[40] POA reporting was introduced into the standard coding process at this study's institution in 2018.

The aim of this retrospective observational study is to demonstrate the capability of POA reporting with regard to differences in diagnosis groups and sex.

MATERIALS AND METHODS

Design

Routinely collected health data of inpatients in acute care were used in this retrospective observational study. The coding was conducted centralised. The coding of AKI was supported by a highly automated exact and validated calculation of AKI stages.

Patient and public involvement

As routinely collected data were used and no intervention took place, patients were not involved. In order to ensure the ethical handling of sensitive data, the study was disclosed to the ethics committee of the canton of Bern, Switzerland. The authors of the study put forward a request of adding POA to the national medical dataset

(Federal Statistical Office of Switzerland) and thereby involved the public.

Setting

The institution's facilities provide all levels of both inpatient and outpatient care (from primary care to highly specialised medicine at the university hospital in the inpatient and outpatient setting, inpatient rehabilitation, all specialities including neonatology and a paediatric hospital). Coding infrastructure, software and processes are identical for all sites. Patients show a high level of complexity (complexity level and number of diagnoses above the Swiss average), and many are transferred from other hospitals with complications at admission. The institution counts four sites with 60 000 inpatient cases per year.

Study population

The study population included all inpatients of acute care of all facilities and all levels of care from 1 January 2019 to 31 December 2020. Patients at admission being 16 years of age or older were included. No further exclusion criteria were applied, that is, primary diagnosis, reason for admission, planned and/or delivered treatment

Data sources

The following datasets were used: (1) Cost data containing information on readmission; (2) Patient Clinical Complexity Level (PCCL) data containing severity scores per case and diagnosis; (3) POA data containing POA values for selected ICD-10-GM (International Statistical Classification of Diseases and Related Health Problems, 10th revision, German Modification) codes per case; (4) Movement data containing the case related movements within the hospital during inpatient stay; (5) Medical statistic datasets containing demographics, diagnosis, admission and discharge information per case.

Several variables were used for the current analysis. A short overview is provided in online supplemental table S1. Details on each variable are presented in the next section.

Data management

All the datasets were merged by using the inpatient case number serving as unique identification (case ID). Cases without POA values and cases missing in cost or movement datasets were deleted. Cases without PCCL values were kept since the individual diagnosis-related Complication and Comorbidity Level (CCL) values were used to calculate the PCCL. The approach used was[41]:

(1) Order CCL scores from biggest to smallest for each case; (2) Add a column for row number starting to 1; (3) Calculate CCL*e $^{-(\text{row}-1)*\ 0.4}$ for each row; (4) Sum all the above values per case; (5) Calculate $\frac{\log(\text{sum}+1)}{\log\left(\frac{3}{0.4}\right)}$ and (6) Round result to get 0, 1, 2, 3 or 4 (values higher than 4 are forced to 4). The data were deidentified from the start and any sensitive information was deleted.

Variables

POA indicator

The inclusion list of diagnoses to be reported is based on the hospital-acquired complications list published by The Australian Commission on Safety and Quality in Health Care.[42] The technical implementation into the coding workplace[43 44] took place in 2017.

The POA coding adhered to the Centers for Medicare & Medicaid Services (CMS) ICD-10 Clinical Modification, Official Guidelines for Coding and Reporting, fiscal year 2017 Appendix I.[45] Captured values were: (1) Yes=Diagnosis present at time of inpatient admission; (2) No=Diagnosis not present at time of inpatient admission; (3) U (unknown)=Documentation insufficient to determine if the condition was present at inpatient admission; (4) W (clinically undetermined)=Provider unable to clinically determine whether the condition was present at inpatient admission and (5) NA (not assigned)=blank.

For this study, we collapsed the different POA categories into two: (1) 'POA no' referring to healthcare-associated conditions and 'POA yes' (including yes, W, NA and U) referring to conditions present at admission.[45]

Sex

In alignment with the WHO and the reported data in the hospitals' administrative system, we defined the variable sex as the "biological category based on reproductive, anatomical, and genetic characteristics, generally defined as male, female, and intersex".[46 47] For the current study, only the answer options 'male' and 'female' were available, values for biological intersex were not captured.

