Occupant Monitoring and Alert System

Field of the Invention

This invention relates to bed occupant monitoring and alert system and refers particularly, though not exclusively, to such a system intended to minimise the likelihood of a person falling from a bed, or leaving a bed when not authorised to do so.

Background to the Invention

In hospitals, hospices and homes for the elderly, high-risk patients who cannot afford a fall are often confined to bed. For such patients a fall may have serious consequences, even death. In consequence patients are often confined to bed using retractable sides and/or physical restraints. However, these are not generally suitable for long-term use. They are also not suitable for patients liable to haemorrhages (e.g. Dengue haemorrhage fever) or with skeletal problems (e.g. osteoporosis).

Summary of the Invention

A bed occupant monitoring and alert system comprising a plurality of sensors to be located relative to at least one mattress so as to be able to detect a patient upon the at least one mattress. Each of the plurality sensors is also for generating and sending a signal to a control unit. The control unit is for sampling the signals as received from the plurality of sensors to determine if the patient is upon at least a portion of the at least one mattress. The control unit comprises a telecommunication module for sending a message to a duty person upon determining there is no patient upon at least the portion of the at least one mattress.

The plurality of sensors may be located between two vertically arranged mattresses, or may be located within the at least one mattress.

There may be three sensors comprising a first sensor at a shoulder region of the patient when the patient is lying on the at least one mattress, a second sensor at a hip region of the patient when the patient is lying on the at least one mattress, and

a third sensor at a foot region of the patient when the patient is lying on the at least one mattress. The plurality of sensors may be moveable relative to the at least one mattress.

Each of the plurality of sensors may comprise an upper plate of an electrically conductive material, a lower plate of an electrically conductive material, an intermediate layer between the upper plate and the lower plate, and a signal generator. The intermediate layer may be of an electrically non-conductive material and may be for biasing the upper plate and the lower plate apart. The intermediate layer may also be compressible by the presence of a patient on the at least one mattress for altering the signal generated by the signal generator.

At least one of the upper plate and the lower plate may be at least one of: concave, recessed, and of a ductile material.

The control unit may further comprise a processor, a microcontroller operatively connected to the processor; the microcontroller being for controlling the telecommunications module and a display module. The control unit may be for monitoring a plurality of beds. The processor may have two inputs for each of the plurality of beds. The two inputs may comprise a first input for receiving the signals, and a second input for enabling and disabling the unit for each bed. The processor may also have a first output for an audible warning, a second output for a visible warning, and a third output for an array of lamps, there being a lamp for each of the plurality of beds. The processor may be a field programmable gate array.

The message may be sent by at least one selected from the group consisting of: SMS, MMS, pager, and telephone call. The message may contain at least one of: the identity of the bed, and the location of the bed.

The control unit may communicate with each sensor wirelessly, or over a wired connection. The signal may be multiplexed, there being a separate signal for each of plurality of sensors. Each of the plurality of beds may be given a unique identity, the control unit sampling the signals as received from each of the plurality beds in the order of their unique identity.

At least one of the audible warning, the visible warning, and at least one of the array of lamps may be activated upon the processor determining there is no patient

upon the at least one portion of the at least one mattress. The activation may remain effective until reset by an operator.

At least one of the audible warning, the visible warning, and at least one of the array of lamps may be activated upon the processor determining there is no patient upon the at least one portion of the at least one mattress. The activation may remain effective until reset by an operator.

The signal may be of a first category if the patient is on at least a portion of the at least one mattress, and may be of a second category if the patient is not upon at least the portion of the at least one mattress. The signal may be continuous.

According to another aspect there is provided a sensor for use in a bed occupant monitoring and alert system, the sensor comprising an upper plate of an electrically conductive materials, a lower plate of an electrically conductive material, an intermediate layer between the upper plate and the lower plate, and a signal generator; the intermediate layer being of an electrically non-conductive material; the intermediate layer being for biasing the upper plate and the lower plate apart, and being compressible by the presence of a patient on the at least one mattress for altering a signal generated by the signal generator to enable the signal generator to generate the signal. The signal may be of a first category if the patient is on at least a portion of the at least one mattress, and may be of a second category if the patient is not upon at least the portion of the at least one mattress. The signal may be continuous.

According to a final aspect there is provided a bed occupant monitoring and alert system incorporating a plurality of sensors as described above.

Brief Description of the Drawings

In order that the present invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative drawings in which:

Figure 1 is a perspective view of a preferred embodiment system;

Figure 2 is a schematic side view of the mattress of Figure 1;

Figure 3 is a schematic block diagram of the control unit of Figure 1; and

Figure 4 is a flow chart for the operation of the system of Figure 1.

