# Predictors and Outcomes of Subdural Hematomas Managed via Subdural Evacuation Port System

*James Mooney[1], Nicholas Erickson[1], Ben Saccomano[1], Pedram Maleknia[2], Winfield S. Fisher III[1]*

■ BACKGROUND: **Subacute subdural hematoma (SDH) is a common pathology most frequently affecting older patients and may be treated operatively through burr holes versus craniotomy or minimally invasively with bedside twist drill craniostomy. Less invasive intervention is favored when possible given a frequently comorbid population. The subdural evacuation port system (SEPS) is a popular treatment option that warrants investigation and reporting of its use and outcomes.**

■ METHODS: **A retrospective review of consecutive patients undergoing SEPS drain placement for chronic or mixed density SDH between 2010 and 2021 was conducted. Outcomes of SDH recurrence, need for operating room procedure after SEPS placement, discharge disposition other than home, and modified Rankin Scale score <3 at discharge were modeled with logistic regression using multiple demographic, clinical, and radiographic features.**

■ RESULTS: **Ultimately, 86 patients (mean age 68) were included in the analysis with 66 (78%) presenting with mixed-density SDHs. Radiographic factors such as hematoma thickness and midline shift were not associated with the need for an operating room procedure after SEPS placement or discharge disposition. However, the presence of septations and mixed-density SDH versus chronic SDH was significantly associated with increased odds of requiring an operative intervention after SEPS placement.**

■ CONCLUSIONS: **Subacute SDHs are a frequent neurosurgical issue in patient populations where less invasive measures are favored. SEPS drainage continues to be an effective treatment option. However, the presence of septations and mixed-density SDHs has a significantly increased odds of requiring surgical intervention that must be considered in the decision to pursue SEPS drainage.**

## INTRODUCTION

Chronic subdural hematoma (cSDH) affects 20 per 100,000 people annually in the United States.[1] The use of the subdural evacuating port system (SEPS; Medtronic, Inc., Minneapolis, Minnesota, USA), a minimally invasive bedside twist drill craniostomy (TDC) performed under moderate sedation, has been shown to have favorable radiographic and clinical outcomes with low rates of adverse effects.[2] These outcomes are comparable with the gold standard treatment strategies such as burr holes or craniotomy.[3-5] However, the morbidity and mortality rates associated with craniotomy have been reported to be as high as 25% and 11%, respectively, compared with a mere 3% with a bedside TDC.[6] These data reflect the fact that the elderly population, more frequently affected by cSDH, carries higher rates of perioperative complications with operations involving general anesthesia, underscoring the value of avoiding it when possible.

**Key words**
- Burr hole
- Craniostomy
- Midline shift
- Septations
- Subdural evacuating port system
- Subacute subdural hematoma

**Abbreviations and Acronyms**
**CI**: Confidence interval
**cSDH**: Chronic subdural hematoma
**GCS**: Glasgow Coma Scale
**mRS**: Modified Rankin scale
**OR**: Operating room
**SDH**: Subdural hematoma
**SEPS**: Subdural evacuating port system
**TDC**: Twist drill craniostomy

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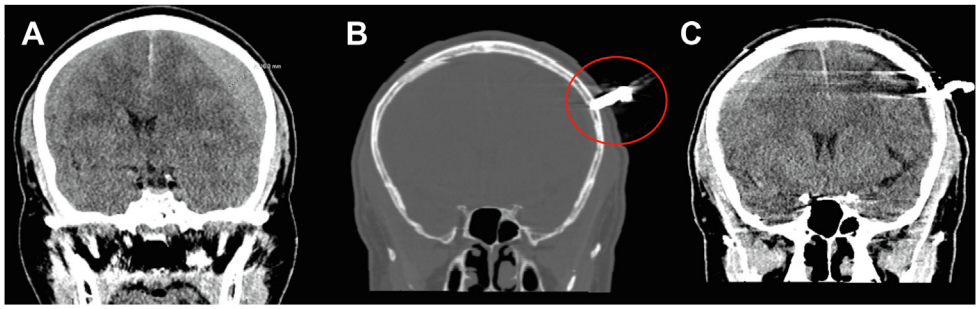


**Figure 1.** Pre–subdural evacuation port system (SEPS) subacute subdural hematoma (**A**) after ideal subdural evacuating port system drain placement (**B**) and adequate post-SEPS drainage (**C**).