ICD codes

The ICD-10-GM[48] is the official classification for encoding diagnoses in Switzerland.[49]

In this study, the coding of category N17 (AKI and stages) relies on a data-driven approach using a complex rule engine.[50] Real-time and retrospective laboratory data from the hospital's clinical data warehouse based on an SQL algorithm was used to apply the specific AKI codes. They were used in this study to define the AKI groups 1–3 and 9 (stages I–III and not classified), see online supplemental table S2 for the selection of ICD-10-GM codes used for grouping cases according to the AKI stages.

Severity indicators CCL and PCCL

In order to outline the possible effects of secondary diagnoses on resource consumption, the ICD-10-GM codes are assessed as a complication or comorbidity for the Diagnosis Related Groups (DRG) system. The severity value CCL is assigned. A complex algorithm of the SwissDRG system calculates the inpatient case's specific PCCL from

the CCLs (cumulative effect).[41] The calculation of the PCCL and CCL per diagnosis does not consider whether a condition arose during the episode of care or not. The PCCL values as well as the CCL values summed per case were used in this study.[41]

Morbidity indicators

Outcome-related variables like ICU and intermediate care (IMC) stay, interhospital transfer and morbidity were selected, see online supplemental table S3. Variables representing morbidity like duration of mechanical ventilation, scores used to quantify, evaluate and allocate nursing workload at ICU level 'NEMS'[8] and the severity score 'SAPS'[9] were chosen (online supplemental table S3).

Further variables

Age at admission was included. Information about admission and discharge was used and when resulting in answer options below 1% were grouped under 'otherwise specified'. The variables "place before admission", "stay after discharge", "type of admission", "care after discharge", "admission decision" and "discharge decision" were included.

Data analysis

The statistical program R, V.4.2.1 for Linux was used with the following packages: dplyr, reshape2, tidyr and janitor for data manipulation and tables; stringr for text manipulation; ggplot2 and ggpubr for creating and arranging plots, see online supplemental table S4.

In order to describe relevant indicators of morbidity and outcomes, a stepwise descriptive analysis of the characteristics was conducted for the study population as a whole and for specific subpopulations (ie, ICD-10-GM codes). The distribution of the POA values was subsequently stratified for the variable sex. The diagnoses were analysed referring to the hierarchical levels of the ICD-10-GM. The AKI stages required an accumulation of certain five-digit ICD-10-GM codes[51] per group. The significance of differences in the incidence of health-associated diagnosis coding with regard to sex was calculated for all AKI stages. Furthermore, a descriptive analysis of several indicators specified for AKI stage, sex and POA coding was carried out. For the reason of small numbers, the coding of acute-on-chronic KD was analysed separately.

Mean with SD and median with IQR were computed for numerical variables and percentages for categorical variables. An overview of the population characteristics was conducted. Stratifications for sex and AKI stages were also conducted.

Bar charts were created for stratifications of POA, sex, CKD and/or AKI stages with or without additional variables. Finally, boxplots stratified by AKI staging for numerical variables were performed.

Coding bias and missing data concerning the AKI and CKD ICD codes could be ruled out by the mentioned automatic process of assigning the diagnoses by calculation. Bias in POA reporting might occur on the coder's and on the provider's side. However, the near real-time calculation of the AKI and CKD diagnoses allows to determine the point of time of diagnosis and allows to point out the differences in POA reporting. All other data used are recorded and processed due to highly standardised processes.

RESULTS

Final dataset

The final datasets included 105 673 inpatient cases and 947 500 diagnoses. Overall, 3865 cases were excluded because of missing PCCL data. Missing PCCL data occurred in cases with ICD codes not carrying this attribute of information at all or in cases containing no ICD coding at all. Therefore, no cases of inpatient acute care and specifically no cases with AKI and CKD diagnoses were affected by exclusions. An overview of the merging process is shown in online supplemental figure S5. An overview of the distribution of overview of the population characteristics is given in online supplemental figure S6.

Stratification by sex

Overview

Comparing the proportion of POA values associated with indicators of patient history, several sex differences can be demonstrated (online supplemental figure S7), for example, healthcare-associated diagnoses of the male subpopulation show a higher proportion of related cases with interhospital transfer or ICU stay than of the female subpopulation (online supplemental table S8).

ICD hierarchy

Comparing the ICD blocks, categories and subcategories of ICD-10-GM codes defined for KD, the proportion of healthcare-associated diagnoses of all diagnoses of that group is higher in male than in female patients (online supplemental table S9).

Table 1 highlights significant sex differences of healthcare-associated diagnoses for all ICD diagnoses, but not for AKI.

