ABSTRACT

Recent years have seen widespread interest in the process of evidence implementation and growth of implementation science. Whilst this work has drawn attention to the challenges and complexities of implementing evidence into everyday practice, for the most part, studies of implementation uphold the ideal of a linear 'pipeline' between research and front-line care. In contrast, this paper adopts a practice perspective on knowledge, and draws on science and technology studies concepts to identify how the socio-material environment contributes to the translation of evidence across multiple organisational and professional boundaries. Findings report on a qualitative case study of implementing fall prevention research evidence at a large teaching hospital in Portugal. Data is from forty-six in-depth semi-structured interviews with clinical and non-clinical staff.

The case highlights how *linked* boundary objects bridge temporally sequential boundaries between research and different practice communities, hence facilitating the translation of research evidence into everyday practice. The initial boundary object (the 'Morse' fall risk assessment scale) contributed to evidence being taken up by specialist nurses within the hospital, while a second boundary object (a pink patient wristband) engendered a change in practice of a wider network of actors. Nevertheless, the symbolic connection between the two linked boundary objects remained precarious, dependent on networks of interaction and communication. The study highlights the role of material objects in the ongoing translation of research evidence into everyday clinical practice.

Keywords: Portugal; boundary objects; linked boundary objects; knowledge translation; implementation research; interprofessional coordination; hospital; case study

1. Introduction

In the past two decades, healthcare services have faced increased expectations to implement evidence-based practices in order to improve their performance and service quality (Wilson et al., 2010). Yet, the ability to translate research evidence and externally developed knowledge into an organisation's everyday practice is still a key challenge for healthcare services (Evans and Scarbrough, 2014). Health service research communities have responded to this challenge through a new field of research, that of Implementation Science (Peters et al., 2013). Nilsen (2015) provides a taxonomy of this growing field, noting the growth of implementation process 'models', implementation determinant frameworks, and formal theories which attempt to explain and predict aspects of implementation. While this literature often draws from a wide range of academic disciplines and approaches, the overall project is one of creating scientific knowledge of the implementation process and developing an "understanding of optimal implementation strategies and generalizability of concepts and constructs." (Moullin et al., 2019:7). Although implementation science models and frameworks do consider the socio-cultural environments or systems within which evidence-based interventions take place (Sobo et al., 2008), they tend to assume an ideal of evidence moving along a 'pipeline' (Bauer et al., 2015) from research into practice in a fundamentally linear way (Kitson, 2009). Knowledge products are generated by research organisations, translated into innovations by pioneers and entrepreneurs and then adopted by front-line clinicians. As a result, significant research has focused on the difficulties of implementation (Evans and Scarbrough, 2014), with an emphasis on potential 'leaks' (and their fixes) between research and practice.

One notable exception to this is the approach of Normalization Process Theory (NPT) (May and Finch, 2009), which seeks to explain how and why practices become routinely embedded or

‘normalized’ into everyday work, highlighting the ongoing work of distributed actors in implementation. NPT draws on insights from Science and Technology Studies (STS) alongside other sociological perspectives, to highlight the way innovation, and particularly new technology, are translated into practice through collective thought and action. However, while NPT has sought to develop an explanation of diffuse social actors’ role in implementation, there has been less focus within studies adopting NPT on the way material objects themselves are tied up in this process (McEvoy et al., 2014). In contrast, Science and Technology Studies more broadly, and Actor Network Theory in particular, have focused on the key role played by material objects in the (re)production of routine practices, and the translation of practices between and across relational actor-networks (Callon, 1986; Latour, 1987). The past ten years has seen increasing attention to the way everyday organisational life is constituted through ‘entanglements’ between the social and the material (Orlikowski, 2007) and the way the human and technological ‘entail each other in practice’ (Carlile et al., 2013:8). In this vein, a number of studies focused on the socio-material production of innovation in healthcare (e.g. Pols, 2012). For example, Stoopendaal and Bal (2013) highlight the way in which the values of a nutrition-improvement project are inscribed and translated into practice through the many, apparently mundane, objects which constituted the training and clinical environments. Focusing on the role of objects in cross-boundary collaborations, Nicolini et al. (2012) demonstrate how ‘assemblages’ of objects afford the performance of local practice.

One widely used concept in consideration of how knowledge boundaries between different communities can be mitigated is that of the boundary object (Carlile, 2002; Kimble et al., 2010; Nicolini et al., 2012; Swan et al., 2007). The concept of boundary objects was proposed by Star and Griesemer (1989) to describe objects that are able to adapt to the local needs of different communities, including having different meanings; yet maintaining a common identity across all

sites. Literature has highlighted that boundary objects can play three roles on cross-boundary collaboration: knowledge exchange, establishing shared meanings, and facilitating collective learning (Hsiao et al., 2012). First, boundary objects can represent, store, and retrieve knowledge across groups, hence allowing the coordination of tasks by facilitating knowledge transfer and making staff's work visible and legible to others (Hsiao et al., 2012). Second, the interpretive flexibility of boundary objects allows them to serve as bridges between intersecting communities without the need of a deep sharing of information (Nicolini et al., 2012) or consensus (Star, 2010). Finally, boundary objects can be used to understand the functioning of a system, including the identification of its problems and in so doing support collective learning (Hsiao et al., 2012) and the negotiation of different functional interests (Carlile, 2004). These three roles contribute to overcome the three types of knowledge boundaries identified by Carlile (2002; 2004) - syntactic, semantic, and pragmatic by, respectively, enabling the creation of a common lexicon, common meanings, and common interests.

