

# Factors affecting patients' use of alarm systems in geriatric hospitals

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*J.Tyrrell, P.Couturier, A.Franco, P.Moulin. Factors affecting patients' use of alarm systems in geriatric hospitals. Gerontechnology 2004; 3(1): 16-28. **Context.** Call-buttons and alarm systems are common for older people living at home. Geriatric in-patients tend to be more dependent and frail. Hospitalisation neither guarantees constant surveillance, nor protection from falls and other hazards. To what extent are the simple call-button systems adequate for older patients in geriatric units? **Objectives.** The objectives of this study were to (i) review the circumstances of accidents which occurred in a geriatric rehabilitation setting; (ii) assess the accessibility of call-buttons provided for elderly patients; (iii) evaluate the perceived safety problems for this patient group and the adequacy of call-buttons. **Methods.** (i) A review of the hospital's accident declaration forms from the previous two years examined the circumstances of in-patient accidents; (ii) An observation schedule was used to assess availability and accessibility of call-buttons for 115 elderly in-patients; (iii) Semi-structured interviews with nursing staff were conducted to discuss the call-button system, and to identify the types of patient who need more assistance. **Results.** (i) Most accidents occurred during daytime, when the patient was alone in his bedroom, and fell; (ii) Call-buttons were available and accessible for less than 10% of patients during daytime; yet most patients needed assistance for basic activities of daily living; (iii) Falls, wandering, and choking were perceived sources of risk for many patients; the conventional call-button system would be unsuitable for alerting staff. **Conclusions.** Accidents within the hospital tend to occur when patients are alone and need to be able to summon assistance. The traditional call-button system for alerting staff is then inadequate. Few geriatric units provide wireless call-buttons and passive alert systems for this population; furthermore, these technologies do not reduce the demands for assistance. Gerontechnology may improve older patients' ability to summon help, but this cannot be a substitute for adequate staffing levels.*

**Keywords:** assistive technologies, patient safety, patient evaluation, geriatric care

Safety and security needs of older patients have attracted much attention. Wandering, falls, and other accidents present problems for the safety of the individual and for those responsible for his care. New technologies have been proposed to improve the quality of life of ageing populations; this emerging field of study is known as gerontechnology<sup>1</sup> or telegerontology<sup>2</sup>. Various devices such as telealarms, videolinks, and remote monitoring systems help to ensure that frail or vulnerable people living alone can alert carers if they require help or in an emergency situation<sup>3-9</sup>. However, most of these initiatives for improving security and assistance have focussed on older people living in the community; relatively little attention has been paid to the experiences and needs of elderly in-patients or those in residential care.

Hospitalised elderly people tend to be frailer and more dependent on carers than their community dwelling peers. During hospital stays, a number of potential problems arise concerning their safety and security. Falls and wandering have received most attention in the literature<sup>3,10-16</sup> although in-patient accidents<sup>17</sup> (e.g. involving equipment such as bedrails) are also a significant safety issue. Apart from physical disability, age-related declines in perceptual-motor skills, and illness, many older in-patients experience confusional episodes during their stay, which can affect their safety awareness and judgement<sup>18</sup>. Dependency levels vary between night and day<sup>19</sup>, as does the hospital environment (e.g. lighting levels, density of staffing). The causes and consequences of accidents, falls, and wandering in institutions have been studied<sup>10-17</sup>, but the difficulties of alerting care staff in these settings are rarely mentioned.

Despite the presence of healthcare professionals, domestic staff, and visitors

in the building, most patients spend much of their time alone and unsupervised; they often have difficulty alerting staff when they require assistance. In France, hospital patients are lodged in small bedrooms, rather than the large ward-style units seen in some other countries, such as the United Kingdom or Ireland.

In a preliminary observational study of patients' calls for assistance on one floor of our geriatric department<sup>20</sup>, we observed a range of methods used for contacting staff, including yelling, asking a third party to alert staff, and tapping against the wall with a solid object. Call-buttons were available, but were used for less than a quarter of calls for assistance. Furthermore, some 18% of calls received no response. Another recent study showed that in over 90% of falls in a nursing home, the patient was unable to get up without help; in 7% of cases, the patient had been on the floor for at least an hour before being discovered<sup>21</sup>. The consequences of a long lie are particularly dangerous for elderly in-patients who are already ill and frail, and the injuries sustained can complicate the recovery process.

