of pressure ulcers. Accordingly, the need exists for improved techniques to manage urinary incontinence.

## SUMMARY

**[0006]** According to a first aspect, there is provided a method including: obtaining, by a data processing system, input data, wherein the input data comprises sensor data collected by an Internet of Things (IoT) device in wireless communication with a radio frequency identification (RFID) sensor associated with a subject; parsing, by the data processing system, the input data to identify sensor data, wherein the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor; comparing, by the data processing system, a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, wherein the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time; determining, by the data processing system, the first energy level is associated with the dry or normalized condition based on the comparison; determining, by the data processing system, the second energy level is associated with a moisture event based on the comparison; in response to determining the second energy level is associated with a moisture event, determining, by the data processing system, the subject associated with the sensor has had an incontinence event; determining, by the data processing system, the sensor data does not include a third energy level within a predefined period of time after receipt of the second energy level at the second time; in response to determining the sensor data does not include the third energy level, determining, by the data processing system, an undergarment or absorbent pad associated with the subject has become saturated; and providing, by the data processing system, a user interface displaying information concerning the incontinence event and the undergarment or absorbent pad associated with the subject has become saturated.

**[0006a]** According to a second aspect, there is provided a system including: one or more data processors; and a non-transitory computer readable storage medium containing instructions which, when executed on the one or more data processors, cause the one or more data processors to perform actions including: obtaining input data, wherein the input data comprises sensor data collected by an Internet of Things (IoT) device in wireless communication with a radio frequency identification (RFID) sensor associated with a subject; parsing the input data to identify sensor data, wherein the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor; comparing a first

energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, wherein the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time;  determining the first energy level is associated with the dry or normalized condition based on the comparison; determining the second energy level is associated with a moisture event based on the comparison; in response to determining the second energy level is associated with a moisture event, determining the subject associated with the sensor has had an incontinence event; determining the sensor data does not include a third energy level within a predefined period of time after receipt of the second energy level at the second time; in response to determining the sensor data does not include the third energy level, determining a undergarment or absorbent pad associated with the subject has become saturated; and providing a user interface displaying information concerning the incontinence event and the undergarment or absorbent pad associated with the subject has become saturated.

**[0006b]** According to a third aspect, there is provided a computer-program product tangibly embodied in a non-transitory machine-readable storage medium, including instructions configured to cause one or more data processors to perform actions including: obtaining input data, wherein the input data comprises sensor data collected by an Internet of Things (IoT) device in wireless communication with a radio frequency identification (RFID) sensor associated with a subject; parsing the input data to identify sensor data, wherein the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor; comparing a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, wherein the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time; determining the first energy level is associated with the dry or normalized condition based on the comparison; determining the second energy level is associated with a moisture event based on the comparison; in response to determining the second energy level is associated with a moisture event, determining a subject associated with the sensor has had an incontinence event; determining the sensor data does not include a third energy level within a predefined period of time after receipt of the second energy level at the second time; in response to determining the sensor data does not include the third energy level, determining a undergarment or absorbent pad associated with the subject has become saturated; and providing a user interface displaying

information concerning the incontinence event and the undergarment or absorbent pad associated with the subject has become saturated.

**[0007]** Embodiments may include one or more of the following features. The method where the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor. The method where the determining the second energy level is associated with the moisture event includes determining a change between the first energy level and the second energy level exceeds a predetermined energy threshold associated with the moisture event or the second energy level exceeds a predetermined energy threshold associated with the moisture event. The method where the first energy level is a first impedance value and the second energy level is a second impedance value different from the first impedance value. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