Although the role of boundary objects on cross-boundary collaboration can contribute to the understanding of the processual dynamics associated with the translation of healthcare research findings into practice, they have received little attention from implementation science researchers (Oborn et al., 2013). This is perhaps surprising as professional boundaries and boundary challenges are widely considered central to the practice of healthcare work. Several studies have highlighted how the social construction of clinical knowledge is strongly shaped within the cultures, language, routines and networks of professional groups (Gabbay and Le May, 2004) with, for example, knowledge more likely to be constructed along rather than across professional lines (Waring et al., 2013). As Oborn et al. (2013) argue, knowledge translation research should give careful attention to how professional boundaries impact on knowledge flows and recognise the importance of tacit knowledge associated with the socialization processes.

Within the relatively small number of studies on boundary objects in cross boundary collaboration between healthcare research and practice, the co-existence of multiple boundary objects has been subject of scant research (e.g. Smith et al., 2014; Swan et al., 2007). Notwithstanding the recognition that different social boundaries require different boundary objects in order for knowledge to be effectively translated (e.g. Smith et al., 2014; Swan et al., 2007), literature on boundary objects has tended to focus on individual objects and its effectiveness in cross-boundary collaboration between *intersecting* communities (e.g. Fox, 2011; Smith et al., 2014; Swan et al., 2007) rather than the networks of relations between multiple communities and multiple objects. Indeed, no study has yet explored how boundary objects could be *linked* in a way that would foster the translation of research evidence between *non-intersecting* communities. As far as the authors are aware, so far only Wiggins et al.'s (2015) specifically explored the concept of coupled/linked boundary objects but in the context of communicating global environment information held by US agencies and organisations to researchers. Our study addresses this gap by exploring how two linked boundary objects can be used to coordinate practice and transfer knowledge across boundaries between *non-intersecting* research and practice communities. In doing so, this article also adds to the limited literature that explores the role of boundary objects in translating research evidence into practice (e.g. Oborn et al., 2013; Swan et al., 2007) and to the literature that explores the influence of context on the effectiveness of boundary objects and the limitations of their applicability (e.g. Turnhout, 2009).

The article proceeds by describing the case study of falls prevention within a Portuguese hospital. Qualitative findings are presented and discussed to elaborate the way in which linked boundary objects contribute to the translation of research evidence into practice.

2. Methods

2.1.Context and case study

The fieldwork was undertaken in a large acute teaching hospital owned by the Portuguese National Health Service. This hospital was purposefully chosen given its recognition in the country as one of the principal innovators and leaders in the area of patient safety management, including fall prevention. Given that the interviewer was external to the hospital, she contacted the hospital's quality management department and arranged a pilot visit to explore the hospital's suitability as a case study. Ethics approval was obtained from both the hospital and the University of York where the first author was based. Data collection took place from August 2008 until February 2010 and it focused on studying the reasons for the creation of a Falls Prevention Group; the projects the group had adopted; how these were designed, developed and implemented, including the role of staff and non-human factors (e.g. physical infrastructure, IT systems, formal procedures, etc.); and what had been the impact of the group's projects on the day-to-day work.

In the elderly, falls and fall-related injuries are amongst the most serious and common medical problems and are the leading cause of both injury deaths and emergency department visits for trauma (Liu et al., 2015). Additionally, falls often lead to hospitalisation and/or bed-bound status or to admission to a nursing home (Oliver et al., 2010). Even when fall related injuries are classified as minor (e.g. joint dislocations, bruises and other soft tissue injuries), they can create considerable suffering for the patient (Bloem et al., 2004).

Even before patient safety became a major topic of research, falls had already been an object of study (e.g. Sheldon, 1960). In the last two decades, influenced by the trend towards greater patient safety, research on risk factors associated with falls and fall prevention programmes has grown significantly. Many studies have focused on assessing the epidemiology of falls, its

causes, proposing fall prevention initiatives and assessing their outcomes (Rubenstein, 2006). Given that fall risk assessment is considered an integral part of a fall prevention programme (Nunan et al., 2018), several checklists have been developed.

The Morse Fall Scale (Morse, 1997) is one of the existing validated fall risk assessment tools developed to assess inpatients' likelihood of falling and its effectiveness is significantly recognised by research evidence (Oliver et al., 2004). The Morse Fall Scale is based on six characteristics of the patient considered as significantly increasing a patient's likelihood of falling. These factors are: history of falling, secondary diagnosis, ambulatory aid, intravenous therapy/heparin lock, gait, and mental status (Morse, 1997). The Morse Fall Scale enables the quantification of the patient's risk of falling for the purpose of preventing falls by attributing a score to the answers given to the six items. The total score resultant from the application of the Scale allows categorizing patients into low, medium, or high risk of falling. Despite significant research on fall prevention and the existence of good evidence on best-practice approaches for preventing falls, the translation of this research evidence into practice not always takes place (Oliver et al., 2010).