The purpose of this investigation was threefold: (i) to study the circumstances of accidents in a geriatric rehabilitation setting; (ii) to examine the utility of the existing alarm systems for summoning help; (iii) to explore nursing staff's views about the existing alarm system and the types of risk situations that required their attention.

There were three stages. The first included a review of accident report forms from the previous two years, which enabled us to identify the circumstances (location, timing, and type of events) where patients were alone, and needed urgent assistance from nursing staff. The second was an observational study of call buttons and

their accessibility within a geriatric rehabilitation unit, with a sample of 115 in-patients. Their levels of dependency on care staff were also evaluated. The third stage explored nursing staff's perceptions about patients-at-risk and their views about the current alarm system.

## REVIEW OF ACCIDENT DECLARATION FORMS FROM THE GERIATRIC HOSPITAL

### Method

We studied retrospectively the number and type of accidents involving older in-patients to identify the types where patients require assistance. The nursing supervisor and a doctor are required to complete a short declaration form for all accidents observed within the geriatric unit. We examined all accident declaration forms from the previous two years. These indicate the patient's name, the timing, location and nature of the event, and the immediate consequences of the incident such as injuries or other clinical observations.

### Results

There were accident declaration forms for 99 incidents, 95 of which occurred when patients were alone. Four incidents where nursing staff or family were present were excluded. Analysis of location, type of incident, and approximate time of discovery of the patients is presented in bar charts (Figure 1).

Falls were the most common incident (94 out of 95 events). The "non-fall" incident involved a patient who undid a safety barrier and left the bed; on returning, this patient knocked against the bed and injured her leg. Of the 95 incidents, 84 (88%) occurred in the patient's bedroom (80) or at the sink (4) in the corner of the bedroom. While only six falls occurred at the toilet, many patients fell because they needed to go to the toilet, and fell either en route or while trying to leave the chair or bed.

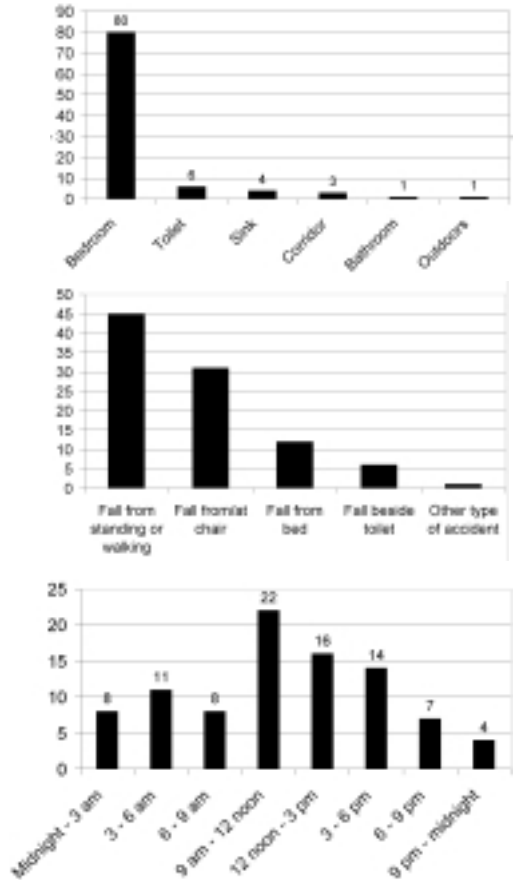


Figure 1: Recorded accidents involving 95 in-patients in a geriatric rehabilitation hospital. a Location; b Type; c Time of occurrence

45 (48%) patients appeared to have fallen while standing or walking; 31(33%) falls were from or beside chairs. Only 12 (13%) of falls occurred beside the bed; one patient had stated that she fell while trying to fetch her call-button. Some of these patients sustained painful bruises, cuts (occasionally requiring stitches), and fractures, although the details noted on the form were limited. Most falls occurred during the day whereas 23 (25%) were reported between 9pm and 6am. It is not known how long the patients waited for help; many could not get up independently or summon assistance and had to wait for staff to discover them. It is not known how the patients were

discovered. None of the incident forms indicated that a call-button had been used to alert staff after the fall; the device would have probably been out of reach if the patient was on the floor.