**[0008]** Disclosed herein is a method including: obtaining, by a data processing system, input data; parsing, by the data processing system, the input data to identify sensor data from a sensor; and comparing, by the data processing system, a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, where the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time. The method also includes determining, by the data processing system, the first energy level is associated with the dry or normalized condition based on the comparison of the first energy level to the second energy level; determining, by the data processing system, the second energy level is associated with a moisture event based on the comparison; and in response to determining the second energy level is associated with a moisture event, determining, by the data processing system, a subject associated with the sensor has had an incontinence event. The method also includes determining, by the data processing system, the sensor data includes a third energy level within a predefined period of time after receipt of the second energy level at the second time; and in response to determining the sensor data does include the third energy level, comparing, by the data processing system, the third energy level to the second energy level. The method also includes determining, by the data processing system, the third energy level is associated with a drying event based on the comparison of the third energy level to the second energy level; in response to determining the third energy level is associated with a drying event, determining, by the data processing system, a undergarment or absorbent pad associated with the subject is unsaturated; and providing, by the data processing system, a user interface displaying

information concerning the incontinence event and the undergarment or absorbent pad associated with the subject is unsaturated. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

**[0009]** Embodiments may include one or more of the following features. The method where the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor. The method where the determining the second energy level is associated with the moisture event includes determining a change between the first energy level and the second energy level exceeds a predetermined energy threshold associated with the moisture event or the second energy level exceeds a predetermined energy threshold associated with the moisture event. The method where the determining the third energy level is associated with a drying event includes determining a change between the second energy level and the third energy level exceeds a predetermined drying threshold associated with a drying event or the third energy level exceeds a predetermined drying threshold associated with a drying event. The method where the first energy level is a first impedance value and the second energy level is a second impedance value different from the first impedance value, and the third energy level is a third impedance value different from the first impedance value and the second impedance value. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

**[0010]** Disclosed herein is a method including: obtaining, by a data processing system, input data; parsing, by the data processing system, the input data to identify sensor data from a sensor; and comparing, by the data processing system, a first energy level and a second energy level from the sensor data to one or more energy levels associated with a stationary position, where the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time. The method also includes determining, by the data processing system, the first energy level is associated with the stationary position based on the comparison. The method also includes determining, by the data processing system, the second energy level is associated with a motion event based on the comparison. The method also includes in response to determining the second energy level is associated with a motion event, determining, by the data processing system, a subject associated with the sensor has moved; and determining, by the data processing system, the sensor data includes a third energy level within a predefined period of time after receipt of the second energy level at the second time. The method also includes in response to determining the sensor data includes the third energy level, determining, by the data processing system, the third energy level is different from the second energy level and the third

energy level exceeds a predetermined activity threshold associated with an activity. The method also includes predicting, by a prediction model of the data processing system, the activity is a subject rolling over in bed or getting out of bed based on a pattern of the sensor data, the determination of the motion event, and the determination that the third energy level is different from the second energy level and the third energy level exceeds the predetermined activity threshold. The method also includes recording, by the data processing system, the prediction that the subject has rolled over in bed or gotten out of bed. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

**[0011]** Embodiments may include one or more of the following features. The method where the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor. The method where the determining the second energy level is associated with the motion event includes determining a change between the first energy level and the second energy level exceeds a predetermined energy threshold associated with the motion event or the second energy level exceeds a predetermined energy threshold associated with the motion event. The method where the first energy level is a first impedance value and the second energy level is a second impedance value different from the first impedance value, and the third energy level is a third impedance value different from the first impedance value and the second impedance value. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

**[0012]** An embodiment of the system further includes the undergarment or absorbent pad, wherein the undergarment or absorbent pad includes: a liquid permeable top sheet. The absorbent article also includes an absorbent material disposed under the liquid permeable top sheet. The absorbent article also includes a nonabsorbent material disposed adjacent to at least a portion of the liquid permeable top sheet or the absorbent material. The absorbent article also includes a liquid impermeable back sheet disposed over the absorbent material such that the absorbent material is disposed between the liquid permeable top sheet and the liquid impermeable back sheet. The absorbent article also includes an attachment structure attached to the liquid impermeable back sheet, where the attachment structure is structured to hold the sensor.

**[0013]** Implementations may include one or more of the following features. The system where the attachment structure is a sleeve structure. The system where the attachment structure is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material.