In the case study hospital, the recognition that falls were the most frequent patient safety incident reported in the hospital motivated the creation of a Falls Prevention Group aimed at reducing the severity of falls and repeat falls. The Falls Prevention Group was created in 2006 as a bottom-up initiative, involving six staff members: three members of the quality management department (a doctor, an engineer, and a lab technician); and three nurses belonging to three of the departments with the highest number of reported patient falls (internal medicine, cardiology and neurology). Since its creation, the group has been engaged in a series of projects. Early work included the analysis of fall statistics and fall incident reports and visits to locations where severe falls had

been reported to speak with ward staff and investigate the incident circumstances. Whenever there was a need to conduct refurbishments to avoid falls, the group liaised with other hospital departments in order to conduct these. The Falls Prevention Group also created a new online form solely for fall reporting to obtain more detailed statistics (e.g. causes, location, time of the fall, patient conditions, care plans) to allow the identification of patterns, and embarked on a campaign inside the hospital to sensitize hospital staff to the importance of reporting all falls, including minor falls. Additionally, the group put in place a set of measures to manage the physical environment of care (e.g. providing paper towels in place of cloth towels to reduce a common source of tripping, seeking to ensure patients were supplied with a bed adjusted to appropriate height) and developed a checklist identifying these hazards to be frequently used in internal patient safety audits. Although these early initiatives led to reduction in fall injury, they also led to the realization amongst the group that achieving more dramatic improvements in safety required the early identification of fall-prone patients. In order to achieve this, the Falls Prevention Group decided to implement the Morse Fall Scale. The findings describe the implementation of the Morse Fall Scale in the case study hospital and consequently the process of translating the fall prevention research evidence summarised in the scale into the hospital's practice.

2.2. Data collection

The first author conducted 46 in-depth face-to-face interviews with 49 interviewees including nurses (25), doctors (8), nurse aides (4), engineers (3), administrative staff (2), health and safety technicians (2), managers (2), social workers (2), and a laboratory technician (1), working across a series of clinical and non-clinical hospital departments. One interviewee was interviewed twice because of their key role on fall prevention projects. Four interviews were conducted with two

interviewees at the same time given practical reasons such as office sharing. Interviews ranged in length between 12 to 120 minutes with an average duration of 43 minutes. Differences in the duration of interviews reflect differences in staff's involvement and knowledge of fall prevention projects. Interviews with staff with limited knowledge of the Falls Prevention Group's projects (e.g. nurse aides) or with limited role in fall prevention (e.g. administrative staff) were significantly shorter.

Interviews were conducted in Portuguese and took place in the hospital at a time proposed by interviewees. Interviewees were selected using a snowball sampling approach, with the interviewer asking respondents to recommend colleagues working in different departments in order to collect data from different perspectives. Interviews followed an interview schedule, employed flexibly in order to allow respondents to present their knowledge in line with their specific occupational context and experience.

All interviews, but two, were audio-recorded and transcribed by the interviewer to ensure trustworthiness (Tilley, 2003). Detailed notes were taken during the two interviews where interviewees felt more comfortable to not be recorded. Before each interview, the interviewer explained the study, provided interviewees with an information sheet and asked them for written informed consent. Given that the case study hospital authorised using its name, quotations were anonymised and reported in a way that ensures anonymity of respondents.

2.3. Data analysis

Interviews were initially analysed following the inductive thematic analysis approach proposed by Braun and Clarke (2006). Transcripts were read and re-read to allow familiarity with the data and the identification of initial codes. Analysis was conducted at semantic or explicit level and thus the analysis focused on what interviewees have said, rather than seeking to identify the

underlying assumptions of interviewees' accounts (Braun and Clarke, 2006). In line with this, manual coding using handwritten notes and marker pens, was employed to avoid decontextualization of data. Data were analysed in its original language, Portuguese in order to enhance the reliability and validity of research (Twinn, 1997). The quotations used in this article were translated into English and later back translated by the first author in order to ensure trustworthiness of data (Tilley, 2003). Initial codes, often based on respondents' own words, were copied into a separate Microsoft word file and grouped into sub-themes and themes. Data analysis was mostly conducted by the first author. The second author helped refining the sub-themes and themes by providing comments and asking questions. The discussions between the two authors about the data and the literatures on boundary objects and knowledge translation led to the consideration of the links between boundary objects, tied into wider relations and boundaries of clinical practice; subsequent analysis involved iteratively reviewing data and prior theoretical insights. By combining inductive and deductive analysis and jointly drawing on theory and empirical findings, the process of data analysis adopted in this paper is in line with Peirce's principles of abductive analysis as outlined by Timmermans and Tavory (2012).