Analysing exclusively the clinical indicators for the ICD-10-GM chapter N and block N1 cases related to healthcare-associated diagnoses of male patients show higher values compared with female patients (n diagnoses, SAPS, NEMS, CCL sum) (online supplemental tables S10 and S11).

ICD 17 AKI stages

8289 ICD diagnoses with POA reporting are grouped into 4024 diagnoses for AKI I, 1340 AKI II and 1412 AKI III. 1345 AKI ICD diagnoses are not classified by AKI stage. The absolute numbers of ICD codes associated with men are higher in all subgroups. The same accounts for the

Table 1 ICD Present On Admission (POA yes) and healthcare-associated (POA no) all diagnoses and AKI by sex

	All diagnoses			AKI		
	POA no	POA yes	All	POA no	POA yes	All
women	25 747 (5.5%)	442 364 (94.5%)	468 111	448 (13.6%)	2846 (86.4%)	3294
men	34 090 (5.9%)	535 711 (94%)	569 801	729 (14.6%)	4269 (85.4%)	4998
	χ^2=810 860, df=1, p value <2.2e−16			χ^2=1.50, df=1, p value=0.2202		

AKI, acute kidney injury; ICD, International Classification of Diseases.

group of acute-on-chronic KD (ICD codes N17 and N18 combined).

Nevertheless, only slight differences can be observed in both female and male patients of all AKI and acute-on-chronic diagnoses of the specific subgroups (figure 1 and online supplemental tables S12 and S13).

Moreover, no significant difference in the distribution of health-associated diagnoses between female and male cases can be observed in any specific AKI stage.

The distribution of AKI and CKD stages for ICD coding of healthcare-associated acute-on-chronic KD (ICD-10-GM N17 and N18) is displayed in online supplemental figure S14 and table S15.

With 238 healthcare-associated ICD diagnoses of women and 356 of men, respectively, the biggest differences between both sexes in absolute numbers can be shown for groups AKI I CKD 2 and AKI III CKD 2 and 3. As most of the groups are of small numbers, we did not execute further analyses.

Figure 2 highlights the proportion of healthcare-associated diagnoses related to the patient history for female and male patients for AKI stages I–III (figure 2 and online supplemental table 16).

The proportion of healthcare-associated diagnoses of women is higher for all AKI stages with regard to 'admission—interhospital transfer' and for AKI II and III with regard to 'discharge—interhospital transfer' than of men. However, for all AKI stages the proportion of 'intensive care' stays is lower.

Compared with men, the following differences of the morbidity indicators of women for healthcare-associated AKI can be highlighted: Significant differences of median values in AKI I for a shorter duration of ICU stay, in AKI II for a higher age, lower SAPS

