volume thresholds for infusions that include PCA boluses. However, users must set low volume thresholds for continuous infusions.

[0004] Issues can occur if the user incorrectly programs a time-based threshold for an infusion that includes PCA boluses, or if the user sets a low volume threshold for an infusion that includes PCA boluses. There is also a high likelihood of human errors in the stressful hospital environment and, specifically, as the user interacts more with programming the pump control system in a medical setting.

[0005] A need accordingly exists for a syringe pump that minimizes user interaction with the syringe pump control system and automatically sets time- and/or volume-based activation thresholds for near empty syringe alarms based on user-inputted infusion therapy type.

SUMMARY

[0006] Example systems, methods, and apparatus are disclosed herein for the automatic programming of a near empty alarm activation threshold based on an infusion therapy type selected by the user on a syringe pump. The example systems, methods, and apparatus are configured to use a preloaded drug library to determine if the selected infusion therapy type includes a PCA bolus or not, and define an appropriate time- or volume-based alarm activation threshold accordingly. The disclosed systems, methods, and apparatus prevent human programming errors by minimizing the need for extensive user interaction with syringe pumps. Further, the disclosed systems, methods, and apparatus allow for automatic programming to increase efficient infusion administration, and prevent programming errors that might result in patient discomfort or injury.

[0007] In light of the disclosure herein, and without limiting the scope of the invention in any way, in an aspect of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, a syringe pump includes an actuator, a syringe holder, a display screen, a memory, and a processor. The memory stores instructions that when executed by the processor, cause the processor to: receive a user-selected infusion therapy type, determine if the user-selected infusion therapy type selected includes PCA boluses or a continuous infusion without bolus, determine a volume-based threshold if the user-selected infusion therapy type

includes PCA boluses, determine a time-based threshold if the infusion therapy type includes a continuous infusion without bolus, calculate or determine infusion therapy progress data related to an administration of an infusion therapy, the infusion therapy progress data including at least one of a total time of infusion or a remaining volume in the syringe, compare the total time of infusion to the time-based threshold when the user-selected infusion therapy type includes the continuous infusion without a bolus, compare the remaining volume in the syringe to the volume-based threshold when the user-selected infusion therapy type includes PCA boluses, and generate a message on the display screen displaying a user alert when the syringe holder on the syringe pump reaches the time-based or volume-based threshold.

[0008] In an aspect of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, a method of operating a syringe pump based on user input includes users selecting an infusion therapy type from a preloaded drug library displayed on a display screen, transmitting the infusion therapy type selected to a processor, the processor communicating with a memory and determining if the infusion therapy type selected includes PCA boluses or a continuous infusion without bolus, transmitting instructions from the memory to the processor that define a volume-based threshold if the infusion therapy type includes PCA boluses, transmitting instructions from the memory to the processor that define a time-based threshold if the infusion therapy type includes a continuous infusion without bolus, a control system automatically converting a user entered volume threshold to a time-based for a continuous infusion without bolus, generating a message on the display screen displaying a user alert when a syringe holder on the syringe pump reaches the time-based or volume-based threshold, and allowing users to control an actuator for the syringe pump based on user input.

[0009] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the drug library includes information on whether the infusion therapy type is delivered as PCA boluses or a continuous infusion without bolus.

[0010] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the user input is a volume-based threshold.

[0011] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the user input is a time-based threshold.

[0012] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the infusion therapy type is a medicine or supplement, the volume of a syringe, the syringe type, a time threshold, a volume threshold, and the volume of a bolus.

[0013] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the preloaded drug library includes the name of an infusion therapy type.

[0014] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the memory matches the infusion therapy type selected from a preloaded drug library displayed on a display screen to an entry in the preloaded drug library, retrieves information on whether the infusion is delivered as PCA boluses or a continuous infusion without bolus.

[0015] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor determines if the time-based threshold is reached by calculating a total infusion time based on a syringe volume and syringe type and an infusion rate, monitoring a running infusion time, and recognizing when the running infusion time is equivalent to the difference between the total infusion time and the time-based threshold.

[0016] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor determines if the volume-based threshold is reached by calculating a total infusion volume using a syringe volume and syringe type, calculating a syringe volume displaced by a plunger using the syringe type, receiving data from a volume sensor tracking the position of a plunger in relation to a syringe, calculating a remaining syringe volume by comparing the difference between the total infusion volume and the syringe volume displaced, and recognizing when the remaining syringe volume equals the volume-based threshold.

[0017] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor determines if the volume-based threshold is reached by calculating a bolus administration time using the syringe volume, the syringe type, and a bolus volume, determining at the start of a bolus if the syringe volume after the bolus will be below the volume-based threshold, and calculating the specific time in the bolus administration time when the syringe volume will equal the volume-based threshold.

[0018] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, transmitting a message to a clinician device.

[0019] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the clinician device is one of a smartphone, a tablet computer, a laptop computer, a workstation, or a pager.

[0020] In an aspect of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, a syringe pump includes an actuator, a syringe holder, a display screen, a memory, and a processor. The memory stores instructions that when executed by the processor, cause the processor to: receive a user-selected infusion therapy type, determine whether the selected user-selected infusion therapy type includes PCA boluses or a continuous infusion without a bolus, determine whether the selected user-selected infusion therapy type includes a volume-based threshold or a time-based threshold, and generate a message on the display screen displaying a user alert when the syringe holder on the syringe pump reaches the time-based or volume-based threshold.

[0021] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor determines a volume-based threshold when the user-selected infusion therapy type includes PCA boluses.

[0022] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor calculates or determines a remaining volume in a syringe on the syringe holder.

[0023] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor compares the remaining volume

in the syringe to the volume-based threshold when the user-selected infusion therapy type includes PCA boluses.

[0024] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor determines a time-based threshold when the user-selected infusion therapy type includes a continuous infusion without a bolus.

[0025] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor calculates or determines total time of infusion.

[0026] In an example of the present disclosure, which may be combined with any other aspect listed herein unless specified otherwise, the processor compares the total time of infusion to the time-based threshold when the user-selected infusion therapy type includes the continuous infusion without a bolus.

[0027] In an example of the present disclosure, any of the structure, functionality, and alternatives disclosed in connection with any one or more of Figs. 1 to 5 may be combined with any other structure, functionality, and alternatives disclosed in connection with any other one or more of Figs. 1 to 5.

[0028] In light of the present disclosure and the above aspects, it is therefore an advantage of the present disclosure to minimize user interaction with the syringe pump control system to minimize human error.

[0029] It is another advantage of the present disclosure to provide a syringe pump control system that automatically sets time and/or volume thresholds for near empty syringe alarms based on user-inputted infusion therapy type.

[0030] Additional features and advantages are described in, and will be apparent from, the following Detailed Description and the Figures. The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the figures and description. Also, any particular embodiment does not have to have all of the advantages listed herein and it is expressly