The identification of preprocedural patient-specific and radiographic risk factors for treatment failure following SEPS will help identify more appropriate candidates for this procedure and reduce the number of patients subjected to multiple procedures, thus mitigating risk while shortening hospital stays. Unfortunately, there is a paucity of literature on this topic despite the increasingly widespread use of bedside TDC.

We present an analysis of our institution's experience with the SEPS technique to help identify various patient and radiographic risk factors associated with inadequate drainage and treatment failure requiring operative intervention.

## METHODS

Following Institutional Review Board approval, the charts of patients undergoing SEPS drain placement from 2010 to 2021 were retrospectively reviewed. As this was a retrospective review, patient consent was neither required nor sought. Patient demographics, medical comorbidities, coagulation status, mechanism of injury, neurologic examination, and pre/post SEPS radiographic findings were extracted from the electronic medical record. Primary outcomes included the dichotomous variables subdural recurrence, need for an operating room (OR) procedure after initial bedside drainage, discharge disposition other than home, and modified Rankin scale (mRS) <3.

Post-SEPS computed tomography of the head and Glasgow Coma Scale (GCS) scores were obtained within 24 hours of SEPS placement for all patients. Each patient's data was only reviewed within their acute hospitalization for SDH, and an OR procedure after SEPS drainage was only documented if it occurred within this acute hospitalization period. Longer-term data were available but not analyzed for the purposes of the present study. General reasons that patients required an operative procedure after bedside SEPS drainage included recurrence of SDH after SEPS, inability to adequately evacuate SDH via SEPS with lack of clinical improvement, and worsening SDH after SEPS or worsening clinical status. Univariate statistics were calculated for each outcome and the additional variables presented earlier. A multivariate model was then created using clinically relevant and statistically significant variables, with odds ratios and 95% confidence intervals (CIs) calculated. The results were considered statistically significant for $P$ values $< 0.05$.

### Surgical Procedure

All SEPS procedures were performed at the bedside in the neurosurgical intensive care unit, neurosurgical step-down unit, or emergency department. The procedures were performed by the neurosurgery residents in their second year of training and higher. Neurosurgery residents were trained and supervised per institutional protocol before they could do the procedure independently.

After conscious sedation, local anesthesia, and computed tomography scan review, a short skin incision allows a twist drill hole to be placed with a 5.8-mm bit. The dura is opened with multiple punctures with an 18-gauge or smaller needle. At this point, SDH fluid is seen emanating from the subdural space. The metal evacuating port is then manually screwed into the hole in the skull so that the tip is positioned in the diploic space, not extending beyond the inner table. The external portion of the evacuating port is then connected to the tubing and bulb suction apparatus. Negative pressure is applied by using the supplied bulb for a variable time period until drainage of subdural fluid is minimal (Figure 1).

## RESULTS

### Demographic and Preintervention Radiographic Data

Overall, 86 patients underwent SEPS placement in the allotted time frame. Patient demographic and preprocedure radiographic data are presented in Table 1. Average patient age was 69 years, and the majority presented with headaches (60%) followed by nausea/vomiting (16%) and weakness (4%). No patients presented with recorded seizures. Most cases were reported to occur spontaneously (48%), followed by the result of a fall (35%), motor vehicle collision (16%), or assault (5%). The majority of patients presented with a GCS of 14–15 (67%). A significant portion of patients was on a form of anticoagulant (15%) or antiplatelet agent (37%). Seven patients (8%) were on both an anticoagulant and antiplatelet agent.