Detailed Description of Preferred Embodiments

To first refer to Figure 1, there is shown a bed 10 having a bed head 12, bed foot 14 and mattress 16. The mattress 16, may be a single mattress or, as shown, two vertically arranged mattresses, being an upper mattress 18 and a lower mattress 20. Between mattress 18, 20 are three sensors 22, 24, 26 (Figure 2). Alternatively, sensors 22, 24, 26 may be located within a mattress 16 if a single mattress is used. Although three sensors are shown, there may be any required or desired number of sensors such as, for example, 2, 3, 4 ,5 or 6. Operatively connected to the sensors 22, 24, 26 is a control unit 21. The connection may be by a cable 23, or may be wirelessly. Control unit is able to communicate with a portable device 26 over a telecommunications link 28. This may be by any suitable methodology.

The sensors 22, 24, 26 may be moveable relative to mattress 16 for patients of different height, or may be fixed relative to mattress 16. Each sensor 22, 24, 26 may comprise an upper plate 30 and a lower plate 32. The plates 30, 32 are both electrically conductive. Alternatively, the plates 30, 32 may have electrically non-conductive regions and electrically conductive regions provided the electrically conductive regions of plate 30 are vertically aligned with the electrically conductive regions of plate 32. The plates 30, 32 are separated by an intermediate layer 34 of an electrically non-conductive material, and which is preferably resilient to bias the plates 30, 32 apart. The resiliency of the intermediate layer 34 should be sufficient to resist the combined weight of upper plate 30 and upper mattress 18, but not when a patient is on the bed 10.

The sensors 22, 24, 26 extend across substantially the full width of mattress 16 and are located along the length of the mattress 16 to coincide with the shoulders, hips and lower legs (e.g. feet) of a patient. In this way when a patient is lying on bed 10 the maximum pressure is applied to sensors 22, 24, 26 by a patient on the bed 10. When the pressure from the patient is applied to a sensor 22, 24 or 26, the intermediate layer 34 is compressed and plates 30, 32 contract to thus close an electrical circuit. To assist this one or both of plates 30, 32 may be concave or recessed to accommodate the intermediate layer 34, with the amount of concavity, or the depth of the recess in each plate 30, 32 being slightly more than half of the

compressed height of intermediate layer 34 if both plates 30, 32 are recessed. This will enable contact between plates 30, 32 at least around their perimeter. Additionally or alternatively, one or both of plates 30, 32 may of a ductile material such as, for example, a relatively thin sheet of metal such as, for example, copper or aluminium.

The intermediate layers 34 each contain a signal generator for generating a continuous signal and sending the signal to the control unit 21. When a patient is on the bed such that one of the sensors 22, 24, 26 is compressed, the signal generated by that sensor is of a first category (e.g. category 1). If the sensor is not compressed, the signal is of a second category (e.g. category 0).

As is stated above, control unit 21 is connected to each sensor 22, 24, 26 by a cable 23, or wirelessly such that it receives signals from each bed to which it is connected, and for which it is enabled. The control unit 21 receives signals from the sensors 22, 24, 26 of each bed separately or as a combined signal and samples and processes those signals in order so as to determine if there is a patient on the bed 10. If a patient is on the bed 10, at least one of the sensors 22, 24, 26 will be compressed and thus the signal will be generated and will be of the first category. Each bed is given a unique identity or identity and this forms part of the signal. Therefore, the control unit 21 knows from which bed each received signal has originated. If desired, each sensor of each bed may be given a unique identity and each sensor may separately send its signal. That would enable the control unit 21 on the bed the patient was located.

By using a signal there is only minimal current passing through sensors 22, 24, 26 thereby increasing the safety aspect, particularly if the mattress becomes soiled by moisture. In the desired form, the signal may be multiplexed so that a different signal is for each sensor 22, 24, 26 thus enabling the control unit 21 to determine if the patient is laying on bed 10 (i.e. a positive result in all three sensors 22, 24, 26), is sitting up in bed (i.e. a positive response in sensors 22, 24 but not 26), or is sitting on the bed ready to try to get out of bed (i.e. a positive response in sensor 24 but not sensors 22, 26) or has crawled to the foot of the bed prior to getting out of bed (i.e. a positive response in sensor 26 but not sensors 22, 24). In this way the control unit 21 can determine not only that the patient is on mattress 16, but with some degree of certainty can predict where on mattress 16 the patient is located.