The absorbent article where a second attachment structure of the one or more attachment structures is attached to the liquid impermeable back sheet over an outer margin of the nonabsorbent material. The absorbent article where a fourth attachment structure of the one or more attachment structures is attached to the liquid impermeable back sheet on a posterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material. The absorbent article where a third attachment structure of the one or more attachment structures is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over the underlying absorbent material. The absorbent article where the one or more attachment structures are a magnetic structure. The absorbent article further including the one or more sensors, where each sensor of the one or more sensors is disposed in a respective attachment structure of the one or more attachment structures. The system where the sensor is a radio frequency identification (RFID) sensor.

**[0014]** An embodiment of the system further includes the undergarment or absorbent pad, wherein the undergarment or absorbent pad includes a liquid permeable top sheet. The absorbent article also includes an absorbent material disposed under the liquid permeable top sheet. The absorbent article also includes a nonabsorbent material disposed adjacent to at least a portion of the liquid permeable top sheet or the absorbent material. The absorbent article also includes a liquid impermeable back sheet disposed over the absorbent material such that the absorbent material is disposed between the liquid permeable top sheet and the liquid impermeable back sheet. The absorbent article also includes the sensor attached to the liquid impermeable back sheet.

**[0015]** Implementations may include one or more of the following features. The system where the sensor is a radio frequency identification (RFID) sensor. The system where the sensor is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material. The absorbent article where a second sensor of the one or more sensors is attached to the liquid impermeable back sheet over an outer margin of the nonabsorbent material. The absorbent article where a third sensor of the one or more sensors is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over the underlying absorbent material. The absorbent article where a fourth sensor of the one or more sensors is attached to the liquid impermeable back sheet on a posterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material.

**[0016]** In an embodiment, the system where the input data is obtained using an internet of things (IoT) device in wireless communication with the sensor. The system where the sensor is a radio frequency identification (RFID) sensor, the IoT device includes a RFID reader and a controller, and the sensor is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material.

**[0017]** The system where a second sensor of the one or more sensors is attached to the liquid impermeable back sheet over an outer margin of the nonabsorbent material. The system where a third sensor of the one or more sensors is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over the underlying absorbent material. The system where a fourth sensor of the one or more sensors is attached to the liquid impermeable back sheet on a posterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material. The system further including an angled bracket including a first end attached to the IoT device and a second end attached to an external antenna connected to the IoT device.

**[0018]** Disclosed herein is a measurement system including: a container. The measurement system also includes a linear array of sensors attached to the container, where each sensor of the array of sensors is positioned on the container relative to a respective liquid volume indictor. The measurement system also includes a computing device including a processor and a memory storage device, where a data table is stored in the memory storage device and the table includes a unique identifier for each sensor of the array of sensors and a respective liquid volume indexed with the unique identifier.

**[0019]** Disclosed herein is a method including: (i) obtaining, by a data processing system, input data. The method also includes (ii) parsing, by the data processing system, the input data to identify all sensor data collected by an internet of things (IoT) device from a plurality of sensors disposed on a collection device, where the parsing includes grouping the sensor data into subsets of sensor data received from each sensor of the plurality of sensors over the window of time based on a unique identifier associated with each of the sensors, and where at least one subset of sensor data received from a sensor of the plurality of sensors includes a first energy level obtained at a first time and a second energy level obtained at a second time that is after or later than the first time. The method also includes (iii) comparing, by the data processing system, a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the plurality of

sensors are deployed. The method also includes (iv) determining, by the data processing system, the first energy level is associated with the dry or normalized condition based on the comparison. The method also includes (v) determining, by the data processing system, the second energy level is associated with a moisture event based on the comparison. The method also includes (vi) in response to determining the second energy level is associated with a moisture event, identifying, by the data processing system, a liquid volume associated with the sensor that is associated with the at least one subset of sensor data. The method also includes repeating, by the data processing system, steps (iii)-(vi) for all other subsets of sensor data associated with other sensors of the plurality of sensors to identify additional liquid volumes associated with the other sensors. The method also includes analyzing, by the data processing system, the liquid volume associated with the sensor and the additional liquid volumes associated with the other sensors to determine a total liquid volume of the collection device. The method also includes providing, by the data processing system, a user interface displaying the total liquid volume of the collection device. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