Of the subdural hematomas (SDHs), 19 (22%) were chronic, 66 (77%) had subacute components, and 1 (1%) had acute

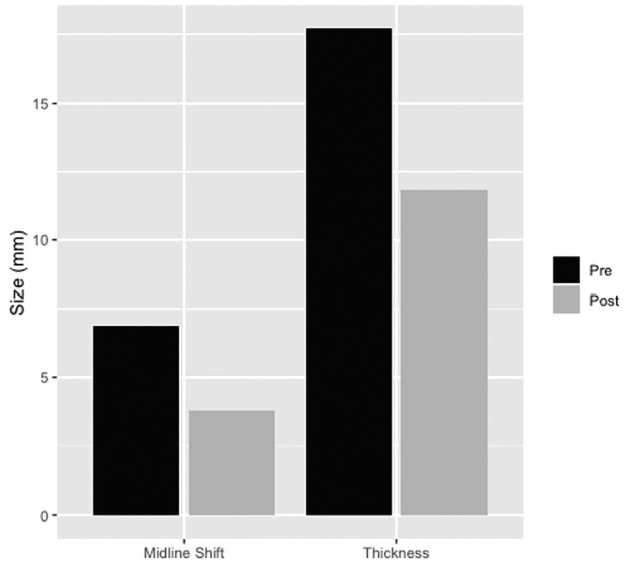


**Figure 2.** Average midline shift and subdural hematoma thickness before and after subdural evacuation port system.

components in a patient with GCS 15, without midline shift, and not requiring a trip to the OR. The average midline shift and SDH thickness were 7 mm and 18 mm, respectively. There were 33 SDHs with septations (38%), and only 2 were without an additional subacute component. Of the 66 SDHs with subacute components, 31 also had the presence of septations (46%).

### Need for Definitive Operative Intervention and Outcomes

On average, midline shift and SDH thickness improved after SEPS placement, by 3 mm and 6 mm, respectively (Figure 2; Table 2). There were 6 patients (7%) where SDH thickness worsened, and half of those required a separate OR procedure. Change in SDH thickness and midline shift pre-SEPS and post-SEPS for the 86 patients are demonstrated in Figures 3 and 4, respectively.

Most frequently, GCS remained unchanged in 57 cases (66%). Nineteen patients had improvement in GCS (22%) while 10 patients had worsening (12%). Overall, 31 patients (36%) required a separate OR procedure (burr holes or craniotomy) after bedside drainage and 21 of those patients (68%) had recurrence of their SDH. Only 1 patient with SDH recurrence did not require an OR procedure for drainage.

### Analysis of Treatment Failure

Univariate analysis of need for definitive OR procedure across age, comorbidities, coagulation status, mechanism of injury, presenting symptoms, GCS, and pre- and post-SEPS radiographic features only found presence of subacute components (odds ratio 7.1, $P = 0.01$) and septations (odds ratio 5.9, $P < 0.001$) to be significantly associated. Univariate analysis of the outcomes SDH recurrence, mRS <3 at discharge, and disposition other than home were without significant associations apart from GCS and mRS (Table 3).

The odds ratios of requiring a definitive OR procedure were calculated using multivariate logistic regression analysis accounting for SDH thickness, midline shift, and patient age. Patients with SDHs with septations had an odds ratio of 3.4 (95% confidence interval 1.1–10, $P = 0.03$) while those with SDHs with subacute components had an odds ratio of 8.0 (95% confidence interval 1.1–59.1, $P = 0.04$) for requiring a definitive OR procedure.

## DISCUSSION

The SEPS bedside procedure provides advantages to the conventional treatment of cSDH with craniotomy or burr hole in that the procedure is performed under conscious sedation, thus sparing patients an OR procedure and the associated risks of general anesthesia.[2,3,7] In patients with significant medical comorbidities that are at high risk for anesthesia, SEPS can be a particularly attractive treatment option. SEPS has gained popularity since its introduction in 2001[7] for the aforementioned reasons and has been associated with faster times to treatment and diminished costs.[8] With an expanding aging population, this treatment option will continue to increase in popularity as a primary intervention for patients with certain SDH characteristics. Only several studies have directly examined factors associated with success and failure after SEPS placement.[2,9,10] The present retrospective single-institution study examined demographic, clinical, and radiographic factors associated with treatment success and failure requiring definitive operative intervention in patients with chronic or mixed-density SDH undergoing SEPS placement.

