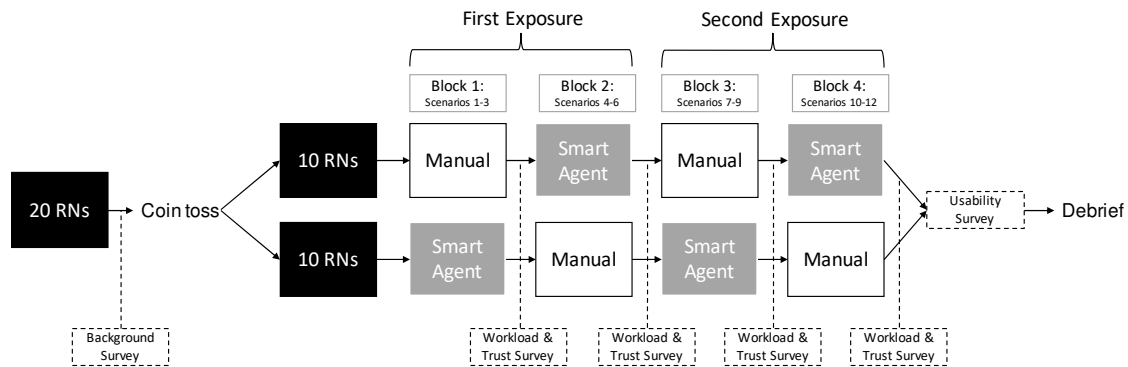


## Appendix

1. Study overview visualization
2. Equipment and Test System
3. Scenario details
4. Participant debriefing form and questionnaires
5. Participant characteristics
6. Supplementary post hoc analysis of results by Participant self-reported frequency of protocol use

## 1. Study overview visualization



This figure illustrates the study design and flow of a simulation session with each critical care registered nurse (RN). Manual is the existing insulin infusion management system in which the nurse used the given patient name and searched the Electronic Health Record for the three values, used the protocol to calculate the correct insulin dose change, and adjusted the pump settings as needed. Smart Agent automates key steps of information retrieval from the Electronic Health Record, performs calculations, and communicates with the infusion pump.

## 2. Equipment and Test System

Technical and clinical process details of the SA system have been previously published.(1, 2) At a high level, the SA system automates calculation, delivery, and documentation of the correct dose of insulin as determined by the institutionally established nurse-managed protocol. The system includes a user interface accessed as a web service from the Epic EHR. This interface is presented as a sidebar window of the active patient record. SA is integrated with the infusion pump (i.e., detects current settings, sends new settings) and the EHR (i.e., extracts patient lab and insulin infusion data, documents changes), and graphically maps the dose selection criteria to the steps of the protocol so that the clinician can see how the dose was determined. The clinician is given the option to accept or override SA dose calculations. If the clinician accepts the SA dose calculation, it is automatically sent to the infusion pump. The clinician then simply accepts changes on the pump, and avoids manual entry of changes.

## References

- 1 Griffiths SM, Sapirstein A, Guzman JC, et al. Automated, Web-Based Solution for Bidirectional EHR-Infusion Pump Communication. *Biomed Instrum Technol* 2019;53(1):30-7.
- 2 Barasch N, Romig MC, Demko ZO, et al. Automation and interoperability of a nurse-managed insulin infusion protocol as a model to improve safety and efficiency in the delivery of high-alert medications. *J Patient Saf Risk Manag.* 2019:2516043519893228.

### 3. Scenario details

Information used in each of the 2 training and 12 experimental scenarios is provided below. For each scenario, participants looked up a patient record in the test Electronic Health Record (EHR) environment, and used the prior infusion rate, and prior and current glucose readings to calculate a change in glucose and new infusion rate. The infusion rate recommended by the protocol for each patient is provided below in the ‘new infusion rate’ column. Information in the last three columns of the table below were not provided to participants, but are provided here as the ‘correct’ solution (i.e., the changes recommended by the protocol) for each case.