3. Findings

The analysis of the interviews identified that although the Morse Fall Scale contributed to the translation of fall research into practice; for this translation to be more widespread, the Falls Prevention Group felt the need to identify patients with a high risk of falling by equipping them with a pink wristband. Whereas in some circumstances the linkage between the two objects was naturally achieved; in other occasions it required additional intervention. Building on STS concepts, the next sections discuss the role of the two material objects in the process of translating fall prevention research into the case study's clinical practice.

3.1. The adoption of the Morse Fall Scale

In 2006/2007, risk management in Portugal was still in its infancy and there was little experience in using advanced procedures to prevent patient falls in other Portuguese hospitals. As a result, the Falls Prevention Group decided to research international practice:

> "We went to the internet, we went to see what other hospitals were doing, mainly abroad as in Portugal there was not a great experience and we found that most hospitals had implemented the Morse Scale of fall risk assessment in patients who are hospitalised, ah, we involved the nursing staff, namely the nursing directorate, we talked with them and we thought that it would be useful to implement it within the hospital." (member of the Falls Prevention Group)

Having obtained the support of the nursing directorate, as it would be nurses who would apply the Morse Fall Scale to hospitalised patients, the Falls Prevention Group proceeded with a series of actions towards its implementation. These included: a) the translation of the scale from its original version in English into Portuguese, b) the design of fall prevention measures to be put in place according to the patient's level of risk (e.g. use of bed rails; assist the patient during the change between the bed and the chair or wheelchair, going and coming from the toilet, while taking a shower), c) working with the hospital's IT department and the software provider to update the nursing software to include the Morse Fall Scale into care pathways and the fall prevention measures into the predefined nursing standard operating procedures, and d) train nurses on how to use the Morse Fall Scale.

Two key challenges initially presented themselves to the Falls Prevention Group, namely the translation of the scale into Portuguese and the calibration of the scale to the local context so that the categories of the scale and the fall prevention procedures designed by the hospital were

aligned with patients' risk of falling and with the International Classification for Nursing Practice (ICNP). As a nurse explained:

> "I know that they tried to adapt the Morse scale to our reality but […] the translation they found at the time for the scale generated some discord, and at the moment I think that the existing protocol [falls prevention procedures] is still a little bit maladjusted. We already spoke with the colleague about it [and they are sorting it out]. When they [Falls Prevention Group] tried to adapt their work and their language of work to the [nursing] software they searched for the best words, but often the ICNP, which is the classification used by the software […] has concepts and words whose meaning is not always equal to the usual meaning of the concepts in the Portuguese language and that is why […] they initially faced difficulties."

Within ANT, translation invokes the way practice and meaning are transformed in relation to networks of relations; in the case study this involved a literal translation of the language of the object to situate it in local practice. In the quote above, we see how the practicalities of language translation also involved the formation of a new practice community, centered on the object.

The informal culture of the hospital facilitated the involvement of all staff, which was crucial in the adoption of measures to overcome the difficulties and hence ensure *coherence* of the scale with nursing work – a key mechanism for the implementation of practices according to the Normalization Process Theory (May and Finch, 2009). As a member of the Falls Prevention Group mentioned:

> "It is important to involve, to be on the ground […] the beginning was fundamental because making this entire hospital move is not easy and everyone

adhered and that is very good, that is commendable and that is why it is important to keep on reformulating, adapting."

The Morse Fall Scale was first introduced in the hospital in 2007 and is applied by nurses to all patients at the time they are admitted at the hospital wards. Patients with a risk score of 0-24 are considered low risk of fall, 25-50 as medium risk of fall, and above 50 as high risk of fall.

3.2. The creation of the pink wristband and its impact on clinical practice

The use of the Morse Fall Scale would allow the translation of research evidence on fall risk assessment into nurses' everyday practice by prompting nurses' early identification of fall-prone patients and implementation of appropriate fall prevention measures. However, given that the Morse Fall Scale is filled in by nurses; is kept on the patient's online record, not accessible to all staff; and the understanding of its six items requires familiarity with specific clinical knowledge only understood by some clinical staff; the scale would fail to *cohere* with other clinicians' work, therefore limiting its scope of implementation. As a result, the Falls Prevention Group felt that, in order for it to be more widely adopted in practice, patients' risk score had to be easily and widely communicated inside the hospital. After considering alternatives, it was decided that patients with a high risk of falling (i.e. score above 50) would be marked out with a pink wristband.

The creation of the pink wristband could be seen to transform the risk score indicated in the Morse Fall Scale in two ways. Firstly, rather than a scale, this made the risk of falling binary, with patients now either categorized as 'high' or 'low' risk. Secondly, the high-risk score category was now physically attached to the patient, potentially visible to all staff who came into contact with the patient and hence enabling staff to quickly identify a fall-prone patient. This was intended to not only contribute to nurses' pragmatic use of the research underlying the Morse

Fall Scale in their day-to-day practice, but to enable all the other professional and occupational groups inside the hospital (including those whose activity takes place outside wards and/or who do not have access to patient's records) to contribute to patient fall prevention without the need to check the online patient's record or even be aware of (or be able to understand) the Morse Fall Scale. In the case study, in addition to nurses, staff that have an active role in preventing patient falls include nurse aides, doctors, other health related staff, porters, hospital volunteers, cleaners and ward-related administrative staff. Other hospital staff can also contribute to patient fall prevention, however as their contact with patients is more limited, their role is normally not as significant.