Prior studies have demonstrated high rates of success with SEPS drainage ranging from 73%–79%.[2,10-12] The largest single-institution retrospective study to date of 171 cSDHs in 159 patients reported a successful drainage rate of 78% based on a lack of need to go to the OR for subsequent treatment with burr hole or craniotomy. The authors reported a lower likelihood of success with the presence of mixed-density subdural collections, as well as collections with >2 intrahematomal septations in these patients.[10] The largest systematic review on SEPS drainage involving 953 patients with cSDH reported a 79% successful outcome rate determined by no subsequent OR procedure and symptomatic improvement.[11] In analysis of specific patient and radiographic factors associated with treatment success, Hoffman et al[9] found older age to be associated with nonroutine hospital discharge and greater clot thickness to be associated with worse outcomes after SEPS. Several studies have additionally reported improved outcomes with a greater volume of SDH drained.[2,10]

While SEPS has been associated with high levels of success initially, complications including delayed hematoma recurrence, the development of new acute bleeding resulting from the procedure, seizures, and mortality have all been reported. Recurrence rates in the literature after SEPS drainage range from 15%–26%, and mortality rates are reasonably low at 2% or less.[4,11-13] However, these rates are small compared with the associated risks of craniotomy for cSDH where morbidity and mortality rates are reported to be as high as 25% and 11%.[14]

**Table 1.** Demographic and Presenting Radiographic Data

| | |
|---|---|
| Age | |
| Mean | 68.8 years |
| Median | 72 years |
| Comorbidities | |
| Hypertension | 81 (94%) |
| Coronary artery disease | 57 (66%) |
| Diabetes | 39 (45%) |
| Chronic kidney disease | 19 (22%) |
| Atrial fibrillation | 15 (17%) |
| Coagulation status | |
| Anticoagulants | 13 (15%) |
| Antiplatelets | 32 (37%) |
| INR >2 | 7 (8%) |
| Thrombocytopenic <100 | 2 (2%) |
| Mechanism | |
| Spontaneous | 41 (48%) |
| Fall | 30 (35%) |
| MVC | 14 (16%) |
| Assault | 4 (5%) |
| Presenting symptoms | |
| Headache | 52 (60%) |
| Nausea/Vomiting | 14 (16%) |
| Weakness | 4 (4%) |
| Seizure | 0 (0%) |
| GCS | |
| 15 | 42 (49%) |
| 14 | 16 (19%) |
| 11–13 | 17 (20%) |
| ≤10 | 11 (13%) |
| Radiographic findings | |
| Subacute | 66 (76%) |
| Septations | 33 (38%) |
| Thickness (mean) | 17.7 mm |
| Midline shift (mean) | 6.9 mm |

INR, international normalized ratio; MVC, motor vehicle collision; GCS, Glasgow Coma Scale.

**Table 2.** Operative Intervention and Outcomes

| | |
|---|---|
| Recurrence | 22 (25%) |
| Need for Operating Room | 31 (36%) |
| Glasgow Coma Scale | |
| Better | 19 (22%) |
| Unchanged | 57 (66%) |
| Worse | 10 (12%) |
| Thickness | |
| Better | 73 (85%) |
| Unchanged | 7 (8%) |
| Worse | 6 (7%) |
| Average change | −5.9 mm |
| Midline shift | |
| Better | 60 (70%) |
| Unchanged | 19 (22%) |
| Worse | 7 (8%) |
| Average change | −3.2 mm |
| Disposition | |
| Home/Home health | 49 (57%) |
| Rehab | 14 (16%) |
| Nursing Home | 20 (23%) |
| Death | 3 (4%) |

The present study reports a slightly lower success rate of 64% than that reported in the literature, with treatment failure defined as need for definitive OR drainage. This rate may be affected by a lower threshold in going to the OR for definitive treatment of SDHs at the authors' institution. The presence of mixed-density collections and septations was found to be associated with treatment failure on multivariate analysis, consistent with several prior findings in the literature.[2,10] The presence of septations has previously been hypothesized to interfere with the SEPS

