ABSTRACT
Hyponatraemia on hospital admission is associated with increased length of stay, healthcare expenditures and mortality. Urine studies collected before fluid or diuretic administration are essential to diagnose the underlying cause of hyponatraemia, thereby empowering admitting teams to employ the appropriate treatment. A multidisciplinary quality improvement (QI) team led by internal medicine residents performed a QI project from July 2020 through June 2021 to increase the rate of urine studies collected before fluid or diuretic administration in the emergency department (ED) in patients admitted with moderate to severe hyponatraemia. We implemented two plan-do-study-act (PDSA) cycles to address this goal. In PDSA Cycle #1, we displayed an educational poster in employee areas of the ED and met with nursing staff at their monthly meetings to communicate the project and answer questions. We also obtained agreement from ED attending physicians and nursing leaders to support the project. In PDSA Cycle #2, we implemented a structural change in the nursing triage process to issue every patient who qualified for bloodwork with a urine specimen container labelled with a medical record number on registration so that the patient could provide a sample at any point, including while in the waiting area. After PDSA Cycle #1, urine specimen collection increased from 34.5% to 57.5%. After PDSA Cycle #2, this increased further to 59%. We conclude that a combination of educational and structural changes led to a significant increase in urine specimen collection before fluid or diuretic administration among patients presenting with moderate-to-severe hyponatraemia in the ED.

PROBLEM
Hyponatraemia, as defined by serum sodium <135 mmol/L, is present in up to 10% of patients admitted to the hospital and is associated with increased length of stay (LOS), healthcare costs and mortality. Elderly patients represent a high-risk group for the occurrence of hyponatraemia, with both age and polypharmacy being independently associated with hyponatraemia. In this population, the incidence of hyponatraemia has been reported to be as high as 34% on admission in hospitalised patients over 65 years old. Furthermore, studies also indicate that symptomatic manifestations of hyponatraemia are more common and more severe in elderly patients, with hyponatraemia independently associated with increased mortality. Urine studies obtained before fluids or diuretics are administered, both of which rapidly alter the composition of urine, are essential in the workup of hyponatraemia aetiology. Despite their clinical utility, urine studies are not frequently obtained in emergency department (ED) patients before fluid or diuretic administration for a variety of reasons. These include patients not being asked to provide a urine specimen during triage and a desire to provide rapid interventions to improve a patient’s clinical status, for example, intravenous fluids in a patient who is clinically dehydrated or intravenous diuretics in a patient who is clinically volume overloaded. A baseline audit of urine collection before fluid or diuretic administration.
diuretic administration in our ED demonstrated a 34% collection rate among patients presenting with moderate-to-severe hyponatraemia, defined as serum sodium <130 mmol/L.4

The participating institution is a medium-sized, 304-bed academic, tertiary care hospital that provides 35 different adult medical and surgical specialties. The facility has a 40-bed ED that serves local and regional patients, many of whom already receive subspecialty outpatient services, including oncology, transplant and neurology care. Hyponatraemia is a frequent diagnosis encountered in patients admitted to internal medicine services, and the elucidation of hyponatraemia aetiology is a frequent challenge faced by these medical teams. Given that urine sodium and osmolality measurements are cornerstone labs in the workup of hyponatraemia aetiology,8 an increased rate of collection of urine samples in the ED before diuretics or intravenous fluids are administered would be helpful for the care of these patients. Therefore, in this quality improvement (QI) project, we aimed to increase the rate of urine collection before fluid or diuretic administration in patients presenting with moderate-to-severe hyponatraemia to the ED by 25%, from a baseline of 34.5% to 42.5%, during the period July 2020 through June 2021.

BACKGROUND

Moderate and severe hyponatraemia, defined by serum sodium <130 mmol/L and 120 mmol/L, respectively, can cause a spectrum of symptoms ranging from weakness and ataxia to coma that can become life-threatening.8 The management of hyponatraemia is complex on multiple levels. First, a variety of aetiologies can cause hyponatraemia, including hypovolemia, hypervolemia, medication effects, neurologic injury, dietary insufficiencies, polydipsia, and endocrinopathies.4 Second, the management of hyponatraemia varies based on the underlying cause, and treatments for each aetiology differ significantly and can be opposite.4 For example, the treatment of hypovolemic hyponatraemia in a dehydrated patient is fluid administration; however, fluid administration in a patient with hypervolemic hyponatraemia from decompensated heart failure would worsen their hyponatraemia and clinical condition. Third, great care must be taken to neither correct hyponatraemia too quickly nor worsen hyponatraemia by applying the incorrect treatment, as this can lead to irreversible central pontine myelinosis or cerebral oedema, respectively, both of which can cause disability and death.9 10

Urine osmolality and sodium measurements are cornerstone labs in the workup of hyponatraemia aetiology.4 Combined with serum studies, physical examinations and medication reviews, urine studies empower an understanding of the physiology driving a patient’s hyponatraemia leading to appropriate diagnosis and treatment. Urine studies should be obtained before intravenous fluid or diuretic administration, as both interventions rapidly alter urine composition and confound the interpretation of urine study results.11 12

Few studies address the rate of urine collection in the ED. A nationwide study of ED services from 2006 to 2008 demonstrated that approximately 90% of admitted patients underwent blood work while 40% had a urinalysis obtained.13 Another study focusing on inappropriate urinalysis testing found that ED urinalysis rates ranged from 19.5% to 78.5% at one institution based on chief complaint, with confused elderly women having the highest urinalysis rate and patients with chest pain having the lowest.14 To our knowledge, the current study is the first to assess the rate of urine collection in patients who present to the ED with hyponatraemia.