The control unit 21 may be used with a plurality of beds 10. For example, it may be used to monitor several beds 10. The number may vary and may be 5, 10, 15 or 20 beds. As each bed will be given a unique ID the control unit 21 can identify each bed. The sampling frequency of control unit 21 may be as required or desired in the circumstances. This may depend on the nature of the patients. For example it may be once a second, once every 500ms, once every 100ms, once every 50ms, or more frequently. With a sampling frequency of once every 100ms and 15 beds, the control unit 21 samples and analyses a signal from each bed every 1.5 seconds.

The sensors 22, 24, 26 on each bed 10 may be able to be switched to a disabled mode if the bed 10 is unoccupied. This may be at the sensors 22, 24, 26 or for the bed 10 at control unit 21.

Figure 3 shows a preferred circuitry for one form of control unit 21. In this case the control unit 21 is for monitoring 15 beds 10. The control unit 21 has a one processor 40, in this case a field programmable gate array. The processor 40 is operatively connected to a microcontroller 41 that controls a display 42 and telecommunications module 43.

There are 15 sensor inputs channels 44 to processor 40, one for each bed 10. A further 15 inputs 49 are provided to enable individual beds to be enabled and disabled at the control unit 21. A download input 45 is also provided to enable processor 40 to be configured, for data entry, and so forth.

The processor 40 also controls three main outputs: an audible alarm 46 such as, for example, a buzzer; a visual alarm 47 such as, for example, an alarm light 47; and a lamp 48 for each bed under control of unit 21. The lamps 48 may be incandescent globes, or light emitting diodes. They may flash when activated, or remain illuminated.

As shown on Figure 4, the operation is that once the sensors 22, 24, 26 and the control unit 21 are connected and switched on (72), each bed 10 that has a patient is enabled (50). Initially, for each enabled bed 10, the audible alarm 46 is silent, the visual alarm 47 is off, and the lamp 48 for each bed 10 is off.

The unit 21 samples the signal from each enabled bed 10 in turn (51). A query is raised (52) to determine the category of the signal received for a particular bed. If of the first category (53) a query is raised (60) to determine if the alarm 46, light 47 and lamp 48 are on. If yes (61) they are switched off (80) and the next bed in turn is selected (54) and the process reverts to step (51). If no (62) at (60) the process is directly to (54). As each bed will have a unique ID, the system can cycle continuously through the signals received from all enabled beds in the order of their ID, or any other suitable, desired or required order.

If at any time the signal is received from a bed 10 is of the second category (55) this indicates there is no patient on the bed. A query is first raised to determine if it the same bed (82). If not (63) it means it is a new patient that has left the bed and the audible alarm 46 is activated (56) as is the visible alarm 47 (57) and relevant lamp 48. The unit 21 then uses a look-up table to find a contact number for a duty person or nurse (58). That number may be for a mobile telephone, pager, or the like. If the number is there (64), a message is sent to that number by telecommunications module 43 (59). The message may be an SMS message, MMS message, a telephone call with a pre-recorded message, a message to a pager, or the like. The message may contain not only the fact that there is an alarm, but may also identify the individual bed at which the alarm has been raised and/or the location of that bed. If the message at (59) contains the bed number, the duty nurse will be aware of the actions of the patient and will be able to take the relevant action. If the message does not contain the bed number, the lamp 48 may be left illuminated (but alarm 46 and visual warning 47 switched off) as an indication that the patient in that bed had been at least temporarily out of the bed.

If there is no number (65) in the look-up table at (58), then the control unit 21 continues to sample signals from the next enabled bed (54) and the cycle continues (51).

If it is the same patient (66) that has left the bed at (82) the next bed in turn is selected (54) and the process continues to step (51).

When the cycle reaches the sampling of an enabled bed, it will sample the signal and determine the signal category and the process repeats as is described above.

If it is the first category (53) and the alarm 46, light 47 and lamp 48 are on at (60) it indicates that the patient has returned to the bed 10. Therefore, the unit 21 switches off the alarm 46, and the visual warning 47 (80) as is described above.

If at (52) the signal is still of the second category (55), the alarm 46, light 47 and lamp 48 remain active until the unit 21 is disabled for that bed 10 (73) by the duty nurse in response to the message sent at (59). The disabling also acts to stop the alarm 46, light 47 and lamp 48 as well as removing the bed from the sampling by unit 21. Upon the duty nurse locating the patient and returning the patient to the bed 10, the unit 21 is enabled for that bed 10 (71). The dashed nature of the lines indicates that these two steps can take place at any time and are performed by the duty nurse on the system, not by the system.

If the duty nurse number is not in the look-up table at (58), the unit 21 does not send the number at (59) but continues to sample the signals from the next enabled bed (54) and the process continues to step (51) and follows the subsequent processing as described above.

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design, construction or operation may be made without departing from the present invention.