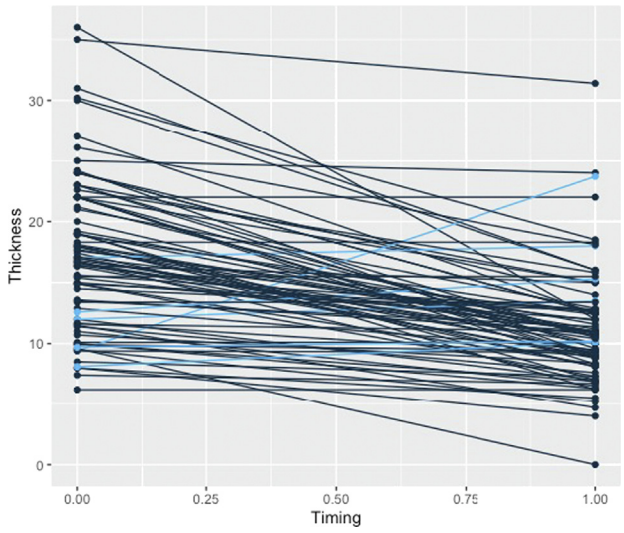


**Figure 3.** Pre– and post–subdural evacuation port system subdural hematoma thickness for 86 patients.

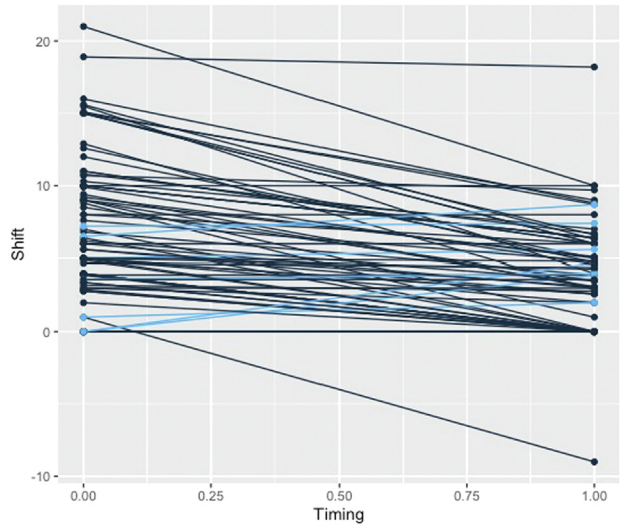


**Figure 4.** Pre– and post–subdural evacuation port system subdural hematoma midline shift for 86 patients.

technique,[8] as well as operative treatment with burr holes.[15] Septations can create noncommunicating compartments hindering the ability of a single twist-drill hole to fully evacuate an SDH. Alternatively, craniotomy facilitates improved visualization of septations and allows for the performance of membranectomies.[16] The presence of mixed-density collections was associated with the highest odds of treatment failure in the present study. These mixed-density SDHs consist of acute components that are more solid and less amenable to drainage through a small craniostomy and closed suction system.

Several studies have directly compared treatment with SEPS with craniotomy, burr hole, and subdural drain placement with mixed findings. Ortiz et al[17] compared subdural drain placement with SEPS for subacute SDH and cSDH, reporting an increased need for second bedside procedure after SEPS placement when compared with a subdural drain. These authors also found SEPS associated with a longer intensive care unit and hospital stay.[17] Flint et al[3] compared bedside SEPS versus burr hole for cSDH similarly, finding a higher 6-month reoperation rate with SEPS (15.6%) compared with burr hole (9.1%) drainage. However, as SEPS was more commonly performed over the years, the difference in reoperation rates disappeared, likely due to increased technical proficiency and improved patient selection.[3] Rughani et al[4] also reported a trend toward higher reoperation with SEPS compared with burr holes with a greater reduction in SDH thickness with burr holes. In contrast, in a retrospective study comparing operative management (burr hole or craniotomy) with SEPS for cSDH, Safain et al[5] reported no difference in reoperation or recurrence rates between procedures.

**Table 3.** Analysis of Odds of Subdural Hematoma Recurrence, Need for Operating Room (OR), Disposition Other than Home and Modified Rankin Scale Score <3 by Patient and Radiographic Factors