In addition of enabling the *coherence* of the Morse Fall Scale with the other clinicians' work, as discussed below, the pink wristband also supported the operationalisation of the implementation of the Morse Fall Scale by facilitating the enrolment and engagement of staff, the integration of the Morse Fall Scale with existing practices, and encouraging change in falls prevention practice.

Material disruption. The presence of the pink wristband was seen to act as a trigger for inter-professional learning around fall prevention measures related with the Morse Fall Scale, therefore supporting the enrolment and engagement of staff in the scale. Given the crucial role of nurses in filling in the Morse Fall Scale and ensuring that the appropriate procedures to prevent falls were implemented, the Falls Prevention Group only targeted nurses for their training on the Morse Fall Scale and related fall prevention measures. As a result, the group did not engage other professional groups. As a nurse described:

> "A member of the Falls Prevention Group came here and explained to me and to a [nurse] colleague […] they brought a printed copy of the scale and the

rules: when we would put the wristband, the measures that we had to put in place and then we passed the information [to the other nurses]."

Whereas some nurses took the initiative of informing other professionals about the meaning of the pink wristband, its linkage to the Morse Fall Scale and the intended implications for care; in other cases, it was the physical presence of the pink wristband, visible during bedside interactions and activities, that prompted discussion of its meaning. As a doctor noted:

"[Interviewer: and do you remember how you got to know about it [pink wristband]? […]]

Looking at patients

[Interviewer: really?]

Yes, when they began to arrive it was 'what is this?' […] it was the nurses of the service who explained the meaning of the pink wristband" (Doctor)

Similarly, a nurse aide mentioned:

"... because I was [commenting] like: 'Ah, a pink wristband! Now wristbands are pink?!' because I didn't know […] Nurses let us know soon, […] look it is like this, there are wristbands and such…"

From these quotes it can be seen that the colour of the wristband, its attachment to patients, and its novelty/distinctiveness were important in drawing attention. As a nurse commented:

"it is a wristband that draws a lot of attention […] but then we also need to see if we don't reach a point where people no longer pay attention. It is like, there was a time that we would do a poster for everything. Then a poster is made

> with information and such, but we reach a point where the corridor is full of posters, no one reads [them]" (Nurse)

As this suggests, rather than an essential property of the wristband itself, it was the novelty of the object that was the basis for inter-group discussion. Further, as this quote suggests, respondents did not receive the wristband in a neutral way; rather it was seen in the context of the increasingly crowded information space of the hospital environment.

Distributing practice. In facilitating learning about the Morse Fall Scale, the pink wristband was also seen to raise common awareness of fall risk across professional and occupational divides and in so doing shape clinicians' work. An example was the way the pink wristband influenced nurse aides' work. Although nurse aides were not in charge of evaluating a patient's health or the design of treatment, they were often involved in close personal care and support activities. Respondents described how the presence of a pink wristband shaped nurse aides' assessment of risk:

> "Of course it helps, even though nurse aides don't know about the Morse Scale [when] they look at the wristband, [they] look to the patient with more attention, it helps to recognize [a fall-prone patient]" (Nurse)

This was particularly important given the shift pattern of clinical work, recognized as an ongoing challenge for close communication among ward nurses and nurse aides. The instant visual indicator of the wristband helped nurse aides make quick judgment as to the level of assistance required without the need for verbal handover or understanding of the Morse Fall Scale:

> "When we come close to the patient and if we don't know him or if we were a day off or… he didn't arrive in our shift, by looking [at the pink wristband] we

automatically know that that patient is a risky patient in that matter of falls" (Nurse aide)

Other members of the multi-disciplinarily team, including doctors, also recognized that the presence of the wristband encouraged staff to consider fall risk:

> "I think that signalling patients who had a fall is very important because after that [fall] others may follow, isn't it?!" (Doctor)

> "The patient with a high risk of falling is identified with a pink wristband that is a warning to all the team know that with that patient is necessary to take extra care. For example, accompany them in ambulation." (Nurse)

Inscribing embodied change. By allowing an easy identification of patients categorized by the Morse Fall Scale as fall-prone, the pink wristband was seen by clinicians as encouraging change in practice:

> "I know that when they have this pink wristband we have to give them a bath, that they tend to fall, they are more debilitated, we have to feed them, we have to assist them more. That is what I have learned." (Nurse aide)

Clinicians also considered the attachment of the wristband to patients to allow more intuitive changes to practice with little additional bureaucratic requirements for the multi-disciplinary team, hence facing minor resistance from clinicians:

> "[the pink wristband] is more about alerting professionals and I am also honest, I think that it is more in this sense that professionals adhere because at this moment if I give indication to do anything else, people no longer have the

> capacity to receive such guidance [due to the existing workload].” (Chief nurse)