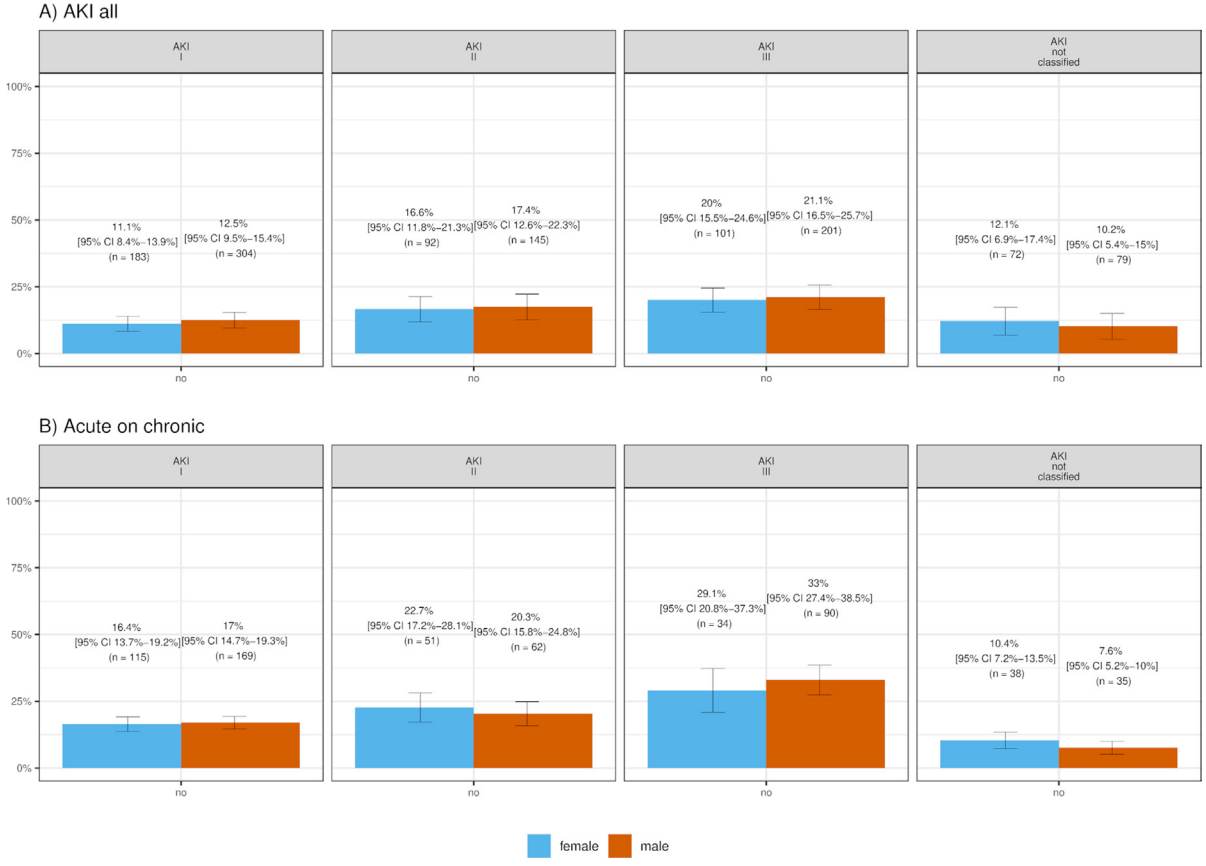

Figure 1 ICD 17 healthcare-associated AKI and acute-on-chronic staging distribution (POA no) by sex. AKI, acute kidney injury; ICD, International Classification of Diseases; POA, Present On Admission.

