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# Improving Discharge Instructions Following a Concussion Diagnosis in the Pediatric Emergency Department: A Pre-post Intervention Study

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**Abstract**

**Introduction:** Many children are discharged from the pediatric emergency department (PED) with incomplete or inappropriate instructions following a concussion. Our objective was to evaluate the effectiveness of a simple intervention in improving discharge instruction disbursement and completeness following PED diagnosis of concussion. **Methods:** A pre/post intervention study of 935 patients (375 preintervention and 560 postintervention) ages 5–19, diagnosed with a concussion and discharged from the PED between July 2016 and November 2019, was performed at a single United States pediatric tertiary-care center. Dedicated provider education sessions were held, and a consensus guideline–based set of discharge instructions were implemented in the electronic health record. Primary outcomes included the presence of return-to-play (RTP) instructions, return-to-learn (RTL) instructions, follow-up recommendations, and "complete" discharge (ie, all 3 components present). Statistical process control charts were generated and tested for special cause variation. **Results:** More patients received instructions for RTP (87% versus 59%) and RTL (60% versus 3%), and a complete discharge was more frequent (45% versus 2%), following the conclusion of the intervention. Only the improvement in RTP instructions was completely sustained into the following academic year, whereas RTL and complete discharge rates declined to 27% and 20%, respectively. **Conclusions:** A simple, low-cost intervention such as peer-to-peer education and consensus guideline–based discharge instruction templates can significantly improve discharge readiness after pediatric concussion. Further work is needed to maintain progress and continue improvements, at our large academic trauma center. *(Pediatr Qual Saf 2021;00:e456; doi: 10.1097/pq9.0000000000000456; Published online 26 August, 2021.)*

## INTRODUCTION

Mild traumatic brain injury (mTBI), including concussion, is common in the pediatric emergency department (PED).[1–3] By nature of the injury, most patients are discharged directly from the PED.[4]

After concussion, patient education and behavioral modifications improve outcomes for pediatric patients.[5] International concussion guidelines[6] outline graded return-to-play (RTP) and return-to-learn (RTL) instructions, allowing patients to reach milestones before resuming full activity. An early return to sports or full-time academics may lead to recrudescent symptoms or prolonged recovery.[7,8] In addition to RTP and RTL, the Center for Disease Control (CDC) now recommends that all patients receive clear follow-up instructions at discharge.[5]

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Unfortunately, many children are discharged without complete instructions or follow-up recommendations.[9–12] Rates of RTP instruction disbursement for children may be as low as 11%–39% at university-based level 1 trauma centers.[13,14] Previously, our PED relied on provider-selected, third-party-created, "stock" discharge instructions. These instructions were variable and frequently inappropriate.[12] Importantly, these instructions were inconsistently updated to reflect changing guidelines and evidence-based management of concussion.

The Concussion in Sport Group (CISG) is an international, multidisciplinary group of experts in sport-related head injuries that have published 5 consensus statements since 2001, most recently in April 2017, on the diagnosis and management of sport-related concussion.[6,15] These guidelines can be applied broadly to those with image-negative (or unimaged) mTBI. At the time of the most recent statement, there were few other pediatric mTBI consensus guidelines. These served as the impetus for our institution to improve postconcussion discharge instructions.

This pre/post intervention study's objective was to evaluate the impact of implementing a guideline-based discharge instruction set and education sessions on the completeness of discharge instructions.

## METHODS

### *Study Design*

An observational pre/post intervention study design was utilized with all outcomes data collected and compared retrospectively. Institutional Review Board approval was obtained before data collection (IRB 130583).

### *Patient Selection*

All subjects were patients evaluated in the PED at a tertiary-care, single-center, academic children's hospital between July 1, 2016 and October 31, 2019. Billing records were queried for ICD-10 code S06.0X indicating a concussion diagnosis rendered at the discretion of the treating provider. Patients ages 5–19 (ie, school-age patients) with a concussion diagnosis and discharged directly from the PED (non-admitted) were included. As the fifth CISG guidelines define concussions as having no acute findings on standard head imaging,[6] patients with acutely negative or absent head imaging were included. Those patients with acute intracranial findings or skull fractures demonstrated on standard head imaging as determined by chart review were excluded.

### *Intervention*

A 2-part model for improvement,[16] quality improvement (QI) initiative was developed to increase the disbursement of appropriate discharge instructions to concussion patients in the PED. From August to October 2017, 3 senior authors (E.H.V., A.A.V., and C.H.P.), a nurse practitioner, and 2 PED faculty offered a series of peer-to-peer education sessions. For PED advanced practice providers, faculty, and fellows, 2 slide-based group lectures were offered, which reviewed the fifth CISG guidelines, youth concussion law, updated concussion discharge instructions, and the referral pathway. Fellows and faculty attendance was strongly recommended but not tracked. The education team gave the same lecture to the full PED nursing staff, and information on the intervention was included in a nursing update email for those who could not attend the meeting. Nursing education was performed to provide additional oversight, ensuring patients received the appropriate instructions.