**[0020]** Disclosed herein is a method including: obtaining, by a data processing system, sensor data from a plurality of radio frequency identification (RFID) sensors associated with a subject. The method also includes determining, by the data processing system using the sensor data, a plurality of incontinent events over a period of time. The method also includes determining, by the data processing system using the determined plurality of incontinent events, a mean intervoiding interval for the subject. The method also includes determining, by the data processing system, a statistical aberration in the determined plurality of incontinent events based on the mean intervoiding interval. The method also includes predicting, by a prediction model, a risk of a subject having or developing a urinary tract infection based on the sensor data and the statistical aberration. The method also includes providing, by the data processing system, a user interface displaying information concerning the predicted risk of the subject having or developing the urinary tract infection. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

**[0021]** Implementations may include one or more of the following features. The method further including: in response to determining the statistical aberration, triggering, by the data processing system, a request for a urinalysis and urine culture to be performed for the subject. The method further including obtaining, by the data processing system, results of the urinalysis and urine

culture, where the predicting the risk of the subject having or developing the urinary tract infection is based on the sensor data, the statistical aberration, and the results of the urinalysis and urine culture. The method further including obtaining, by the data processing system, additional data including time interval of meals, iv rates, g tube feed rates, or a combination thereof, where the predicting the risk of the subject having or developing the urinary tract infection is based on the sensor data, the statistical aberration, the results of the urinalysis and urine culture, and the additional data. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

**[0022]** Disclosed herein is a method including: obtaining, by a data processing system, sensor data from a plurality of radio frequency identification (RFID) sensors associated with a subject. The method also includes determining, by the data processing system using the sensor data, a plurality of motion events over a period of time. The method also includes determining, by a first prediction model, using the determined plurality of motion events, a pattern of motion activity. The method also includes predicting, by a second prediction model, a risk of a subject having or developing a decubitus based on the sensor data and the pattern of motion activity. The method also includes providing, by the data processing system, a user interface displaying information concerning the predicted risk of the subject having or developing the decubitus. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

**[0023]** Implementations may include one or more of the following features. The method further including obtaining, by the data processing system, additional data including frequency of staff engagement with the subject, where the predicting the risk of the subject having or developing the decubitus is based on the sensor data, the pattern of motion activity, and the additional data. Implementations of the described techniques may include hardware, a method or process, or computer software on a computer-accessible medium.

**[0024]** In some embodiments, a system is provided that includes one or more data processors and a non-transitory computer readable storage medium containing instructions which, when executed on the one or more data processors, cause the one or more data processors to perform part or all of one or more methods disclosed herein.

**[0025]** In some embodiments, a computer-program product is provided that is tangibly embodied in a non-transitory machine-readable storage medium and that includes instructions configured to

CLAIMS

1. A method comprising:

obtaining, by a data processing system, input data, wherein the input data comprises sensor data collected by an Internet of Things (IoT) device in wireless communication with a radio frequency identification (RFID) sensor associated with a subject;

parsing, by the data processing system, the input data to identify sensor data, wherein the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor;

comparing, by the data processing system, a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, wherein the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time;

determining, by the data processing system, the first energy level is associated with the dry or normalized condition based on the comparison;

determining, by the data processing system, the second energy level is associated with a moisture event based on the comparison;

in response to determining the second energy level is associated with a moisture event, determining, by the data processing system, the subject associated with the sensor has had an incontinence event;

determining, by the data processing system, the sensor data does not include a third energy level within a predefined period of time after receipt of the second energy level at the second time;

in response to determining the sensor data does not include the third energy level, determining, by the data processing system, an undergarment or absorbent pad associated with the subject has become saturated; and

providing, by the data processing system, a user interface displaying information concerning the incontinence event and the undergarment or absorbent pad associated with the subject has become saturated.

2. The method of claim 1, wherein the determining the second energy level is associated with the moisture event comprises determining a change between the first energy level and the

second energy level exceeds a predetermined energy threshold associated with the moisture event or the second energy level exceeds a predetermined energy threshold associated with the moisture event.