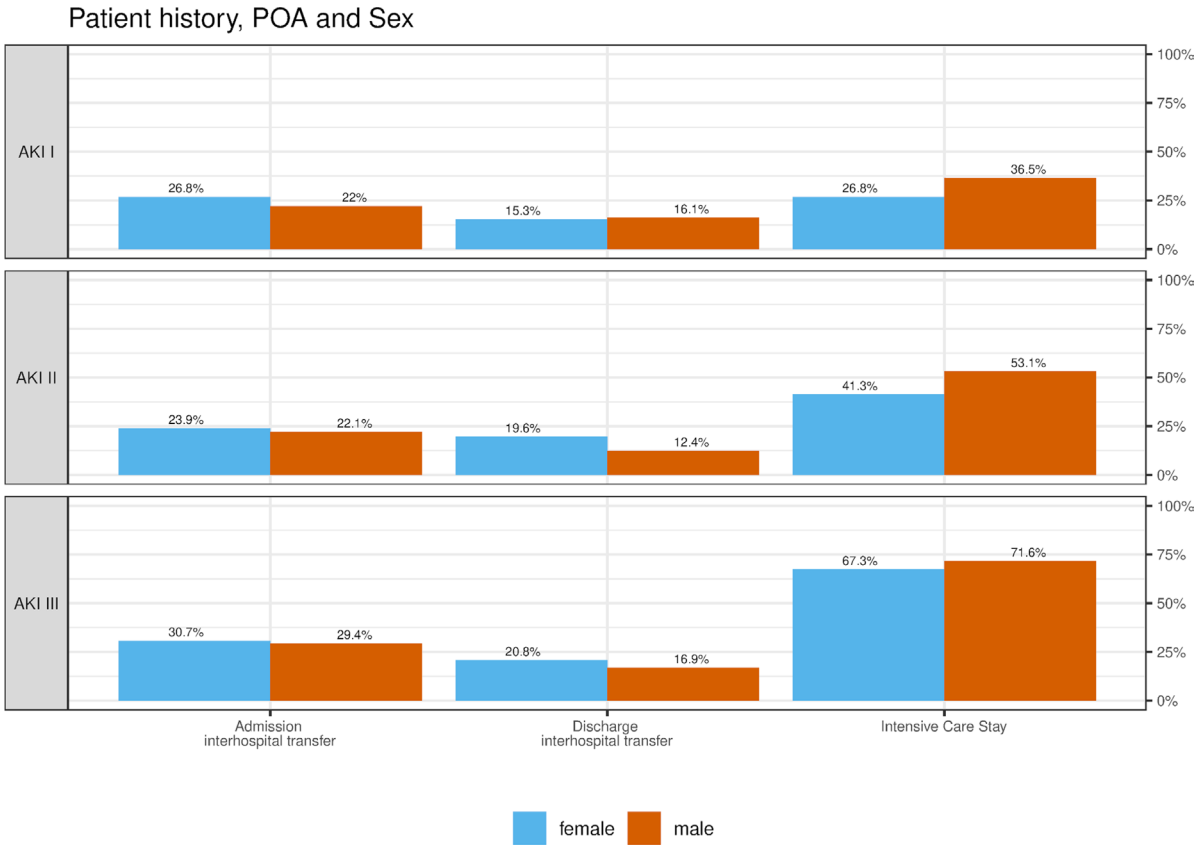

Figure 2 ICD N17 stages of healthcare-associated AKI (POA no) patient history by sex. AKI, acute kidney injury; ICD, International Classification of Diseases; POA, Present On Admission.

score and less CCL sum, in AKI III for a higher age and fewer ICD coded diagnoses (figure 3 and online supplemental table S16).

Mortality

The mortality related to healthcare-associated diagnoses of AKI is higher for female patients (all AKI diagnoses 19.3%, AKI stage II 26.1%, AKI stage III 41.6% and acute-on-chronic KD 14.3%, male patients 16.4%, 15.9%, 33.8% and 11.8%, respectively) (figure 4 and online supplemental table S17).

DISCUSSION

General remarks

The objective of this explorative study was to test the POA reporting for its capability of indicating group differences with regard to outcome. Subsequently, we explored sex differences in the distribution of POA status, associated patient history and clinical indicators. When analysing subgroups, we focused on ICD chapter N 'Diseases of the genitourinary system' containing clinically highly relevant diagnoses for both sexes and showing significant differences in POA reporting on all levels. In this study, we could make differences between female and male patients apparent which might induce a deeper analysis of larger populations in future. We could relate the defined outcome indicators to healthcare-associated AKI by making use of the POA reporting and highlighting sex differences. The diagnosis-onset reporting using the POA indicator was essential to uncover sex differences in healthcare-associated AKI.

Main findings

The reporting of healthcare-associated diagnoses corresponds to the defined indicators of patient history and morbidity.

For ICD chapter N 'Diseases of the genitourinary system', we found a significant sex difference in the distribution of healthcare-associated diagnoses (women 5.9%, men 5.2%).

The acuity of AKI when healthcare-associated corresponds to patient history, for example, a higher proportion of ICU stays and interhospital transfers. The female population shows a lower proportion of received ICU treatment but higher rates of interhospital transfers. The selected variables of patient history and morbidity were inconsistently linked to the severity of the AKI stages and did not correspond to mortality.

Significant sex differences can be demonstrated for a higher age in healthcare-associated AKI II and III, a shorter duration of ICU stay in AKI I, lower SAPS score in AKI II and III, less CCL sum in AKI I and fewer ICD-coded diagnoses in AKI III.

The mortality during hospitalisation related to the healthcare-associated diagnoses of all analysed ICD blocks, categories, AKI stages and acute-on-chronic KD