## AVAILABILITY AND ACCESSIBILITY OF CALL-BUTTONS

### Method

An observation study assessed the availability and accessibility of patients' call-buttons, as they were used for a minority of calls in the preliminary study. Figure 2 shows the type of call-buttons provided to patients at the time of study. Figure 2 shows the type of call-buttons provided to patients at the time of study. All patients (n=115) were visited in their rooms at the geriatric unit. An observation schedule was completed for each patient (presence/absence of call-button; call-button within reach of patient; patient position at time of visit).



Figure 2: Bedside call-button device provided for in-patients in a geriatric rehabilitation hospital

### Results

The 115 patients included 30 men and 85 women. The mean age was 85.3 years, with a range between 69 and 97 years. All patients had been admitted for either follow-up care or rehabilitation. There was a wide range of diagnoses; the most common included femoral neck fractures, dementia, strokes, and hip replacements. Most patients had multiple diagnoses, including some with confusional states or

depression. We evaluated their dependency levels or needs for assistance rather than classifying by primary diagnosis or reason for admission to the unit.

Levels of dependency among the 115 in-patients were assessed using an international structured rating scale, the Katz Index<sup>22</sup>. This was chosen as it is designed for use with hospitalised people, suitable for elderly patients, and available in French. It assesses dependency in six areas of activities of daily living (ADL): bathing, dressing, toileting, transfers, continence, and eating (Table 1). The nursing staff responsible for each patient rated their independence for each activity.

Table 1: Dependency levels of elderly in-patients as classified by Katz Index<sup>22</sup> (n=115)

Class	Number of Patients	Katz classification criteria
A	14	Independent in feeding, continence, transferring, going to the toilet, dressing & bathing
B	7	Independent for all but one of these functions
C	11	Independent in all but bathing and one additional function
D	12	Independent in all but bathing, dressing, & one additional function
E	21	Independent in all but bathing, dressing, going to the toilet, & one additional function
F	15	Independent in all but bathing, dressing, going to the toilet, transferring, and 1 additional function
G	30	Dependent in all six functions
Other	5	Dependent in at least two functions, but not classifiable as C,D,E, or F
Total	115	

An itemised analysis of the Katz Index revealed a high level of dependence on nursing staff for assistance with ADL: 57%

of patients were dependent for bathing, 54% for dressing, 41% for transfers; 39% needed help for toileting, 34% had continence problems, and 21% needed assistance for eating. Most patients (88%) required assistance with at least one of these basic ADL's; furthermore, patients who are dependent for transfers, toileting, continence, or eating will need assistance from carers throughout the day.

### *Patient positions*

At the time of the visits (between 9.30am and 1pm), 80 (69%) patients were sitting out of bed: 77 in chairs and 3 in wheelchairs. Space restrictions and the design of hospital rooms meant that chairs are usually placed opposite the end of the bed. 32 (28%) patients were in or on their beds; three patients were standing or walking about in their rooms.

### *Presence of alarms*

Of the 115 patients, 103 (90%) had a call-button in their room, 7 had no call-button, 4 had buttons which were unplugged from the socket, and 1 had a broken device.

### *Positioning of alarms*

Each call-button has a wire connecting it to a socket in the wall, near the head of the bed. Given that many patients move around the room during the 24 hour period, we noted if the call-button was accessible from the bed, since all patients spend some time in bed, but not all patients walk about. Of the 103 patients who had an alarm, 45 (44%) had a call-button within reach of the bed. However, only 8 of these 45 patients were in bed at the time of the visit. In other words, only 8 (7%) of the 115 patients observed had a call-button within reach. In 58 (56%) cases, the call-buttons were out of reach or in an inaccessible place, such as on an overhead shelf or having fallen behind the locker.

### *Accessibility of alarms*

The call-buttons are only usable when

patients are sitting or lying in bed. During the daytime visits to the room, only 32 (28%) patients were in or on their beds. Of these, 24 (75%) did not have a call-button within reach. A large proportion of alarms were inaccessible, even from the bed (56%); they had been wrapped up on hooks, placed on a shelf over the bed, left hanging behind the bed, trailing on the floor, or tidied away out of reach. This may have been done during room cleaning by domestic staff, or when the patient was being attended to by nursing staff.