Secondarily, the intervention consisted of updating discharge instructions for concussion based on published recommendations from the fifth CISG meeting. These were available in print form for distribution at discharge starting in August 2017, to coincide with the education sessions, and within the Epic (www.epic.com) electronic health record for inclusion in the discharge paperwork starting November 1, 2017.[6] These instructions were standard for all patients. **Materials, Supplemental Digital Content, *http://links.lww.com/PQ9/A298***, includes a copy of these instructions. We did not implement best practice advisories. The new discharge instructions were clearly labeled, but alternative instruction sets remained available due to institutional restrictions.

Of note, updated CDC guidelines for the management of pediatric mTBI were published in the middle of the postintervention period.[5] Given the substantial overlap of these guidelines with the CISG guidelines, we decided not to revise the instructions or process at that stage.

### *Data Extraction and Discharge Instruction Evaluation*

Our team extracted demographics, records of provided discharge instructions, follow-up recommendations, and outpatient referral orders from the medical record. We did not consider statements made solely in a provider's note regarding RTP, RTL, and follow-up recommendations as adequate. Study personnel manually reviewed all discharge instructions. A senior author independently reviewed 10%–20% of records to ensure definitions were consistently applied.

The team considered RTP instructions as adequate when they: (1) stated that the patient must be kept out of practice, games, and physical activity until cleared by a licensed healthcare provider (as defined by state law)[17] and (2) referenced utilizing a graded RTP protocol.

Adequate RTL instructions were present if they included: (1) recommending a reduced workload and (2) extra time to complete assignments and a resting plan if symptoms recur. School excuses detailing activity accommodations were considered adequate. The liberal definitions for RTP and RTL allowed the results to overestimate the information included, thus offsetting the underestimating effect of not recognizing provider documentation of counseling as adequate.

Adequate follow-up recommendations were present if the discharge paperwork recommended a concussion follow-up appointment with either a primary care provider/general practitioner or specialist within 1–2 weeks. "Complete" discharge criteria included adequate RTP instructions, RTL instructions, and follow-up recommendations. Study primary outcomes include the presence of RTP and RTL instructions and whether the discharge was "complete."

Secondary outcomes included referral and follow-up at our institution. We defined a referral as mention of, or electronic order to, a provider or clinic for a specified postconcussion follow-up visit. Referrals were further coded as referrals to a provider outside our medical system, or an in-system provider. If the patient received an in-system referral, a "referral order" was documented as present. PED providers chose where to refer patients based on their clinical judgment and patient or family preferences.

A confirmed follow-up visit was documented if it occurred specifically for concussion care and occurred within 30 days of the PED visit. An "ED bounce-back" occurred if the patient returned to the emergency department within 7 days only for symptoms related to the original injury.

### *Statistical Analysis*

Descriptive statistics were performed. Chi-square tests compared the frequencies of patients receiving appropriate discharge instructions and attributes of patients receiving or not receiving each specific instruction. Statistical process control (SPC) charts were created for the primary outcomes and in-system referrals using the R package "qicharts2." The Western Electric rules and Anhøj rules were used to identify special cause variation (SCV) and accordingly place centerline shifts.[18,19] A $P$ value less than 0.05 was defined a priori as statistically significant. Statistical analyses were performed on R software 3.6.0 (http://www.r-project.org/).

## RESULTS

Of the 935 PED patients seen with a concussion diagnosis, 375 patients were seen preintervention and 560 postintervention. Slight demographic and management differences were noted between preintervention and postintervention groups (Table 1). Notably, there was a relationship between intervention status and what type of provider discharged the patient ($P < 0.001$). Specifically, more fellows discharged patients in the postintervention group (20% versus 5%). Patients

**Table 1. Demographic and Clinical Information for Patients Seen before and after the Intervention**

| | Before Intervention Completed | After Intervention Completed | | |
|---|---|---|---|---|
| | N = 375 | N = 560 | $\chi^2$ | *P* |
| Sex | | | $\chi^2(1) = 0.28$ | 0.594* |
| Female | 38% (142) | 36% (203) | | |
| Male | 62% (232) | 64% (357) | | |
| Race | | | $\chi^2(2) = 24.2$ | <0.001*† |
| Black or African American | 29% (109) | 21% (117) | | |
| White | 56% (209) | 71% (397) | | |
| Other | 15% (57) | 8% (46) | | |
| Ethnicity | | | $\chi^2(2) = 18.6$ | <0.001*† |
| Hispanic or Latinx | 6% (21) | 9% (53) | | |
| Not Hispanic or Latinx | 81% (302) | 84% (472) | | |
| Unknown | 14% (52) | 6% (35) | | |
| Age (y, mean ± SD) | 12.25 ± 3.59 | 13.06 ± 3.43 | | <0.001‡ |
| Primary language | | | $\chi^2(1) = 2.86$ | 0.091* |
| English | 96% (361) | 94% (525) | | |
| Other | 4% (14) | 6% (35) | | |
| Insurance | | | $\chi^2(3) = 33.3$ | <0.001*† |
| Private/military | 36% (134) | 52% (292) | | |
| Medicaid | 38% (144) | 34% (193) | | |
| Uninsured/self-pay | 6% (22) | 3% (18) | | |
| Unknown | 20% (75) | 10% (57) | | |
| Concussion mechanism | | | $\chi^2(1) = 0.63$ | 0.427* |
| Sport-related | 49% (183) | 46% (258) | | |
| Nonsport-related | 51% (192) | 54% (301) | | |
| Head imaging | | | $\chi^2(1) = 7.78$ | 0.005* |
| Received | 42% (156) | 51% (285) | | |
| Not received | 58% (219) | 49% (275) | | |
| Discharge provider | | | $\chi^2(3) = 52.31$ | <0.001*† |
| Attending/faculty | 37% (139) | 24% (136) | | |
| Fellow | 5% (20) | 20% (112) | | |
| Resident | 49% (185) | 51% (287) | | |
| Mid-level provider/nursing staff | 8% (31) | 4% (25) | | |