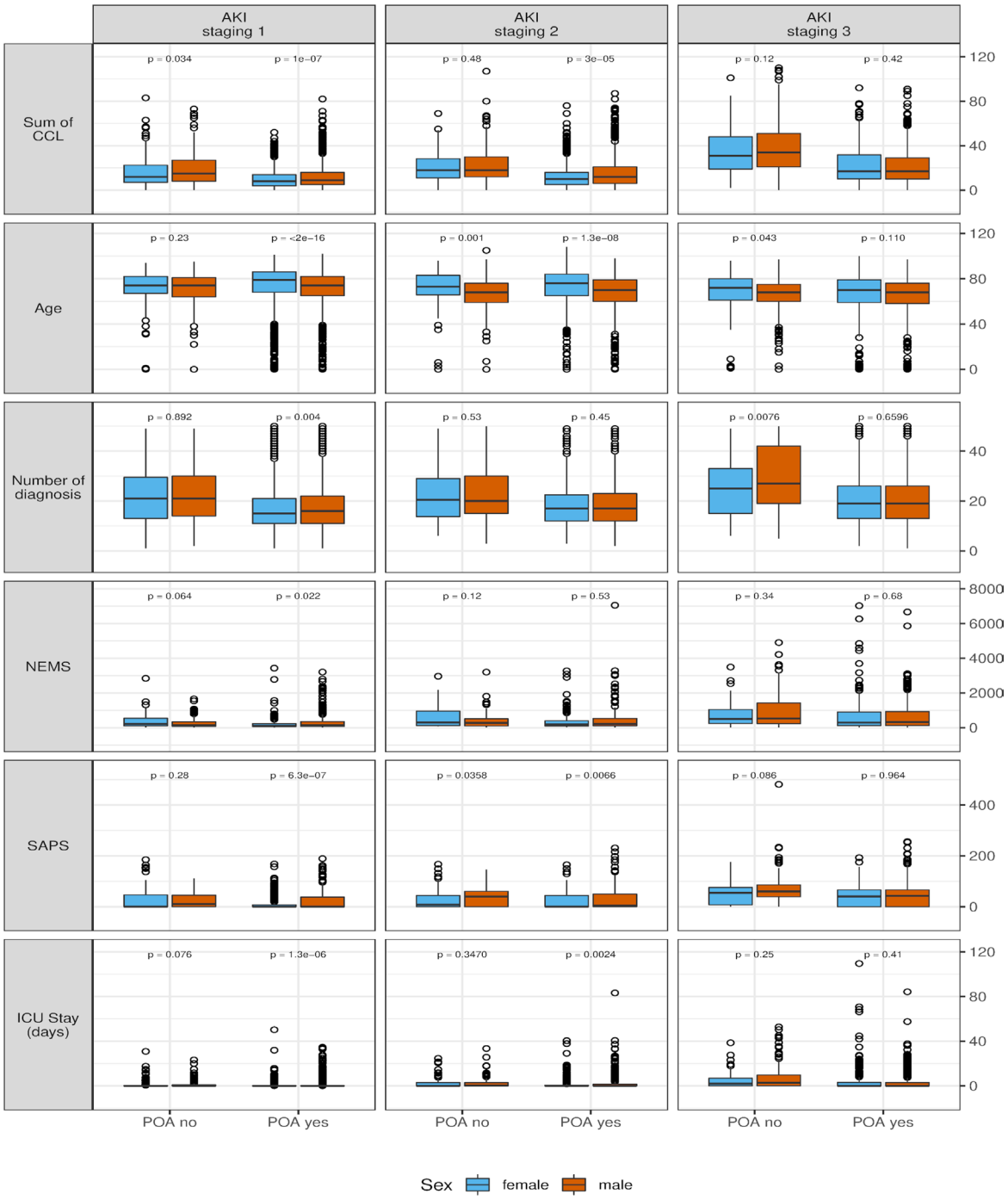

Figure 3 ICD N17 Present On Admission (POA yes) and healthcare-associated (POA no) AKI morbidity indicators by sex. AKI, acute kidney injury; CCL, Complication and Comorbidity Level; ICD, International Classification of Diseases; ICU, intensive care unit; NEMS, Nine Equivalents of Nursing Manpower Use Score; SAPS, Simplified Acute Physiology Score.

stages was higher than of diagnoses of these groups reported not to be healthcare-associated. The mortality was highest for the subgroups AKI II and III and acute-on-chronic KD of female patients (26.1%, 41.6% and 14.3% of healthcare-associated diagnoses related to cases of female patients).

Discussion of the findings

In this study, we demonstrated the usability of diagnosis-onset reporting and identified the association of postadmission diagnoses with patient history, morbidity, mortality and sex. However, not all the analysed groups showed statistically significant differences.

The diagnoses reported to be healthcare-associated relate to a higher proportion of interhospital transfer, ICU and IMC stays, elevated SAPS and NEMS scores and mechanical ventilation hours, higher age, more diagnoses, a higher CCL sum and a higher PCCL. These findings reflect the clinical situation of complications