3. The method of claim 1 or 2, wherein the first energy level is a first impedance value and the second energy level is a second impedance value different from the first impedance value.

4. A system comprising:

one or more data processors; and

a non-transitory computer readable storage medium containing instructions which, when executed on the one or more data processors, cause the one or more data processors to perform actions including:

obtaining input data, wherein the input data comprises sensor data collected by an Internet of Things (IoT) device in wireless communication with a radio frequency identification (RFID) sensor associated with a subject;

parsing the input data to identify sensor data, wherein the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor;

comparing a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, wherein the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time;

determining the first energy level is associated with the dry or normalized condition based on the comparison;

determining the second energy level is associated with a moisture event based on the comparison;

in response to determining the second energy level is associated with a moisture event, determining the subject associated with the sensor has had an incontinence event;

determining the sensor data does not include a third energy level within a predefined period of time after receipt of the second energy level at the second time;

in response to determining the sensor data does not include the third energy level, determining a undergarment or absorbent pad associated with the subject has become saturated; and

providing a user interface displaying information concerning the incontinence event and the undergarment or absorbent pad associated with the subject has become saturated.

5. A computer-program product tangibly embodied in a non-transitory machine-readable storage medium, including instructions configured to cause one or more data processors to perform actions including:

obtaining input data, wherein the input data comprises sensor data collected by an Internet of Things (IoT) device in wireless communication with a radio frequency identification (RFID) sensor associated with a subject;

parsing the input data to identify sensor data, wherein the parsing includes grouping the sensor data from the sensor over a window of time based on a unique identifier associated with the sensor;

comparing a first energy level and a second energy level from the sensor data to one or more energy levels associated with a dry or normalized condition for an environment in which the sensor is deployed, wherein the first energy level is obtained at a first time and the second energy level is obtained at a second time that is after the first time;

determining the first energy level is associated with the dry or normalized condition based on the comparison;

determining the second energy level is associated with a moisture event based on the comparison;

in response to determining the second energy level is associated with a moisture event, determining a subject associated with the sensor has had an incontinence event;

determining the sensor data does not include a third energy level within a predefined period of time after receipt of the second energy level at the second time;

in response to determining the sensor data does not include the third energy level, determining a undergarment or absorbent pad associated with the subject has become saturated; and

providing a user interface displaying information concerning the incontinence event and the undergarment or absorbent pad associated with the subject has become saturated.

6. The system of claim 4, further comprising the undergarment or absorbent pad, wherein the undergarment or absorbent pad comprises:

a liquid permeable top sheet;

an absorbent material disposed under the liquid permeable top sheet;

a nonabsorbent material disposed adjacent to at least a portion of the liquid permeable top sheet or the absorbent material;

a liquid impermeable back sheet disposed over the absorbent material such that the absorbent material is disposed between the liquid permeable top sheet and the liquid impermeable back sheet; and

an attachment structure attached to the liquid impermeable back sheet, wherein the attachment structure is structured to hold the sensor .

7. The system of claim 6, wherein the attachment structure is a sleeve structure.

8. The system of claim 6 or 7, wherein the attachment structure is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material.

9. The system of claim 4, further comprising the undergarment or absorbent pad, wherein the undergarment or absorbent pad comprises:

a liquid permeable top sheet;

an absorbent material disposed under the liquid permeable top sheet;

a nonabsorbent material disposed adjacent to at least a portion of the liquid permeable top sheet or the absorbent material;

a liquid impermeable back sheet disposed over the absorbent material such that the absorbent material is disposed between the liquid permeable top sheet and the liquid impermeable back sheet; and

the sensor attached to the liquid impermeable back sheet.

10. The system of claim 9, wherein the sensor is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material.

11. The system of claim 9, wherein the IoT device comprises a RFID reader and a controller, and the sensor is attached to the liquid impermeable back sheet on an anterior side of the liquid impermeable back sheet over an interface between the underlying absorbent material and the nonabsorbent material.