*Pearson chi squared.
†Applies to test of null hypothesis that distribution of counts across categories is the same between column groups, $P < 0.05$ suggests distribution is dependent on column group.
‡Wilcoxon test.

receiving RTP instructions were more frequently male, older, injured during sports, and seen after the intervention (Table 2). Patients who received RTL instructions were younger and most often seen after the intervention (Table 3). Those that received complete discharge instructions were slightly younger and usually seen after the intervention (Table 4).

### *Primary Analysis*

SPC charts are presented in Figure 1. SCV was detected across the full study period for RTP, RTL, and complete discharge. SPC charts for RTP, RTL, and complete discharges demonstrated improvement by centerline shifts occurring shortly after completing the full intervention. Rates of RTP showed a sustained improvement (59%–87%, Fig. 1A). Although RTL demonstrated an initial improvement (3%–60%), a centerline downshift was triggered around July 2018 (60%–27%, Fig. 1B). This centerline downshift coincided with the start of the new academic year. Complete discharges (Fig. 1C) also improved following the intervention (2%–45%); however, this improvement was not sustained (centerline downshift: 45%–20%). This centerline downshift coincided with the new academic year. No SCV was detected for in-system referrals, confirming a stable and unchanged rate during the study period (Fig. 1D).

### *Secondary Outcomes*

Comparisons of secondary outcomes from preintervention to postintervention are provided in Table 5. Following the intervention, patients were more frequently referred to an in-system provider (48% versus 35%, $P = 0.001$). Of those referred within our health system, referral orders were more frequent following the intervention (57% versus 39%, $P = 0.003$). However, there was no change in follow-up attendance (47% versus 54%, $P = 0.267$). Notably, placing a referral order was associated with a completed follow-up visit ($P = 0.044$). Full comparisons between patients who did and did not receive a follow-up referral and who did and did not receive a follow-up referral and between those who did and did not complete a follow-up visit are provided in **Tables 1 and 2, Supplemental Digital Content, http://links.lww.com/PQ9/A298**.

**Table 2. Comparison of Patients Receiving to Those Not Receiving RTP Instructions**

| | Instructions Not Given | Instructions Given | | |
|---|---|---|---|---|
| | N = 229 | N = 706 | $\chi^2$ | *P* |
| Intervention completion | | | $\chi^2(1) = 93$ | <0.001* |
| Before | 67% (154) | 31% (221) | | |
| After | 33% (75) | 69% (485) | | |
| Sex | | | $\chi^2(2) = 10.9$ | 0.004* |
| Female | 45% (102) | 34% (243) | | |
| Male | 55% (126) | 66% (463) | | |
| Race | | | $\chi^2(2) = 3.03$ | 0.387*† |
| Black or African American | 28% (64) | 23% (162) | | |
| White | 60% (138) | 66% (468) | | |
| Other | 12% (27) | 11% (76) | | |
| Ethnicity | | | $\chi^2(2) = 0.91$ | 0.636*† |
| Hispanic or Latinx | 7% (15) | 8% (59) | | |
| Not Hispanic or Latinx | 83% (191) | 83% (583) | | |
| Unknown | 10% (23) | 9% (64) | | |
| Age (y, mean ± SD) | | | — | <0.001‡ |
| | 11.81 ± 3.98 | 13.03 ± 3.29 | | |
| Primary language | | | $\chi^2(1) = 0$ | 1* |
| English | 95% (217) | 95% (669) | | |
| Other | 5% (12) | 5% (37) | | |
| Insurance | | | $\chi^2(3) = 2.12$ | 0.548*† |
| Private/military | 41% (95) | 47% (331) | | |
| Medicaid | 39% (90) | 35% (247) | | |
| Uninsured/self-pay | 4% (10) | 4% (30) | | |
| Unknown | 15% (34) | 14% (98) | | |
| Concussion mechanism | | | $\chi^2(2) = 39.6$ | <0.001* |
| Sport-related | 29% (67) | 53% (374) | | |
| Non-sport-related | 71% (162) | 47% (331) | | |
| Head imaging | | | $\chi^2(1) = 0.83$ | 0.361* |
| Received | 50% (114) | 46% (327) | | |
| Not received | 50% (115) | 54% (379) | | |
| Discharge provider | | | $\chi^2(3) = 6.82$ | 0.078*† |
| Attending/faculty | 35% (81) | 27% (194) | | |
| Fellow | 12% (28) | 15% (104) | | |
| Resident | 48% (111) | 51% (361) | | |
| Mid-level provider/nursing staff | 4% (9) | 7% (47) | | |

*Pearson chi squared.
†Applies to test of null hypothesis that distribution of counts across categories is the same between column groups, $P < 0.05$ suggests distribution is dependent on the column group.
‡Wilcoxon test.