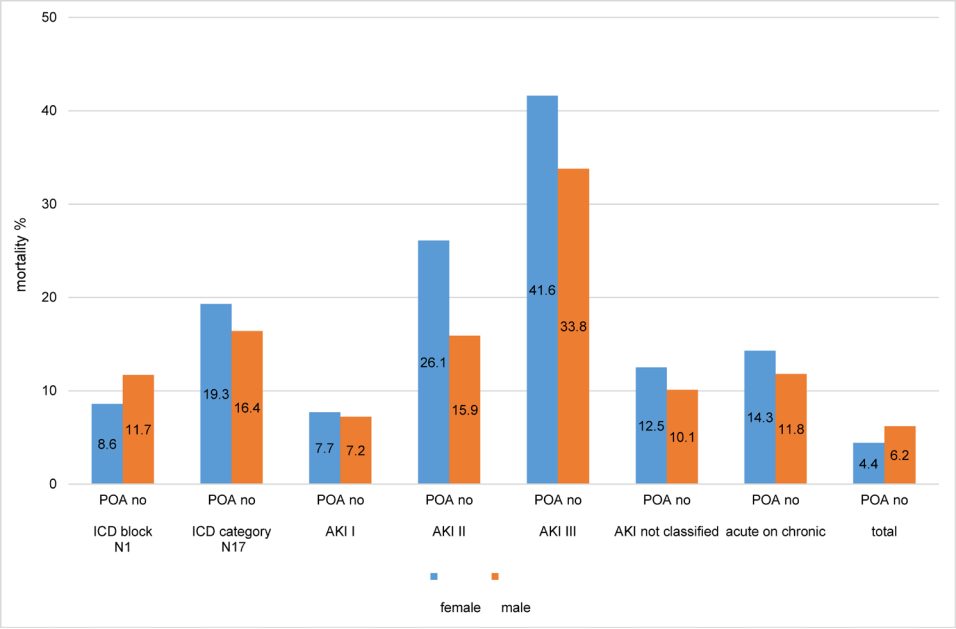

Figure 4 Mortality ICD hierarchy healthcare-associated AKI (POA no) by sex. AKI, acute kidney injury; ICD, International Classification of Diseases; POA, Present On Admission.

and comorbidities evolving after admission in inpatient care. Except for older age, the results of the reported healthcare-associated diagnoses displayed a higher morbidity and more complex patient history for males than for females. However, being descriptive in this study the association and the confounders of the variables cannot be defined. Overall, we demonstrated this for all examined diagnoses (AKI and stages, acute-on-chronic KD) and found statistically significant differences in some subgroups between the POA values and sex. In our population, the proportion of diagnoses related to female patients was lower than those related to male patients. In general, a low detection rate of diagnoses and stages may cause a lower admission rate to the ICU[18 20 52] and underestimated morbidity and conservative treatment could lead to worse outcomes.[53 54] A lower detection rate can be discussed but does not apply for AKI, CKD and acute-on-chronic KD at our institution as by automated detection (algorithm of clinical decision support system CDSS) all diagnoses and stages are captured during inpatient stay. However, the CDSS is currently not implemented for clinical use in the information system. Therefore, the calculated diagnoses and stages do not have an immediate effect on the patients' treatment if not recognised otherwise. Nevertheless, the diagnoses we analysed in this study were approved by the clinician before effectively coded. We could prove in a former study that this method supports the reliability of diagnosis.[50]

Our results of the analysis of the AKI stages showed lower values for indicators related to morbidity in the group of diagnoses associated with females, but a higher mortality. Therefore, a deeper evaluation of the implied sex differences in staging of KD should follow.

In past studies, it could be shown that the incidence of HA-AKI was greater in men than women when KDIGO criteria were used but differences disappeared when staging was conducted according to the RIFLE (Risk, Injury, Loss of kidney function, and End-stage kidney disease) criteria.[27] On the other hand, we assume that care-seeking behaviour and the offered intensity of care might be influenced by the patient's age alone independently from comorbidities.[7 54 55] Both could explain the higher mortality we observed in the female patients.

As AKI is not an independent diagnosis but expression of a heterogeneous set of disorders characterised by an acute organ dysfunction, the diagnosis-onset reporting and sex differences need further investigation with regard to risk adjustment. Observational studies have shown a variety of risk factors like pre-existing susceptibilities of individual patients related to the severity of AKI.[56] Concerning risk adjustment and definition of outcome indicators used in this and other studies, it should be mentioned that the underlying data might not appropriately represent women. For instance, neither the validation of the NEMS nor of the SAPS scores (and as preliminary work of the TISS-28) was based on equally distributed datasets of female and male ICU patients.[8–10] Therefore, it can be questioned, if they are as appropriate to assess morbidity/severity and nursing workload for female patients as they are for male patients. Furthermore, risk adjustment for hypertension, diabetes mellitus, cardiological complications and liver cirrhosis which often accompany AKI should consider that these conditions are not adequately sex-represented, and related research is impacted by lacking sex stratification.[6 57]

As mortality in our study was highest for the subgroups of healthcare-associated diagnoses AKI II and III and acute-on-chronic KD of female patients, we should expect matching results with regard to indicators for patient history and morbidity, which we did only partially.