Block	Patient	Prior Infusion Rate Entry Time in MAR	Prior Infusion rate in MAR & on Pump (insulin units)	Prior Glucose Reading Time	Prior Glucose Reading (mg/dL)	Current Glucose Reading Time	Current Glucose Reading (mg/dL)	Change in Glucose Reading (mg/dL)	New Infusion Rate (insulin units)	Change in Infusion Rate (insulin units)
Orientation	Insulin, Testa	0600 am	3	0545 am	251	650 am	242	-9	4	1
	Insulin, Testb	0600 am	2	0545 am	193	650 am	149	-44	1.5	-0.5
1	Insulin, Testc	0600 am	1	0545 am	168	650 am	154	-14	1	0
	Insulin, Testd	0600 am	4	0545 am	325	650 am	317	-8	6	2
	Insulin, Teste	0600 am	1.5	0545 am	128	650 am	128	0	1	-0.5
2	Insulin, Testf	0600 am	3.5	0545 am	285	650 am	215	-70	2.5	-1
	Insulin, Testg	0600 am	2.5	0545 am	107	650 am	158	51	3.5	1
	Insulin, Testh	0600 am	3	0545 am	125	650 am	179	54	5	2
3	Insulin, Testi	0600 am	4.5	0545 am	288	650 am	232	-56	3.5	-1
	Insulin, Testj	0600 am	2	0545 am	134	650 am	178	48	2.5	0.5
	Insulin, Testk	0600 am	4	0545 am	375	650 am	339	-36	5	1
4	Insulin, Testl	0600 am	3.5	0545 am	215	650 am	168	-47	2.5	-1
	Insulin, Testm	0600 am	1	0545 am	205	650 am	185	-20	1.5	0.5
	Insulin, Testn	0600 am	3.5	0545 am	242	650 am	249	7	5.5	2
Extra	Insulin, Testo	0600 am	2	0545 am	135	650 am	139	4	2	0

EHR = Electronic Health Record

MAR = Medication Administration Record

#### 4. Participant debriefing form and questionnaires

##### BACKGROUND SURVEY ITEMS

How many years have you been a nurse?

How many years have you been a critical care nurse?

How often do you care for a patient using the Yale Infusion Protocol?

Every shift (more than once a week)

Once a week

Once a month

Less than once a month

## POST SCENARIO / BLOCK SURVEY ITEMS

### NASA Task Load Index Scale

Using the scale below, please rate the degree of demand you felt while completing the scenarios. **Focus your responses on your experience in the last set of scenarios.**

- How mentally demanding was the task?
- How physically demanding was the task?
- How hurried or rushed was the pace of the task?
- How successful were you in accomplishing what you were asked to do?
- How hard did you have to work to accomplish your level of performance?
- How insecure, discouraged, irritated, stressed, and annoyed were you?

### Trust in automation scale

#### Instructions:

Below is a list of statements for evaluating trust between people and automation. There are several scales for you to rate intensity of your feeling of trust, or your impression of the system while operating it. Please indicate your level of agreement with the following statements on the scale provided. **Provide your responses while thinking about the system you just used, in the last block of scenarios.**

Note: Responses are recorded on a seven-point scale (1 = not at all; 7 = extremely)

- The system is deceptive.
- The system behaves in an underhanded manner.
- I am suspicious of the system's intent, action, or outputs.
- I am wary of the system.
- The system's actions will have a harmful or injurious outcome.
- I am confident in the system.
- The system provides security.
- The system has integrity.
- The system is dependable.
- The system is reliable.
- I can trust the system.
- I am familiar with the system.

## POST SESSION SURVEY

Participants will complete the System Usability Scale twice, once for each of the conditions. The order of completing surveys will be counterbalanced across participants.

### System Usability Survey

I think that I would like to use this system frequently.

I found the system unnecessarily complex.

I thought the system was easy to use.

I think that I would need the support of a technical person to be able to use this system.

I found the various functions in this system were well integrated.

I thought there was too much inconsistency in this system.

I would imagine that most people would learn to use this system very quickly.

I found the system very cumbersome to use.

I felt very confident using the system.

I needed to learn a lot of things before I could get going with this system.

## Smart Agent Usability Testing Debrief form

- What do you think about the SmartAgent system?
  -
- Do you think it would be helpful to have a system like this?
  - 
  - Why or why not?
    -
  - Would it make managing insulin infusions...
    - Easier?
    - More efficient?
    - Safer?
- Can you think of anything that would make SmartAgent more useful or usable?
  - 
  - Can we improve clarity or simplicity of its use?
    -
  - Can we do anything to make it more efficient / fit your workflow better?
    -
  - Can we provide better feedback about what it is doing?
    -
- Do you foresee any problems with this system if it is eventually put in use?
  - 
  - Are there any risks or hazards to using it?
    -
  - Do you think other nurses would use it?
    -
- Any other comments or feedback about SmartAgent?
  -





## 5. Participant characteristics

<b>Nursing Experience</b>	<b>Mean (SD)</b>	<b>Median (IQR)</b>	<b>Range</b>
Years of nursing experience	5.0 (8.9)	2 (3.8)	0.6 - 37
Years of critical care nursing experience	4.5 (8.6)	2 (1.4)	0 - 35

<b>Insulin Protocol Use</b>	<b>Frequency</b>	<b>N</b>	<b>%</b>
Frequency of use for the Yale Insulin Infusion Protocol	> Once/week	3	15
	Once/week	7	35
	Once/month	10	50