## DISCUSSION

Despite clear evidence that using templates can improve the readability and content of discharge instructions,[20–23] current pediatric mTBI literature demonstrates widespread inadequacy of discharge instructions from the PED.[12–14,24] Although these prior works identify an important problem, there is a dearth of literature demonstrating clear steps institutions can take to improve. Our study provides evidence that simple interventions, that is, peer-to-peer education and improved discharge paperwork, can improve compliance with current guidelines and patient discharge readiness following a concussion.

Although our intervention improved guideline adherence in discharge instructions, further progress is needed. Overall, across 28 months of PED visits, only 155 of 935 (16.6%) patients diagnosed with concussion met the criteria for a complete discharge. Of those, 95% occurred following the completion of the intervention. Although an impressive improvement was seen for the remainder of the initial academic year in which the interventions occurred, as new providers entered the PED with the changing roles and responsibilities the following academic year, this improvement decreased by more than 50%. This decline in the subsequent academic year and overall low rate of complete discharge suggests that many discharges occurred without our discharge instruction template, which remained constant over time. Improvement relies predominantly on providers and education, which may change or wane over time. These challenges are not unique to our center or region as three prior geographically disparate studies have found similar issues with appropriate discharge instructions only occurring for 11%,[13] 15%,[24] and 34%[14] of PED patients. However, our successful efforts demonstrate that change can be affected, and furthermore, more rigorous modifications to the process may be even more effective.

Frequently shifting guidelines and the ever-changing science regarding concussion recovery pose hurdles to reliable discharge instruction completion following concussion. For example, the CISG has published evolving guidelines roughly every 3–4 years since 2001; the American Academy of Neurology and American Medical Society of Sports Medicine published guidelines in 2013; and the CDC and Ontario Neurotrauma Foundation published guidelines on pediatric mTBI one month apart

**Table 3. Comparison of Patients Receiving to those Not Receiving RTL Instructions**

| | Instructions not given | Instructions given | | |
|---|---|---|---|---|
| | N = 729 | N = 206 | $\chi^2$ | *P* |
| Intervention complete | | | $\chi^2(1) = 137$ | <0.001* |
| Before | 50% (365) | 5% (10) | | |
| After | 50% (364) | 95% (196) | | |
| Sex | | | $\chi^2(1) = 0.99$ | 0.319* |
| Female | 38% (275) | 34% (70) | | |
| Male | 62% (453) | 66% (136) | | |
| Race | | | $\chi^2(2) = 4.63$ | 0.201*† |
| Black or African American | 24% (175) | 25% (51) | | |
| White | 65% (473) | 65% (133) | | |
| Other | 11% (81) | 11% (22) | | |
| Ethnicity | | | $\chi^2(2) = 1.32$ | 0.517*† |
| Hispanic or Latinx | 8% (58) | 8% (16) | | |
| Not Hispanic or Latinx | 82% (599) | 85% (175) | | |
| Unknown | 10% (72) | 7% (15) | | |
| Age (y, mean ± SD) | | | — | <0.001‡ |
| | 13.01 ± 3.41 | 11.74 ± 3.68 | | |
| Primary language | | | $\chi^2(1) = 0.08$ | 0.778* |
| English | 95% (690) | 95% (196) | | |
| Other | 5% (39) | 5% (10) | | |
| Insurance | | | $\chi^2(3) = 15.2$ | 0.002*† |
| Private/military | 47% (344) | 40% (82) | | |
| Medicaid | 36% (261) | 37% (76) | | |
| Uninsured/self-pay | 5% (36) | 2% (4) | | |
| Unknown | 12% (88) | 21% (44) | | |
| Concussion mechanism | | | $\chi^2(1) = 0.13$ | 0.72* |
| Sport-related | 48% (346) | 46% (95) | | |
| Nonsport-related | 52% (382) | 54% (111) | | |
| Head imaging | | | $\chi^2(1) = 2.1$ | 0.148* |
| Received | 48% (353) | 43% (88) | | |
| Not received | 52% (376) | 57% (118) | | |
| Discharge provider | | | $\chi^2(3) = 5.12$ | 0.163*† |
| Attending/faculty | 30% (222) | 26% (53) | | |
| Fellow | 13% (94) | 18% (38) | | |
| Resident | 51% (371) | 49% (101) | | |
| Mid-level provider/Nursing staff | 6% (42) | 7% (14) | | |

*Pearson chi squared.
†Applies to test of null hypothesis that distribution of counts across categories is the same between column groups, $P < 0.05$ suggests distribution is dependent on the column group.
‡Wilcoxon test.