Most patients (72%) were out of bed during the daytime visit, as the study was conducted in a geriatric rehabilitation unit. The call-buttons are not accessible from chairs, or when the patient is moving around the room. There is also a call-bell on the wall in the toilet area, but this can be difficult to use if the patient has fallen, or is in an unstable position.

## **NURSES' VIEWS CONCERNING CALLS FOR ASSISTANCE AND PATIENTS AT RISK**

### **Method**

Semi-structured interviews were conducted with all members (nurses and aides) of the nursing staff to present the findings about patients' use of call-buttons. We asked the nursing staff to identify (i) problems associated with responding to patients' calls for help; (ii) which of the current 115 patients they considered as being at-risk in terms of safety, as well as stating the type of risk.

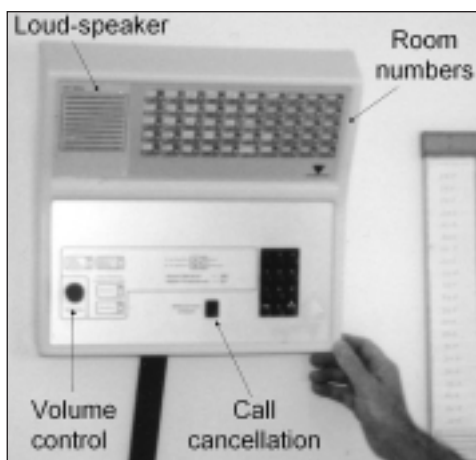
### **Results**

Three issues emerged from these interviews. First of all, the nursing staff were aware that they often were unable to respond to patients' requests for help, as they tended to be elsewhere and could not see or hear the alert signals. The signals arrive at a reception panel in the nurses' office, which emits a bleeping sound and indicates the room number of the caller.

Figure 3 shows the main features of this call reception panel. However, the nurses' office is often unoccupied while the personnel are performing routine care tasks with patients. Also, on call-button activation, a light flashes in the corridor outside their room, but this cannot be seen immediately if there are no personnel in the corridor area. Secondly, they identified lunchtimes and nighttime as being particularly difficult periods for acknowledging and responding to calls, as there were less staff available; for example, at night, there are only three staff members on each floor, with about forty patients per floor. Thirdly, the nursing staff felt that some patients had heightened needs or special risks, and that they should be alerted immediately if these patients needed help. Examples were patients at risk of choking, at risk of falling, or patients who wandered from their rooms often due to confusional states or cognitive disability. These interviews gave qualitative information about the types of situations where patients needed assistance, and also reflected the high levels of dependency on nursing staff. A more detailed investigation of these issues was conducted, focussing on the 115 patients who had been included in the

observation study of call-buttons. We interviewed the nursing staff in smaller subgroups of three or four, and asked them to evaluate each patient under their care in terms of perceived risk. Usually, the nursing personnel provide care for up to 20 patients per corridor at any given time, and they indicated whether or not each of their patients was perceived as being at risk or in need of surveillance. Of the 115 patients, 48 were identified as being at risk by their nursing staff. The most common risk mentioned was falls (94%). These are most likely to occur while patients are out of bed, and thus far from a call-button. The reasons given for these potential falls were diverse; factors included dizziness, postural instability, difficulties in mastering the use of walking frames and canes, impaired safety awareness, or poor lighting at nighttime. Some falls were likely to occur suddenly, whereas others were likely to occur gradually, such as sliding from a chair. One patient was at risk of wandering, and one patient was judged to be at risk of choking. Also, one stroke patient was unable to call vocally for assistance.

*Figure 3: Call reception panel in nurses' office indicating which patient has requested assistance*



## DISCUSSION AND RECOMMENDATIONS

The results from these three studies highlight needs and difficulties experienced by elderly in-patients and care staff, as well as inadequacies of the traditional call-button system in the hospital environment. Some problems are related to poor design and erroneous assumptions about how the call-button system works. Others are due to human factors, including the functional abilities of patients, staffing levels, and a lack of awareness of patient needs. These issues are discussed, and some recommendations are made about improving alarm provision in hospitals, as well as extending clinical and gerontechnology research.