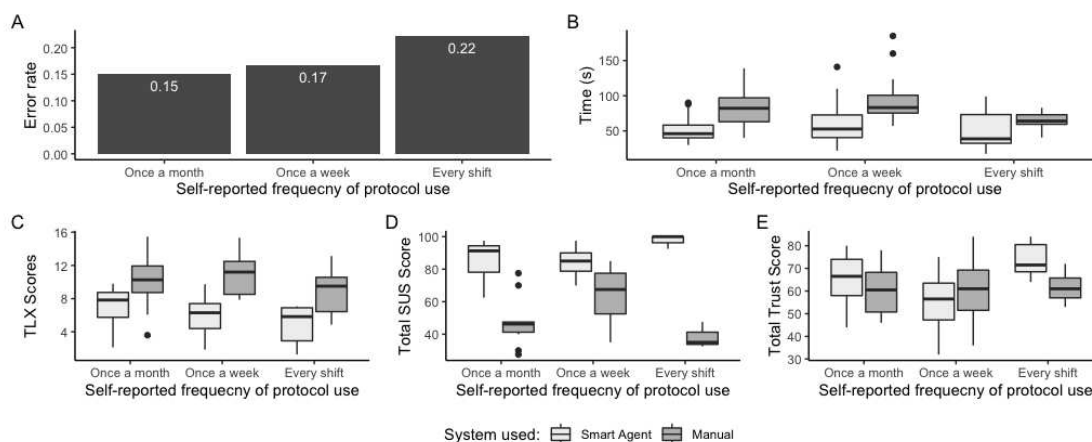
<b>Unit Representation</b>	<b>N</b>	<b>%</b>	
<b>Type</b>	ICU	14	70
	Stepdown	6	30
<b>Surgery Specialty</b>	Cardiac	9	45
	General	11	55

SD, standard deviation; IQR, interquartile range; ICU, intensive care unit

## 6. Supplementary post hoc analysis of results by Participant self-reported frequency of protocol use

In this section we provide a descriptive analysis of study outcomes by self-reported protocol use in their work. Of the 20 participants, 15% (3) reported using an insulin infusion protocol every shift (or more than once per week), 35% (7) at least once per week, and 50% (10) at least once a month. Due to a relatively low sample size we provide only descriptive data.

Study outcomes by condition and self-reported frequency of protocol use



A: Error rates by self-reported protocol use for Manual condition only  
 B: Time (in seconds) to complete scenario by condition and self-reported protocol use  
 C: Perceived workload (weighted NASA TLX) by condition and self-reported protocol use  
 D: Perceived usability (Total Systems Usability Scale score) by condition and self-reported protocol use  
 E: Trust by condition and self-reported protocol use

### Error rates

We report error rates for the manual condition only (as no errors occurred in the smart agent condition). As shown below, there appears to be a trend for HIGHER overall error rates with increasing self-reported frequency of protocol use.

Self-reported frequency of use	Number of participants (Number of trials)	Total Error Count for Manual Condition	Overall Error Rate for Group
Every shift (more than once a week)	3 (18)	4	22%
At least once a week	7 (42)	7	17%
At least once a month	10 (60)	9	15%

### Efficiency

	Efficiency: Mean (Standard Deviation) in seconds		
	Total	Smart Agent	Manual
Every shift (more than once a week)	56.5 (21.0)	51.6 (15.1)	65.2 (11.6)
At least once a week	74.2 (28.8)	58.9 (23.8)	89.6 (25.0)
At least once a month	67.3 (26.0)	51.6 (15.1)	83.0 (25.1)

### Workload

	NASA TLX Scores: Mean (Standard Deviation)		
	Total	Smart Agent	Manual
Every shift (more than once a week)	6.8 (3.5)	7.1 (2.6)	8.9 (3.2)
At least once a week	8.4 (3.5)	5.9 (2.3)	10.9 (2.6)
At least once a month	8.6 (2.9)	4.9 (2.2)	10.1 (2.7)

### Usability

	Perceived Usability: Mean (Standard Deviation)		
	Total	Smart Agent	Manual
Every shift (more than once a week)	67.9 (32.9)	97.5 (4.3)	38.3 (8.0)
At least once a week	74.1 (17.6)	84.3 (9.2)	63.9 (18.6)
At least once a month	66.6 (32.9)	85.5 (11.7)	47.8 (15.6)

### Trust

	Trust Scores: Mean (Standard Deviation)		
	Total	Smart Agent	Manual

Every shift (more than once a week)	67.7 (9.6)	73.7 (9.8)	61.7 (7.0)
At least once a week	58.4 (13.3)	55.6 (12.5)	61.3 (14.0)
At least once a month	63.2 (10.4)	65.6 (8.2)	61.7 (10.7)