**Table 4. Comparison of Patients with and without a Complete Discharge***

| | Incomplete Discharge N = 780 | Complete Discharge N = 155 | $\chi^2$ | *P* |
|---|---|---|---|---|
| Intervention complete | | | $\chi^2(1) = 94.5$ | <0.001† |
| Before | 47% (367) | 5% (8) | | |
| After | 53% (413) | 95% (147) | | |
| Sex | | | $\chi^2(1) = 0.92$ | 0.338† |
| Female | 38% (293) | 34% (52) | | |
| Male | 62% (486) | 66% (103) | | |
| Race | | | $\chi^2(2) = 9.93$ | 0.019†‡ |
| Black or African American | 24% (186) | 26% (40) | | |
| White | 65% (504) | 66% (102) | | |
| Other | 12% (90) | 8% (13) | | |
| Ethnicity | | | $\chi^2(2) = 2.08$ | 0.353†‡ |
| Hispanic or Latinx | 8% (63) | 7% (11) | | |
| Not Hispanic or Latinx | 82% (640) | 86% (134) | | |
| Unknown | 10% (77) | 6% (10) | | |
| Age (y, mean ± SD) | | | — | 0.007§ |
| | 12.87 ± 3.47 | 12.03 ± 3.66 | | |
| Primary language | 5% (42) | 5% (7) | $\chi^2(1) = 0.2$ | 0.658† |
| English | 95% (738) | 95% (148) | | |
| Other | 5% (42) | 5% (7) | | |
| Insurance | | | $\chi^2(3) = 7.62$ | 0.055†‡ |
| Private/military | 46% (362) | 41% (64) | | |
| Medicaid | 36% (282) | 35% (55) | | |
| Uninsured/self-pay | 5% (36) | 3% (4) | | |
| Unknown | 13% (100) | 21% (32) | | |
| Concussion mechanism | | | $\chi^2(1) = 0.02$ | 0.886† |
| Sport-related | 47% (367) | 48% (74) | | |
| Nonsport-related | 53% (412) | 52% (81) | | |
| Head imaging | | | $\chi^2(1) = 0.81$ | 0.368† |
| Received | 48% (373) | 44% (68) | | |
| Not received | 52% (407) | 56% (87) | | |
| Discharge provider | | | $\chi^2(3) = 4.81$ | P = 0.186†‡ |
| Attending/faculty | 30% (234) | 26% (41) | | |
| Fellow | 13% (104) | 18% (28) | | |
| Resident | 51% (399) | 47% (73) | | |
| Mid-level provider/nursing staff | 6% (43) | 8% (13) | | |

*Defined as the presence of RTP and RTL instructions as well as follow-up recommendations.
†Pearson chi squared.
‡Applies to test of null hypothesis that distribution of counts across categories is the same between column groups, $P < 0.05$ suggests distribution is dependent on the column group.
§Wilcoxon test.

in 2018.[5,25–27] Given the frequent changes, providers likely have trouble choosing what guidelines to adhere to and when to do it. As a result, the active intervention appears more effective than relying solely on provider recognition and implementation of published guidelines,[28] as neither the publication of the CISG or CDC guidelines was associated with any substantial change in complete discharges, as demonstrated in Figure 1C. Furthermore, as our data suggests many discharges occurred without the use of updated instructions, the removal of extraneous, outdated, and incorrect discharge instruction sets may be another effective way to sustain improvements. Similarly, best practice advisories and required diagnosis-associated instruction sets developed using the most recent guidelines represent relatively straightforward success methods in a rapidly evolving field.

### *RTP and RTL*

Our intervention resulted in a sustained substantial improvement in RTP instructions. Similar to prior studies,[13,14] having a nonsport-related concussion was associated with decreased likelihood of receiving RTP instructions; however, the actual gap between those receiving RTP instructions with nonsport-related injuries compared to sport-related injuries (41.7% versus 77%, respectively) narrowed postintervention (83.4% versus 90.3%). The narrowing of this gap reflects improved recommendation consistency and contributes to the improvement's stability. Even when not involved in typical organized sports, children may be participating in activities that risk a recurrent injury, such as unorganized playground sports, extreme sports, or similar. Since these activities occur outside the supervision of a coach, athletic trainer, or team physician, parents need to clearly understand how and when children can return safely to all activities.