Baseline measurement

The primary measure evaluated in the current study was the per cent of patients admitted from the ED with moderate to severe hyponatraemia (defined as serum sodium <130 mmol/L) that had urine collected prior to any intravenous fluid resuscitation or diuretic administration. Data on ED urine collection prior to intravenous fluid resuscitation for moderate to severely hyponatremic patients were collected by first identifying all patients within the ED who presented with sodium levels <130 mmol/L. Once these patients were identified within the baseline measurement time of 1 July 2019 to 26 December 2019, their charts were evaluated by the QI project team. Orders within the electronic medical records (EMRs) were reviewed for timing of urine collection (based on laboratory results such as urinalysis, urine sodium or urine osmolality) compared with initial intravenous fluid or diuretic orders. If patients had urine collections time stamped before intravenous fluids were initiated, they would count as a positive collection. The baseline measure for the study was 34%.

We felt that was also important to select a balancing measure which might suggest potential negative outcomes from our plan-do-study-act (PDSA) interventions. To that end, ED LOS was identified as a valuable balancing measure. Through our two PDSA cycles that incorporated education and triage modification to improve urine collection, it was important to consider whether these interventions might increase the total LOS for patients within the ED prior to the decision to admit, which could have further downstream effects such as making ED encounters less efficient and potentially affecting overall bed availability. This counterbalancing measure was determined by collecting LOS data in patients with moderate to severe hyponatraemia that met the inclusion criteria for this project as defined previously. The ED LOS was calculated as the time from initial triage in the ED to time to admit order by the ED provider. The baseline balancing measure for the study was 135 min.

Design

A multidisciplinary, internal medicine resident-led QI team convened from 1 July 2020 through 1 June 2021 on
a monthly basis. The QI team consisted of first through third year residents and representatives from ED nursing staff and physicians with an internal medicine physician experienced in QI serving as a mentor. The DMAIC (define, measure, analyse, improve, control) framework as taught by the institution guided the project. Data were obtained through analysis of the EMR of patients admitted from the ED as described in the measure section.

Our first intervention in PDSA Cycle #1 was designed to educate providers, staff and patients regarding the importance of hyponatraemia management and potential delays in effective treatment based on delays in urine collection and analysis. This was based on the premise that education is the foundation of a successful QI project in that interventions are more likely to succeed if stakeholders have a common understanding and agreement on the importance of the problem and theory of proposed solutions. This allowed for the establishment of a more effective baseline understanding of existing systems and more comprehensive viewpoints through discussions with a variety of stakeholders such as ED providers, internal medicine providers, ED nursing staff, ED triage staff, administrators and patients.

Our second intervention in PDSA Cycle #2 was designed to implement a structural change in the ED triage process to incorporate urine specimen container allocation to appropriate patients. This was based on the premise that structural changes would increase the longevity of the project and help maintain any gains that were made. The synergistic effect of education to relevant care teams along with change in triage protocols was expected to have a positive impact on hyponatraemia management and improvement in patient care.

During the early stage of project design and initiation, key potential problems involved ensuring engagement with stakeholders as well as a commitment to organisation and follow through among the QI team. It was important to recognise team members’ outstanding commitments outside the project to active patient care and other activities. To leverage the best possible outcomes from the project, meetings needed to be efficient and well communicated, with meeting minutes and action plans that could be frequently checked on. Furthermore, it was also important to network with other key personnel within the hospital and expand the QI project personnel as appropriate to meet its goals. For example, representatives from ED nursing leadership were involved after this key stakeholder group was identified.