The analysis of accident forms revealed that most declared accidents (95%) had

occurred when patients were alone. The amount of time between the incident and the discovery of the patient is unknown, and probably highly variable ranging from minutes to hours<sup>21</sup>. Many patients fell during day-time, when the number of support people (staff and visitors) is higher than at night. Although the causes of the falls are diverse and unknown, many seem to have occurred when patients were transferring or walking about, a finding common to other hospital studies<sup>13</sup>. Some patients should have had assistance before they fell, but since the call-buttons are often out of their reach, they would have had difficulty summoning help before attempting transfers or walking about, often to and from the toilet area.

The observational study of patients' bedrooms indicated that only 7% of the 115 patients had a call-button within reach during the daytime. This result helps to explain why they were rarely used to summon help in the preliminary observational study<sup>20</sup>. Alternative systems are needed to ensure that patients can summon assistance when they are out of bed and thus prone to accidents (Figure 1).

The staff interviews about patient risks highlighted an important distinction about alarm systems and patient needs. One category of patients includes those conscious of their need for assistance, e.g. a patient who realises he is slipping from a chair, a patient who is conscious after a fall, or a patient who is aware he needs help to walk to the toilet. This group requires *active* alarm systems within reach, allowing the patient to summon assistance, while not involving trailing wires across the room. Wireless devices worn as a bracelet or on a belt<sup>23,24</sup> are preferable to pendant-type buttons which are often perceived as cumbersome and are known to be frequently discarded by community dwelling users.

A second category of patients is either

unaware of their need for assistance due to cognitive problems or impaired judgement, or because they have lost consciousness e.g. before or following a fall. These patients require *passive* alert systems, which do not depend on their initiative, ability, or willingness to activate them. Such devices can be either worn by the patient or placed in the environment. One type of passive alert system is the fall detector<sup>6</sup>; this small device is designed to be worn by the patient, and uses accelerometers and/or tilt meters to monitor the user. It can be programmed to generate a warning signal to carers if it detects unusual changes of position due to a fall. More recently, a small patch-type device has been developed which is worn by patients who need help with transfers; it emits a signal to warn the patient if he attempts to stand or move without carer assistance<sup>25</sup>. Alternatively, unobtrusive sensors can be placed in various locations in the room (around the bed, under the chair seat or mattress, under the carpet, or at the doorways) to monitor patient activity during the day or night<sup>26-28</sup> or to detect potentially unsafe manoeuvres.

In our study, some accidents involved patients who had undone restraints or climbed over bedrails placed to protect them, and subsequently fell. Some suffered minor injuries including cuts, bruises, and suspected fractures; earlier detection of these manoeuvres with passive alert systems might have allowed nursing staff to intervene earlier. Since the study was conducted, national guidelines have been published about the use of physical restraints and bedrails<sup>29</sup> recommending that their prescription should be avoided when possible. Providing passive or active alert systems are promising alternatives to restraining patients in the interests of safety or fall prevention, although there is limited published evidence about their clinical effectiveness.

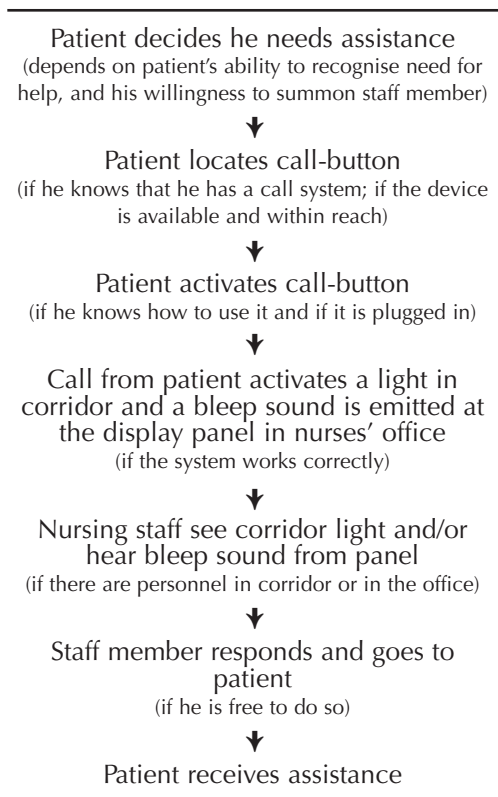
Overall, our results indicate that the conventional call-button is not adapted to the needs and functional abilities of most elderly in-patients. In our hospital, its usability was limited to a minority of patients who were in bed. Even these people were unable to use the simple call-button if placed out of reach; the second study indicates a need to improve staff awareness about positioning call-buttons as part of routine patient care. Although the provision of call-buttons is occasionally mentioned in the contexts of patient safety or fall prevention<sup>13,29,30</sup>, it is not enough to equip a room with a call system: the call-button must be made accessible for the patient whenever he is left alone. This simple step is rarely mentioned in the literature on fall prevention, and no published studies have examined the extent to which care staff routinely ensure that call-buttons are within reach for frail elderly patients.