RTL instructions are very important because premature return can drive a cycle of recurrent symptoms, and compound adverse academic performance.[8] However, prolonged rest may also predispose children to prolonged symptoms,[29,30] highlighting the importance of instructions emphasizing a short period of rest followed by a graduated return to activities. RTL instruction disbursement improved following the intervention, but the improvement lagged in the following academic year. The difficulty sustaining the initial improvement may reflect provider

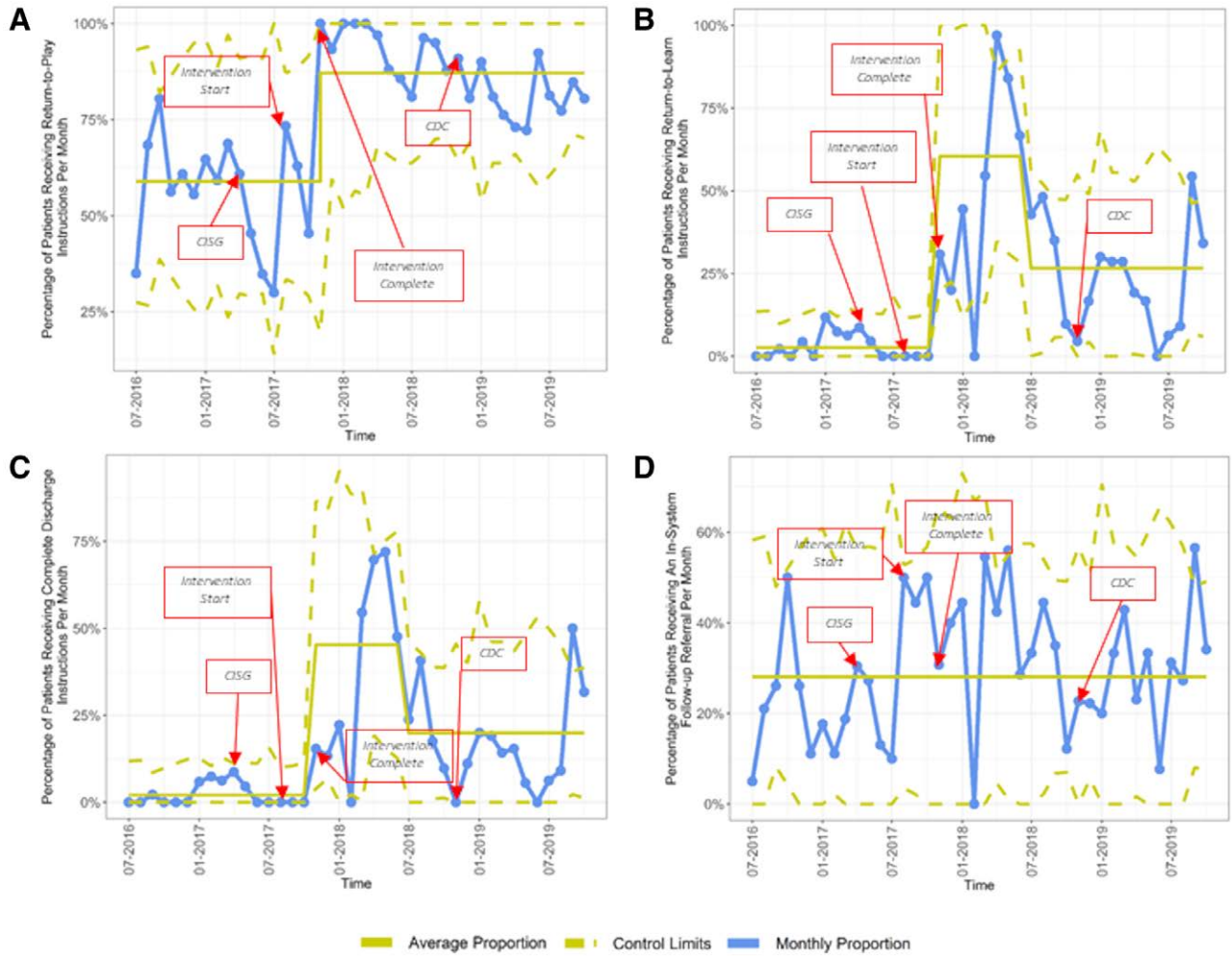


**Fig. 1.** Control charts of discharge instruction rates by month. Statistical process control charts showing the percent of concussed patients per month discharged with RTP instructions (A), RTL instructions (B), complete discharge instructions (C), and in-system referral (D). Centerline shifts were placed based on special cause variation identified using the Western Electric and Anhøj rules. CISG notates the release of the fifth Concussion in Sport Group Consensus Guidelines; Intervention Start notates the beginning of education sessions and new print instructions available; Intervention Complete notates the completion of educations sessions and implementation of new electronic discharge instructions; CDC notates the publication of the Centers for Disease Control pediatric mild traumatic brain injury guidelines.

unfamiliarity with RTL guidance, which is more recent than RTP precautions. Although the education's effect expectedly waned, future interventions will aim to eliminate incorrect and incomplete discharge instruction sets, forcing providers to choose the updated set. Summarily, although the intervention was helpful in improving RTL instructions, system changes that both streamline the discharge process and reduce the ability to select incorrect