At the same time, it was recognized by some nurses that the wristband remained a source of accountability:

> “Currently those in the ward know that there is a scale and the scale gives us a score and according to that score there are interventions [to be put in place] and in fact people have to operationalize these on the ground. If they don’t operationalize then something is not right and then that person has to be called to account. Imagine that there I see a patient with a pink wristband, ah… the nurse who is responsible for that patient did not take the measures appropriate to the situation, I have to tell them ‘Oh, what's going on?!’ Was it because of forgetfulness? What was the situation that allowed it?! Because if the patient falls in this situation one has to be accountable.” (Nurse)

While the pink wristband appeared to act as an effective reference object for implementing research evidence included in the Morse Fall Scale within everyday practice, underlying the linkage between the two objects was the assumption that hospital staff were familiar with the meaning of the pink wristband, without which the *coherence* of a practice is not established (May and Finch, 2009). As discussed in the next section, this was not always the case.

3.3. The precarious object-object link

Although, as discussed above, the fact that some patients were wearing the pink wristband triggered ward doctors’ and nurse aides’ curiosity about its meaning; the wristband was less effective in facilitating inter-professional learning with groups whose work was peripheral to ward-based clinical practice. For example, around two years after the implementation of the

Morse Fall Scale, the Falls Prevention Group realized that some porters had not attached any meaning to the pink wristband and hence were not able to enact it:

> "… Once I asked a porter if he knew what a pink wristband meant. He told me no. That information should be universal within the hospital, at general level, including porters who should know why the patient has this … as should other services and technicians. I don't know if technicians know what [the pink wristband] means." (Nurse)

The awareness of the fact that not all healthcare professionals knew about the pink wristband, led the Falls Prevention Group to develop strategies to widen the communication of the meaning of the pink wristband to all staff. As a nurse commented:

> "It is fundamental to involve the whole team [in the prevention of patient falls]. I think it does not make much sense to only target doctors, only target nurses; if, for example a nurse aide doesn't know what a pink wristband is […]. If I have an inpatient in service A, during their hospital stay they are not always physically at that service, they go to the x-ray, etc. It is fundamental that who does this transport knows that that patient is fragile; it is fundamental that those who wait in the service, for example at the x-ray unit, know that that patient with that wristband is a fragile patient, it is fundamental that the technician who will make the x-ray and who is in the room to lift the patient, to position [the patient] know that that patient is a fragile patient. This is the puzzle that is being done now."

In addition to the need of all staff to know the meaning of the pink wristband, from the outset it is crucial that nurses are fully involved in the process of assessing patient's risk of falling and in

case a patient has a high risk of falling that they equip the patient with the pink wristband. As a nurse pointed out:

> "Nurses are essential, they are the key point for [fall prevention] to go well and for the implementation of the directives that come from the risk department [and the Falls Prevention Group]".

If in the case study hospital existed nurses that were not correctly applying the Morse Fall Scale, including equipping the patient with the pink wristband in the case of a high-risk score, then the entire initiative would fail and it could actually lead to worse care outcomes. The existence of the procedure of equipping high-risk of fall patients with a pink wristband in itself leads staff in the hospital to assume that a fall-prone patient will always have a pink wristband. In other words, the effective translation of fall prevention research into the case study's practice requires that both of the two linked objects become routinely embedded into practice.

4. Discussion

This paper set out to examine the role of two linked boundary objects (the Morse Fall Scale and the pink wristband) in the translation of fall risk assessment research evidence into practice. Findings highlight that the two boundary objects played complimentary but non-redundant roles in this process. As presented on Figure 1, the Morse Fall Scale allowed the translation of fall risk assessment research into the case study's ward nurses' practice and the pink wristband allowed other staff to identify patients considered by the Morse Fall Scale as fall-prone, without the need to access patient's records or understand the scale.