As the only unambiguous measure was mortality, this may question the appropriateness of the chosen indicators. The mortality rate related to the diagnoses may even be higher because we only considered inhospital mortality. It is unclear, which role a potential underdiagnosis of comorbidities plays, which may lead to a low detection of events relevant for outcome and mortality. To improve the future work at our institution, the integration of, for example, the Charlson Comorbidity Index[58] into the health record would facilitate risk adjustment. However, it could be demonstrated in a thesis (ICD-10-GM codes; German dataset) that the rather simple approach of counting the number of coded ICD codes,[59] which we applied in our study, is a usable severity indicator.

Due to the small numbers, we reported only a few results for acute-on-chronic KD. Essentially, they agree in interpretation with the results of AKI and staging, as we observed a higher mortality. Also, patient history and morbidity show higher values and proportions for the healthcare-associated conditions and mortality in the group of diagnoses associated with female patients. Nevertheless, the staging of AKI and CKD in acute-on-chronic KD should be analysed further, as until now it is often under-reported at discharge, and administrative data are not available to the extent of AKI and CKD at our institution and elsewhere.[36 60] Therefore, not only the diagnosis-timing of the highest stage should be analysed, but the disease progression during hospitalisation measured by encoding all stages. As the CDSS is also designed to monitor AKI progression, it encourages analyses of the course of KD in future.

Our analysis shows that by implementing the POA indicator in healthcare systems the utility of routinely collected health data could be improved. National stakeholders show a high interest in quality monitoring by further developed administrative datasets[61] and in improved risk models. A proposal for extension of the national dataset for diagnosis timing was put forward to the Swiss Federal Statistic Office in 2018 but rejected at that time.[62 63]

Based on the findings, we suggest that the POA indicators should be considered for medical statistics and quality management.[64 65]

Strength

To our knowledge, this is the first study to analyse the association of the POA indicator and sex differences to outcome and morbidity data using a highly reliable and precise dataset of ICD coding of AKI with an exact staging and of acute-on-chronic KD. A data-driven automatic approach ensures the reliable diagnoses, staging and subsequent ICD coding.[50] Therefore, in this study, data are not impacted by a low ICD coding and/or documentation quality of the diagnoses themselves. Available data of ICD coding of acute-on-chronic disease based on routinely collected health data are a strength as until now the diagnosis of acute-on-chronic KD is poorly understood and very often under-reported in documentation, ICD coding and POA reporting.[36 40]

Limitations

This study demonstrates how valuable routinely collected data can be in detecting expected and unexpected results using the POA indicator even with the choice of an explorative approach. However, due to the analysis via exploration and description of data accessed at our institution for the first time, the study's main limitation is the lack of adequate methods to thoroughly analyse the variables' associations and possible confounders. A regression analysis should be the next step. Moreover, due to small numbers, it was not possible to interpret sufficiently significant levels of some of the subgroups. Moreover, with regard to mortality, we were limited to inhospital mortality and did not consider mortality after hospitalisation, although it is known to be elevated in association with KD.[66] Another drawback of this retrospective observational study is the lacking risk adjustment, especially for relevant comorbidities and age, which might contribute to sex differences. This study does not cover the overall incidence and prevalence of KD.

CONCLUSIONS

The POA indicator proved to be a valuable variable to flag diagnoses arising during the episode of care for analysis of administrative data. Diagnoses of AKI and acute-on-chronic KD could be successfully indexed, and differences with regard to patient history, morbidity, mortality and sex could be made transparent. Sex differences of healthcare-associated AKI and stages could be highlighted. The higher mortality of female patients with healthcare-associated diagnoses could not be linked to a higher morbidity of that group as defined in this study. Ruling out the possibility of sex-related underdiagnosis of AKI staging, we recommend the implementation of the automated algorithm to assign the diagnoses of CKD and AKI as a CDSS into production for clinical use. Moreover, a deeper evaluation of the implied sex differences in staging of KD according to different criteria is needed.

In order to obtain a larger study population, especially for the diagnosis of acute-on-chronic disease, the necessity of a diagnosis-onset reporting in national health statistics can be confirmed. Awareness of biases and disparities by transparency is a sensible step in improving clinical decision-making.

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