**Table 5. Comparison of Secondary Outcomes before and after the Intervention**

| | Before Intervention Complete | After Intervention Complete | | |
|---|---|---|---|---|
| | N = 375 | N = 560 | $\chi^2$ | *P** |
| Received follow-up recommendation | 79% (296) | 70% (393) | $\chi 2(1) = 8.88$ | 0.003 |
| Referred to | N = 296 | N = 392 | $\chi 2(1) = 10.3$ | 0.001 |
| In-system provider | 35% (105) | 48% (187) | | |
| Outside provider | 65% (191) | 52% (205) | | |
| Orders for referral | N = 102 | N = 185 | $\chi 2(1) = 8.6$ | 0.003 |
| Order placed | 39% (40) | 57% (106) | | |
| Order not placed | 61% (62) | 43% (79) | | |
| Follow-up attendance | N = 104 | N = 187 | $\chi 2(1) = 1.23$ | 0.267 |
| Attended follow-up | 54% (56) | 47% (88) | | |
| Did not attend follow-up | 46% (48) | 53% (99) | | |
| ED bounce-back | 2% (9) | 2% (11) | $\chi^2(1) = 0.2$ | 0.652 |

*Pearson chi squared.
ED, emergency department.

instructions (ie, instruction sets linked to diagnoses) are required, in addition to consistent education, to ensure patients continue to receive proper guidance at discharge.

### *In-system Referral and Follow-up*

Although not the goal of the intervention, in-system referrals increased. Yet, the completion of an in-system follow-up visit did not change despite more referrals. This result could have been anticipated as follow-up rates following any TBI are consistently poor overall for both adults and children.[10,31] Both travel distance and socioeconomic status play important roles in whether patients follow-up, and these factors contribute to stagnant follow-up rates.[31] However, patients were overall more likely to be referred and complete in-system follow-up appointments if they were older and had a sport-related concussion. This suggests that a patient's need for sport-specific clearance or care may drive follow-up rates at our institution.

### *Limitations*

This study has several limitations. First, the chosen definition for discharge completeness was strict. Provider–patient verbal interaction and counseling can improve parent recall of discharge instructions, and we may have underestimated the actual completeness of discharges with definitions focused on written instructions.[32] However, provider notes do not necessarily or accurately reflect the extent of counseling; therefore, a better understanding of discharge counseling should be accessed through postinteraction patient surveys.

Second, we identified demographic and management differences between the preintervention and postintervention periods. Patients in the postintervention period were more frequently discharged by fellows rather than attendings. This may reflect the increased number of fellows who matriculated in the postintervention period or increased fellow interest in concussion patients following the education sessions. However, we did not find that fellows were more or less likely than attendings to supply the expected discharge elements.

Finally, our intervention consisted of several changes occurring over a 2-month period and it is not possible to attribute the success to one component. Furthermore, given the scope of interventions, department attitudes, attention, and excitement regarding the project may have played a confounding role in observed improvements.

## CONCLUSIONS

Simple interventions, such as provider education and guideline-based discharge instruction templates, can have a meaningful impact on discharge completeness measures. These interventions are low cost and may be easily rendered at most institutions. The difficulty in achieving sustained long-term improvement highlights the importance of considering interactions between patient factors and provider decisions to inform interventions and continuous education. Perhaps, a rigorous clinical pathway system with defined concussion order sets, making it easier to do the expected best practices, could be added to the reliability tool box, to help achieve greater sustained change.

## DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

## REFERENCES

1. Sarmiento K, Thomas KE, Daugherty J, et al. Emergency department visits for sports- and recreation-related traumatic brain injuries among children - United States, 2010-2016. *MMWR Morb Mortal Wkly Rep*. 2019;68:237–242.
2. Mannix R, O'Brien MJ, Meehan WP III. The epidemiology of outpatient visits for minor head injury: 2005 to 2009. *Neurosurgery*. 2013;73:129–134.
3. Peterson AB, Xu L, Daugherty J, et al. Surveillance Report of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations and Deaths - United States, 2014. Centers for Disease Control and Prevention, US Department of Health and Human Services; 2019. Accessed January 13, 2020.
4. Coronado VG, Haileyesus T, Cheng TA, et al. Trends in sports- and recreation-related traumatic brain injuries treated in US Emergency Departments: the National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP) 2001-2012. *J Head Trauma Rehabil*. 2015;30:185–197.
5. Lumba-Brown A, Yeates KO, Sarmiento K, et al. Centers for disease control and prevention guideline on the diagnosis and management of mild traumatic brain injury among children. *JAMA Pediatr*. 2018;172:e182853.
6. McCrory P, Meeuwisse W, Dvořák J, et al. Consensus statement on concussion in sport-the 5th International Conference on Concussion in Sport held in Berlin, October 2016. *Br J Sports Med*. 2017;51:838–847.
7. Iverson GL, Gardner AJ, Terry DP, et al. Predictors of clinical recovery from concussion: a systematic review. *Br J Sports Med*. 2017;51:941–948.
8. Ransom DM, Vaughan CG, Pratson L, et al. Academic effects of concussion in children and adolescents. *Pediatrics*. 2015;135:1043–1050.
9. Tarimala A, Singichetti B, Yi H, et al. Initial emergency department visit and follow-up care for concussions among children with medicaid. *J Pediatr*. 2019;206:178–183.
10. Seabury SA, Gaudette É, Goldman DP, et al; TRACK-TBI Investigators. Assessment of follow-up care after emergency department presentation for mild traumatic brain injury and concussion: results from the TRACK-TBI Study. *JAMA Netw Open*. 2018;1:e180210.
11. DeMatteo CA, Lin C-YA, Foster G, et al. Evaluating adherence to return to school and activity protocols in children after concussion [published online ahead of print December 24, 2019]. *Clin J Sport Med*. doi: 10.1097/JSM.0000000000000800
12. Upchurch C, Morgan CD, Umfress A, et al. Discharge instructions for youth sports-related concussions in the emergency department, 2004 to 2012. *Clin J Sport Med*. 2015;25:297–299.
13. Lane AD, Berkman MR, Verbunker D, et al. Retrospective chart analysis of concussion discharge instructions in the emergency department. *J Emerg Med*. 2017;52:690–698.
14. De Maio VJ, Joseph DO, Tibbo-Valeriote H, et al. Variability in discharge instructions and activity restrictions for patients in a children's ED postconcussion. *Pediatr Emerg Care*. 2014;30:20–25.
15. Aubry M, Cantu R, Dvorak J, et al; Concussion in Sport Group. Summary and agreement statement of the First International Conference on Concussion in Sport, Vienna 2001. Recommendations