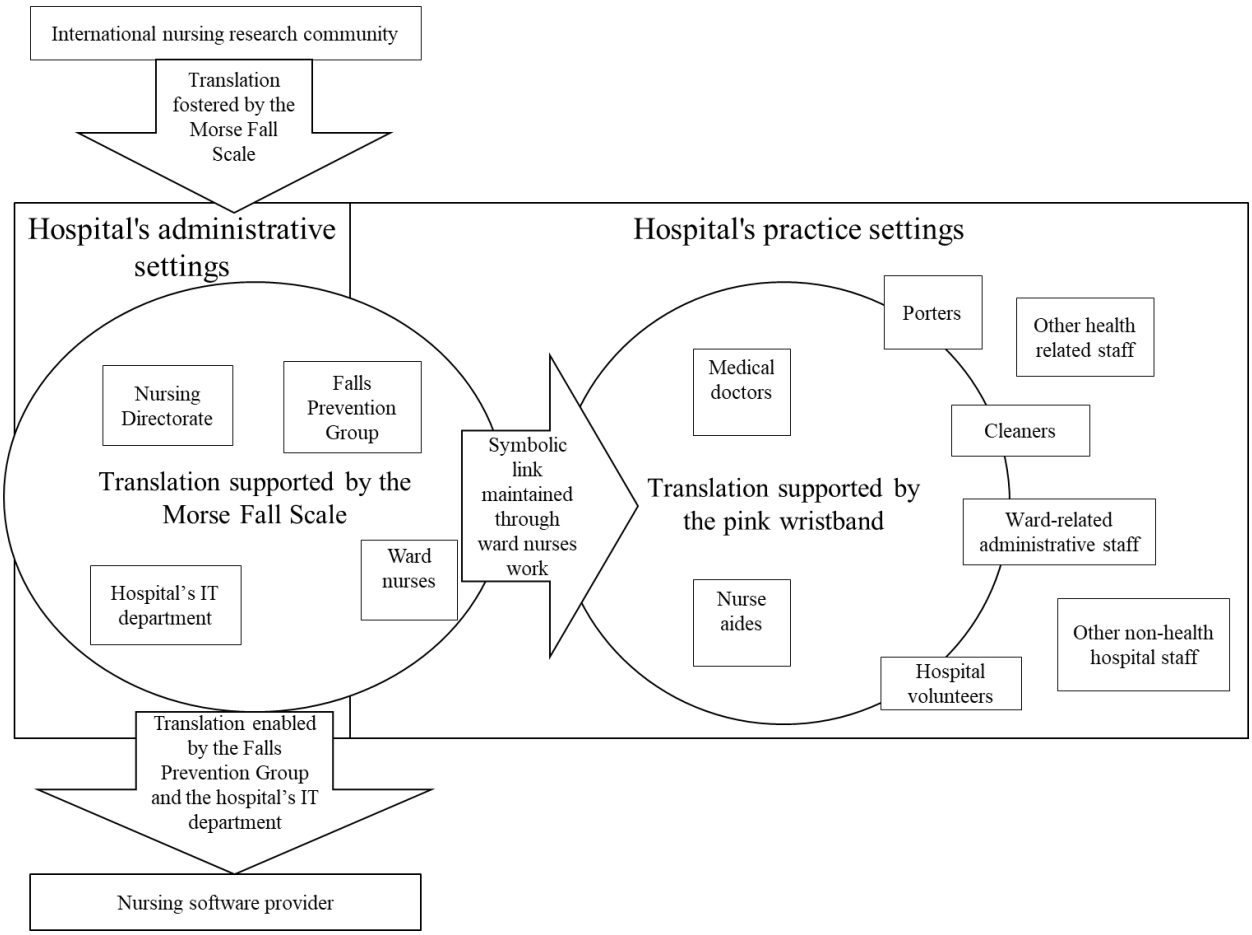

Figure 1 – Entities involved in the translation of fall risk assessment research into practice

Relating these findings to previous research, we suggest our study raises a number of relevant insights for the contribution of objects to knowledge translation. Our study focuses on the process of translating fall risk assessment research from the literature all the way through its routinely embedding into clinicians' and non-clinicians' practice, thus adding to existing literature, which has mostly focused on some parts of the translation process. For example, Swan et al.'s (2007) study focused only on the theoretical 'buy-in' from practice communities to participate in research, but stopped short of investigating evidence being translated into everyday work.

Additionally, our study allows understanding how boundary objects can be linked to jointly perform the three roles of boundary objects identified in the literature: knowledge exchange, establishing shared meanings, and facilitating collective learning (Hsiao et al., 2012) and in so doing enable overcoming the three types of knowledge boundaries identified by Carlile (2002; 2004) – syntactic, semantic, and pragmatic. This constitutes one of the key contributions of our study in that as previous research had focused on investigating the independent use of different boundary objects, it focused on the roles played by individual objects in crossing knowledge boundaries (e.g. Kimble et al., 2010; Swan et al., 2007), rather than on the opportunities created by linking different objects.

Associated with this, another key contribution of our study is the understanding of how boundary objects can allow knowledge translation across intersecting and non-intersecting communities. This contrasts with previous studies in that by focusing on individual objects would only investigate knowledge translation between the intersecting communities that each of the objects could bridge, rather than exploring knowledge translation across all intersecting and non-intersecting communities involved.

In line with Berg's (1997) work on the sociology of the formal, in our study, the gap between research evidence and practice was not crossed in one step but required "a series of intermediate, representational activities performed by *materially heterogeneous entities*" (Berg, 1997:144). Additionally, consistent with Berg (1997), the link between the reference (pink wristband) and the referent object (Morse Fall Scale) in the translation of research evidence into practice relied on the relationship between the formal characteristics of the objects and the work of the ward nurses. Whereas the Morse Fall Scale enabled the formal representation of a patient's risk of falling, the score obtained through the application of the scale to a specific patient is the result of

nurse's work in filling in the scale. The pink wristband was used to signal patients with a high risk score of falling as identified by the Morse Fall Scale, yet ward nurses had to communicate the meaning of the pink wristband to other hospital staff and in this way, maintain the symbolic link between the two objects. This is in line with the normalization process theory, which highlights the need for continuous investment by agents to sustain the integration of a practice in its social contexts (May and Finch, 2009) and the notion of boundary objects as "a set of work arrangements that are at once material and processual" (Star, 2010:604).