The study did not examine staff perceptions of patients' requests for help. This is a complex issue, worthy of further investigation, as it is clear that attitudes to patients' requests are variable. Some staff members are more favourably disposed to responding than others; some patients are perceived as being more demanding than others, and nursing personnel are obliged to prioritise the various demands on their time. Responding to patient alarm calls is just one of a wide range of responsibilities for nursing staff, and can be a potential source of stress when staff feel overworked<sup>31</sup>. Furthermore, as seen in community-based studies<sup>32</sup>, patients' attitudes towards carers differ; some people are reluctant to ask for help or to bother the nurses, while others make numerous requests throughout the day. Recent publications promote the idea that in-patient accidents might be reduced by improving patient education<sup>13,30</sup>; specifically, nursing staff should actively encourage older patients to ask for help when they need it rather than attempting unsafe transfers, as

well as verifying that they know how to use their call-button.

We did not test the technical reliability of the call-button system, but occasional design-related problems were observed in our hospital, e.g. loose socket connections or faulty transmission of calls. Such problems further reduce the likelihood of call-buttons being used successfully to alert staff, as well as undermining staff and patient confidence in the system. Table 2 summarises the assumptions underlying the use of in-patient call-button systems, and the various problems we identified in our study.

*Table 2: Use of alarm system: Assumed procedure from patient's call to staff assistance, and contingencies observed at each stage*



The most important limitation of our study is that our observations of patients and



their alarm buttons were confined to one building within the geriatric service, although the equipment was similar to that used in many institutions in France. Verbal feedback following the presentation of these results at national and international conferences indicated that the shortcomings of our alarm system, our patients' safety issues, and staffing levels were common to other geriatric institutions, although a minority of buildings have more up-to-date equipment. Dependency levels vary enormously between hospitals and care settings in France<sup>33</sup> as in other countries; some institutions have large numbers of patients with advanced levels of cognitive disability. Furthermore, staff-patient ratios vary between care-settings, as does the architecture and equipment available. Finally, the participants in our study are not necessarily representative of all institutionalised geriatric in-patients, but are typical of older patients hospitalised for follow-up care or rehabilitation.

## Evaluating patient's requirements and functional abilities

A range of technologies is required within the hospital setting, so that rehabilitation teams can prescribe an alarm system which is adapted to the functional abilities and safety needs of each patient. This requires an evaluation of both the patient and the hospital environment, an issue which has received minimal attention in clinical literature. Although definitive assessment guidelines are beyond the scope of this paper, we recommend that the evaluation of the patient should consider the following dimensions: (a) his current cognitive functioning, especially his safety awareness, judgement and understanding of what a call-button is for; (b) his physical functional abilities, e.g. the ability to locate and use a call-button, the ability to transfer safely, eyesight; (c) previous safety or security issues, e.g. complaints of dizziness, history of falls or wandering, and tendency to take risks, and (d) his

rehabilitation programme, e.g. identify those who are being *encouraged* to walk about during the day. Psychological and occupational therapy assessments should include this type of information about a patient's functional abilities and limitations.