for the improvement of safety and health of athletes who may suffer concussive injuries. *Br J Sports Med*. 2002;36:6–10.
16. Fereday S, Malbon N. A guide to quality improvement methods. Healthcare Quality Improvement Partnership Ltd. 2015. https://www.hqip.org.uk/wp-content/uploads/2018/02/guide-to-quality-improvement-methods.pdf. Accessed October 15, 2020.
17. Lee T, Diamond A, Solomon G, et al. Return to learn/return to play: concussion management guidelines. Tennessee Department of Health. 2017. https://www.tn.gov/content/dam/tn/health/documents/Returning_to_Learn_Guidelines.pdf. Accessed January 10, 2020.
18. Anhøj J. Diagnostic value of run chart analysis: using likelihood ratios to compare run chart rules on simulated data series. *PLoS One*. 2015;10:e0121349.
19. Montgomery DC. *Introduction To Statistical Quality Control*. 7th ed. John Wiley and Sons Inc; 2013:204–205.
20. Unaka N, Statile A, Jerardi K, et al. Improving the readability of pediatric hospital medicine discharge instructions. *J Hosp Med*. 2017;12:551–557.
21. Hammad EA, Wright DJ, Walton C, et al. Adherence to UK national guidance for discharge information: an audit in primary care. *Br J Clin Pharmacol*. 2014;78:1453–1464.
22. Chadwick W, Bassett H, Hendrickson S, et al. An improvement effort to optimize electronically generated hospital discharge instructions. *Hosp Pediatr*. 2019;9:523–529.
23. Mueller SK, Giannelli K, Boxer R, et al. Readability of patient discharge instructions with and without the use of electronically available disease-specific templates. *J Am Med Inform Assoc*. 2015;22:857–863.
24. Sarsfield MJ, Morley EJ, Callahan JM, et al. Evaluation of emergency medicine discharge instructions in pediatric head injury. *Pediatr Emerg Care*. 2013;29:884–887.
25. Silverberg ND, Iaccarino MA, Panenka WJ, et al; American Congress of Rehabilitation Medicine Brain Injury Interdisciplinary Special Interest Group Mild TBI Task Force. Management of concussion and mild traumatic brain injury: a synthesis of practice guidelines. *Arch Phys Med Rehabil*. 2020;101:382–393.
26. Giza CC, Kutcher JS, Ashwal S, et al. Summary of evidence-based guideline update: evaluation and management of concussion in sports: report of the Guideline Development Subcommittee of the American Academy of Neurology. *Neurology*. 2013;80:2250–2257.
27. Harmon KG, Drezner JA, Gammons M, et al. American Medical Society for Sports Medicine position statement: concussion in sport. *Br J Sports Med*. 2013;47:15–26.
28. Curran JA, Gallant AJ, Zemek R, et al. Discharge communication practices in pediatric emergency care: a systematic review and narrative synthesis. *Syst Rev*. 2019;8:83.
29. Thomas DG, Apps JN, Hoffmann RG, et al. Benefits of strict rest after acute concussion: a randomized controlled trial. *Pediatrics*. 2015;135:213–223.
30. Schneider KJ, Leddy JJ, Guskiewicz KM, et al. Rest and treatment/rehabilitation following sport-related concussion: a systematic review. *Br J Sports Med*. 2017;51:930–934.
31. Lundine JP, Peng J, Chen D, et al. The impact of driving time on pediatric TBI follow-up visit attendance. *Brain Inj*. 2020;34:262–268.
32. Thomas DG, Bradley L, Servi A, et al. Parental knowledge and recall of concussion discharge instructions. *J Emerg Nurs*. 2018;44:52–56.