**Strategy**

In PDSA Cycle #1, a multipronged educational outreach was initiated with the aim to enhance knowledge of hyponatraemia and the importance of urine studies obtained before intravenous fluid or diuretic administration. A poster was placed in employee areas of the ED as well as in the patient bathrooms for patient awareness, that advertised the project and its potential benefits. Representatives from the QI team met with the ED physician and nursing leadership was obtained through in-person discussions and through invitations to QI meetings. We found PDSA Cycle #1 to be very positively received, with many comments from ED nursing staff and providers that they appreciated the education, agreed with the project and its potential benefits. Representatives from the QI group met with the ED nursing staff at their monthly meeting to communicate the project and answer questions. Buy-in from ED physician and nursing leadership was obtained through in-person discussions and through invitations to QI meetings. We found PDSA Cycle #1 to be very positively received, with many comments from ED nursing staff and providers that they appreciated the education, agreed with the aims of the project, and wanted to contribute. Online supplemental figure 1 during this first cycle, the representatives from the QI team periodically checked in with the ED staff to ensure there was continued awareness of the project, and also that the educational posters remained displayed prominently. Thirty days after initiation of this PDSA cycle, data was again collected measuring the percentage of patients with moderate to severe hyponatraemia who had urine collected (see the Results section). At this point, it was decided to initiate a second PDSA to continue the improvement as well as increase the strength of the control plan.

In PDSA Cycle #2, a procedural change was implemented in the nursing triage algorithm whereby patients expecting to need bloodwork were issued a urine specimen container during nursing triage labelled with their patient information. Instruction to provide a sample at their next voiding episode were given by nursing triage
staff to patients. In this manner, patients could provide a urine specimen even while in the waiting area. Importantly, the triage algorithm did not automatically order urinalysis or urine electrolytes. Rather, it simply provided labelled containers so that an unaltered urine specimen could be obtained that could then be used for analysis if an order was later placed by either ED or admitting providers. The provision of labelled urine specimen containers was not reported to interfere with the triage process.

RESULTS
During the baseline data collection period, 34.5% patients who were admitted from the ED with the primary diagnosis of moderate to severe hyponatraemia had urinalysis performed in the ED before administration of fluid or diuretics. After PDSA Cycle #1, this increased to 57.8%. After PDSA Cycle #2, this increased further to 59% (figure 1).

Regarding the balancing measure of ED LOS, the baseline measurement was 135 min from first order placement to admission order. After PDSA Cycle #1, this was 127 min. After PDSA Cycle #2, this increased to 162 min (figure 2).

Lessons and limitations
Our QI project’s aim was to increase the rate of collection of urine specimens obtained in the ED before the administration of intravenous fluids without increasing the ED LOS. Our project met and surpassed its primary goal, with most of the improvement obtained after PDSA Cycle #1. This supports the power of education and leadership buy-in needed to improve the quality of processes in the ED. Somewhat to our surprise, the magnitude of increase between PDSA Cycle #1 and #2 was minimal, suggesting that the structural change to ED triage did not contribute in a significant additive manner to the educational efforts and buy-in obtained after PDSA Cycle #1. Possible explanations include that ED staff were already providing urine specimen containers based on interventions in PDSA Cycle #1 or that many patients were unable to provide a urine specimen before being administered interventions such as intravenous fluids or diuretics.

Due to the descriptive nature of our study, statistical significance of these differences was not assessed. As PDSA Cycle #1 was strictly an educational intervention, changes in attitude, behaviours, and awareness could have been assessed with an additional survey. Though PDSA Cycle #2 engaged many patients in collecting urine studies, we acknowledge that the triage process is not perfect and may miss those with hyponatraemia associated with an unrelated chief complaint or diagnosis. Importantly, our study included patients who were brought in by emergency medical services and may have received intravenous fluids in the field.

Our balancing measure of ED LOS demonstrated a variable trend. It is likely that the observations were multifactorial and that the PDSAs were not solely responsible for the increase seen in PDSA Cycle #2. Two important confounders for the balancing measure were that our ED experienced a 20% increase in volume of patients across our QI period and the ED was under construction with the addition of a new patient care area. The 20% increase in the balancing measure from baseline to after PDSA Cycle #2 corresponds proportionately to the increase in patient volume over the same period.

We note that a previous study demonstrated that ordering a urinalysis led to, on average, a 32 min increase in ED LOS. An important difference between studies is that our QI project focused on urine specimen collection, not ordering of urinalysis or urine electrolytes.

The generalisability of our study is unknown as it took place at a single academic medical centre within a relatively short 5-month intervention period. Our sample size only included moderate-severe hyponatraemia cases. Furthermore, it should be noted that as of writing, our interventions (educational and procedural) have yet to be tested for sustainability in maintaining noted improvement in urine collected prior to intravenous fluid or diuretic administration. To this end, our QI group intends to re-perform analysis in patients with moderate to severe hyponatraemia to assess the sustainability of our intervention. Thoughts for future research projects include evaluating the impact of increasing urine collection in the ED before intravenous fluids or diuretic administration on accurate diagnosis of hyponatraemia, hospital LOS, hospital readmissions, number of nephrology consults placed and morbidity/mortality.

CONCLUSION
Elucidating the aetiology of hyponatraemia before premature administration of intravenous fluids has potentially significant implications on healthcare costs, hospital LOS, and mortality. Our findings demonstrated that healthcare education and distribution of urine specimen containers in the triage process improved the numbers of urine specimens collected in the ED. This study serves as an initial benchmark in hopes of larger trials to investigate impact on patient care and safety.

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