The provision of reliable and accessible alarm systems should improve an elderly patient's ability to *request* assistance quickly. An impressive range of hospital alarm systems are being marketed, but relatively few geriatric hospitals are equipped with up-to-date systems such as wirefree alarms and movement detectors. Readers unfamiliar with these alarm systems are advised to look on the internet where an increasing number of sites present photographs and technical details of products which are either at an experimental stage, or on sale for individuals or institutions. Useful key-words for searching include: wireless emergency responses, or personal emergency response system (PERS), telealarm, or fall detectors.

Furthermore, the usefulness of new types of alarm equipment needs to be tested by the users<sup>34</sup>. The experiences and views of nursing staff and patients are important indicators when choosing between systems, rather than a sole reliance on the assumptions of third parties such as hospital directors, budget managers, designers, or engineers. For example, the nursing staff in our study favoured the introduction of portable call receptors, which would allow them to receive patient calls wherever they were in the unit.

Our observational study was conducted during the day, but the call-buttons were difficult to find in the dark; the inclusion of a luminous feature on some models facilitates night-time use<sup>35</sup>. The current market of institutional alarm products offers another choice: whether or not to integrate the call-button within multifunctional patient control devices such as remote

light-switches. For some patients, it is easier to use a single-purpose call-button, but other users may prefer the multifunctional models.

## Human factors in alarm use: future directions for research

Providing up-to-date gerontechnology in hospitals may reduce both the number of at-risk situations and subsequent accidents, although there is a need for more scientific studies to demonstrate their impact on patient care. Modern alert systems or gerontechnology are often perceived as *automatically* improving patient safety or well-being, but this is based on the assumption that there are enough people available to respond promptly to calls for assistance or warning signals. The fact that patients can call upon staff more easily may add to the workload of nursing personnel, and the alarm technology is not a substitute for adequate staffing levels in hospital settings. While it is true that some passive alert systems may reduce the need for surveillance, the patients' needs for assistance are not met or reduced by an effective alarm system itself. Where staffing is already inadequate, more calls or alert signals may increase feelings of stress and overload for care staff. Also, if there is no response to calls for assistance, the patients' confidence in nursing personnel may be undermined.

The provision of an effective means of summoning help and/or patient monitoring is an important indicator of quality of care. The analysis of incident forms leads us to think that some accidents were avoidable, had the patients been assisted when they originally needed help. Most studies of falls are retrospective, and rely on the quality of the information recorded at the time of the incident<sup>13</sup>. Prospective studies of in-patient accidents might include more detailed information about how the patient was discovered, whether he had attempted to call for assistance

before getting into difficulty, and whether or not the individual was previously identified by care staff as being at risk. Finally, patient preferences for different types of alert systems, and their willingness to use them, are in need of research, as studies of community dwelling elders have found a wide range of attitudes to using call systems<sup>4,5,32</sup>.

Some other psychological issues were not within our present scope but deserve attention in future studies of alarm use in hospital or residential care settings. These include observing staff responses to patient calls, as well as examining elderly in-patients' experiences and views about asking for assistance, and their attitudes to risk taking. Another issue is the extent to which patients with cognitive disabilities (such as Alzheimer's disease) are able to use call-buttons appropriately; cognitively impaired patients are frequently perceived as not requiring call-buttons, or *a priori* incapable of using them. Furthermore, people with a diagnosis of dementia are often *automatically* regarded as candidates for passive alert systems such as monitoring or even electronic tagging<sup>36,37</sup>, rather than as patients who may also require reassurance or assistance from carers. People with dementia are not a homogeneous group. Although patients may suffer to a varying degree from memory deficits, apraxias, impaired judgement, or communication problems, people at the early stages of dementia have different needs, functional abilities, and degrees of insight<sup>38,39</sup>. Specific systems that give reminders or warnings about unsafe manoeuvres to users show some promise with people who have mild cognitive impairments<sup>25,40</sup>, but patients' use of the routinely available equipment is understudied.

## CONCLUSION

The conventional call-button system is not adapted to the needs and functional abili-

ties of older in-patients, and additional alarm systems are required to improve patient safety and well-being. The reduction of at-risk situations and subsequent accidents (which can complicate the rehabilitation programme and prolong the hospital stay) are important issues in the care of older in-patients. We hope that this population receives more attention from gerontechnologists and clinical researchers in the future.

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