| | Recurrence | | Need for OR | | Disposition | | mRS <3 | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **OR** | ***P*** | **OR** | ***P*** | **OR** | ***P*** | **OR** | ***P*** |
| Age | 0.99 | 0.61 | 0.97 | 0.06 | 1.02 | 0.18 | 1.01 | 0.62 |
| Anticoagulation use | 1.36 | 0.64 | 1.13 | 0.84 | 2.60 | 0.17 | 4.06 | 0.08 |
| Antiplatelet use | 0.55 | 0.27 | 0.71 | 0.48 | 1.90 | 0.17 | 1.31 | 0.56 |
| Fall | 0.63 | 0.39 | 0.83 | 0.70 | 2.56 | 0.06 | 1.12 | 0.81 |
| MVC | 0.43 | 0.30 | 0.43 | 0.22 | 0.90 | 0.86 | 0.57 | 0.33 |
| Headache | 0.93 | 0.88 | 1.31 | 0.56 | 0.56 | 0.20 | 0.81 | 0.64 |
| Nausea/Vomiting | 0.43 | 0.30 | 0.43 | 0.22 | 0.90 | 0.86 | 0.57 | 0.33 |
| Poor GCS | 0.97 | 0.97 | 0.56 | 0.50 | 2.20 | 0.35 | 4.87 | 0.15 |
| Subacute components | 3.67 | 0.08 | **7.05*** | **0.01** | 0.73 | 0.56 | 0.45 | 0.17 |
| Septations | 1.91 | 0.20 | **5.87*** | **<0.001** | 1.09 | 0.85 | 0.76 | 0.54 |
| Pre-MLS | 1.06 | 0.19 | 1.08 | 0.07 | 0.98 | 0.62 | 0.98 | 0.62 |
| Prethickness | 1.03 | 0.37 | 1.01 | 0.68 | 1.01 | 0.78 | 1.02 | 0.56 |
| Post-MLS | 1.07 | 0.21 | 1.09 | 0.11 | 0.98 | 0.76 | 0.98 | 0.65 |
| Postthickness | 1.02 | 0.49 | 1.01 | 0.73 | 1.02 | 0.49 | 1.01 | 0.79 |

Bold values indicate statistical significance with $P < 0.05$.
mRS, modified Rankin Scale; MVC, motor vehicle collision; GCS, Glasgow Coma Scale; MLS, midline shift.
*Statistically significant odds ratios.

During SEPS, SDH localization is typically performed using measurements from the plain computed tomography scan using the external auditory canal as a reference point without the use of neuronavigation. The nature of the bedside procedure precludes the adequate visualization and management of involved blood vessels, as well as the stripping of membranes that have been heavily associated with SDH recurrence.[18] The medical complexity of the patients undergoing SEPS placement and greater blood thinner usage may all contribute to the elevated failure and reoperation rates reported after SEPS drainage. However, for these medically complex patients, the risks of general anesthesia and operative intervention must be carefully evaluated.

The present study confirms and adds to prior literature indicating that SEPS drainage is a safe and effective first-line procedure for certain patients with cSDH. These data should be used to tailor this procedure to those most likely to benefit based on a combination of preprocedural radiographic and clinical criteria. Patients with clearly defined membranes with more acute/mixed appearing SDHs may benefit from direct operative intervention where these membranes and bleeding vessels can be adequately visualized and treated. However, with an aging population, SEPS will continue to increase in popularity and failure rates will diminish as patient-selection and technical proficiency improves. Refinements of the indications for the use of SEPS must be made to diminish complication and reoperation rates going forward.

### Limitations

The study is limited by its retrospective design, small number of patients, and short-term clinical outcome. Retrospective studies are subject to unidentified confounders, imbalanced cohorts, incomplete data sets, misinterpretation of data, recall bias, selection bias, and observer bias. Reoperation was selected as the primary outcome because it is consistently noted in the Electronic Medical Record and objective. An objective primary outcome that is consistently noted in the Electronic Medical Record was felt to mitigate the aforementioned limitations of a retrospective study. Symptomatic improvement based on GCS score should be interpreted with caution as symptoms from chronic and subacute SDH vary considerably, making improvement difficult to quantify and standardize.

## CONCLUSIONS

SEPS is a safe and effective option in the management of subacute SDH in appropriately selected patients. Patients with septations and mixed-density SDH components on preprocedural imaging have a higher odds of requiring a definitive OR procedure for treatment. These factors must be considered when determining the optimal patient for SEPS drainage.

## CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**James Mooney:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing — original draft, Writing — review & editing. **Nicholas Erickson:** Conceptualization, Data curation, Investigation, Methodology, Validation, Visualization, Writing — original draft, Writing — review & editing. **Ben Saccomano:** Data curation, Formal analysis, Investigation, Validation, Writing — review & editing. **Pedram Maleknia:** Data curation, Investigation, Validation, Writing — review & editing. **Winfield S. Fisher:** Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing — review & editing.

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