The Claims:

1. A bed occupant monitoring and alert system comprising:

(a) a plurality of sensors to be located relative to at least one mattress so as to be able to detect a patient upon the at least one mattress;

(b) each of the plurality sensors also being for generating and sending a signal to a control unit;

(c) the control unit being for sampling the signals as received from the plurality of sensors to determine if the patient is upon at least a portion of the at least one mattress;

(d) the control unit comprising a telecommunication module for sending a message to a duty person upon determining there is no patient upon at least the portion of the at least one mattress.

2. A system as claimed in claim 1, wherein the plurality of sensors are located between two vertically arranged mattresses.

3. A system as claimed in claim 1, wherein the plurality of sensors are located within the at least one mattress.

4. A system as claimed in any one of claims 1 to 3, wherein there are three sensors comprising a first sensor at a shoulder region of the patient when the patient is lying on the at least one mattress, a second sensor at a hip region of the patient when the patient is lying on the at least one mattress, and a third sensor at a foot region of the patient when the patient is lying on the at least one mattress.

5. A system as claimed in any one of claims 1 to 4, wherein the plurality of sensors are moveable relative to the at least one mattress.

6. A system as claimed in any one of the claims 1 to 5, wherein each of the plurality of sensors comprises an upper plate of an electrically conductive material, a lower plate of an electrically conductive material, an intermediate layer between the upper plate and the lower plate, and a signal generator; the intermediate layer being of an electrically non-conductive material; the intermediate layer being for biasing the upper plate and the lower plate apart, and being compressible by the presence of

a patient on the at least one mattress for altering a signal generated by the signal generator enabling the signal generator to generate the signal.

7. A system as claimed in claim 6, wherein at least one of the upper plate and the lower plate is at least one of: concave, recessed, and of a ductile material.

8. A system as claimed in any one of claims 1 to 7, wherein the control unit further comprises a processor, a microcontroller operatively connected to the processor; the microcontroller being for controlling the telecommunications module and a display module.

9. A system as claimed in claim 8, wherein the control unit is for monitoring a plurality of beds, the processor having two inputs for each of the plurality of beds, the two inputs comprising a first input for receiving the signals, and a second input for enabling and disabling the unit for each bed.

10. A system as claimed in claim 9, wherein the processor has a first output for an audible warning, a second output for a visible warning, and a third output for an array of lamps, there being a lamp for each of the plurality of beds.

11. A system as claimed in any one of claims 8 to 10, wherein the processor is a field programmable gate array.

12. A system as claimed in any one of claims 1 to 11, wherein the message is sent by at least one selected from the group consisting of: SMS, MMS, pager, and telephone call.

13. A system as claimed in anyone of claims 1 to 12, wherein the message contains at least one of: the identity of the bed, and the location of the bed.

14. A system as claimed in any one of the claims 1 to 13, wherein the control unit communicates with each sensor wirelessly, or over a wired connection.

15. A system as claimed in any one of claims 1 to 14, wherein the signal is multiplexed, there being a separate signal for each of plurality of sensors.

16. A system as claimed in any one of claims 9 to 11, wherein each of the plurality of beds is given a unique identity, the control unit sampling the signals as received from each of the plurality of beds in the order of their unique identity.

17. A system as claimed in claim 10 or any one of claims 11 to 16 when appended to claim 10, wherein at least one of the audible warning, the visible warning, and at least one of the array of lamps is activated upon the processor determining there is no patient upon the at least one portion of the at least one mattress.

18. A system as claimed in claim 17, wherein the activation remains effective until disabled by an operator.

19. A system as claimed in claim 17, wherein the activation remains effective until the patient returns to the at least one portion of the at least one mattress.

20. A system as claimed in any one of claims 1 to 19, wherein the signal is of a first category if the patient is on at least a portion of the at least one mattress, and is of a second category if the patient is not upon at least the portion of the at least one mattress.

21. A system as claimed in claim 20, wherein the signal is continuous.

22. A sensor for use in a bed occupant monitoring and alert system, the sensor comprising an upper plate of an electrically conductive material, a lower plate of an electrically conductive material, an intermediate layer between the upper plate and the lower plate, and a signal generator; the intermediate layer being of an electrically non-conductive material; the intermediate layer being for biasing the upper plate and the lower plate apart, and being compressible by the presence of a patient on the at least one mattress for altering a signal generated by the signal generator.

23. A sensor as claimed in claim 22, wherein the signal is of a first category if the patient is on at least a portion of the at least one mattress, and is of a second category if the patient is not upon at least the portion of the at least one mattress.

24. A sensor as claimed in claim 22 or 23, wherein the signal is continuous.

25. A bed occupant monitoring and alert system incorporating a plurality of sensors as claimed in any one of claims 22 to 24.