As a result, in line with science and technology studies, the symbolic connection between the two linked boundary objects remained precarious because until the identity of the pink wristband and the role of staff in falls prevention initiatives become stabilized, i.e. all actors are successfully enrolled in the process (see e.g. Callon, 1986); the link between the two objects is dependent on a relatively small, locally situated, group of nursing staff. Indeed, whereas inside wards the pink wristband was able to trigger communication between other clinicians and nurses, outside wards the same did not happen as the pink wristband did not cohere with non-ward staff's work. This resulted in a lack of embeddedness of fall risk assessment research evidence outside wards which is consistent with the view that translation is a process (Callon, 1986). The meaning of the objects was thus not only cultural; the material form of the object 'mattered'. Most of the literature on boundary objects suggests that boundary objects are formed in relations of practice, and their importance is mainly symbolic, which implies their meaning is elastic. Similarly, while ANT allows for agency of objects, the importance of material forms is played down against objects meaning within networks of human-object relations (Olsen, 2013). However, in line with recent work (e.g. Olsen, 2013), findings evidence that the material form itself is crucially important to the role of objects in crossing boundaries. It was the attachment to

the body of the patient in a visible position that allowed the pink wristband to disrupt old and inscribe new practices.

This perspective of organisational change as a fluid process contrasts with the prevailing mechanistic view of knowledge translation, rooted in linear models of change (Styhre, 2002). In line with views of an healthcare organization as a "complex, interactive, organic entity" (Kitson, 2009:218), our results demonstrate how knowledge translation does not necessarily follow a series of predefined stages as depicted in the 'translational science continuum' (Mitchell et al., 2010), the 'knowledge to action process' (Graham et al., 2006) or in other knowledge transfer models (see e.g. Mitchell et al., 2010, for a thematic analysis of theoretical models for translational science in nursing). As a result, these models provide a limited view in their understanding of change. We suggest evidence is best seen as translated into contexts of practice, composed of both social and material elements.

Our findings also highlight how professional/occupational group membership performs a critical role on intra-organisational knowledge transfer. In the case study hospital, occupational group's membership directly influenced the perceptions of knowledge ownership hence impacting on how the extant knowledge was translated between staff. Initial dissemination activities targeting nursing hierarchies were seen to strengthen knowledge boundaries, reinforcing an understanding of knowledge of fall prevention as under the nursing domain. The importance of recognizing interdependencies and intergroup boundaries in translating evidence has been previously noted by Dopson (2007). The unconscious exclusion of other professional groups goes in line with previous research that points out that information circulates more within groups than between groups (Burt, 2000) and that a functional organisational structure acts as a barrier for knowledge sharing across different groups (Tagliaventi and Mattarelli, 2006).

Finally, the use of the pink wristband to signal high risk of falling patients had an impact on staff communication. The adoption of the pink wristband prompted nurse aides and doctors to question nurses about its meaning, yet two years after its implementation porters were still not aware of it. In this case, instead of being a bridge between professional groups, the pink wristband behaved as a wall, as unconsciously the pink wristband was perceived as a substitute of the verbal communication between staff in relation to patient's risk of falling, hence reducing porters' awareness of fall-prone patients. This goes in line with Oswick and Robertson's (2009) argument that boundary objects can in fact be barricades or mazes instead of bridges and anchors. As Wenger (2000:236) points out, "boundary objects do not necessarily bridge across boundaries because they may be misinterpreted or interpreted blindly." This is in line with the theory on material infrastructure which argues that collaboration is sustained by a basic sociomaterial infrastructure, formed by a number of objects and artifacts, including communication system; without which collaboration is impossible (Nicolini et al., 2012). In the case study, the physical proximity and close interaction among ward clinicians fostered the inclusion of the pink wristband in the basic sociomaterial infrastructure of wards. The same did not happen to the basic sociomaterial infrastructure between ward clinicians and staff working outside wards (e.g. porters) due to the distance between them in terms of physicality and work practices.

According to Star (2010), boundary objects imply a shared space and shared structure. Our findings add to this by pointing out that although linked boundary objects can be used in the context of the co-existence of several basic sociomaterial infrastructures; there will be the need of additional intervention to align the structures of those communities that do not share the same space. In the case study, this alignment started to be done by the Falls Prevention Group when explaining the pink wristband to non-ward staff. This is line with Blumer (1986) who argues that

although people or groups can occupy the same spatial location, their environment is only formed by objects that they recognize and know and with Tagliaventi and Mattarelli's (2006) study that found that the physical proximity and sharing of common values contributes to the sharing of practices among professional groups.

Although this study contributes to the understanding of how healthcare research evidence can become translated into practice through linked boundary objects, it has limitations associated with the qualitative methodology adopted. Findings were based on a single hospital with a high learning culture and relate to the implementation of a scale which is internationally recognized as useful in addressing falls – one of the case study's most critical patient safety incidents. As a result, in other organisational settings the dynamics involved in the translation into practice of research considered by clinicians as less important and/or not so widely adopted might be significantly different and therefore these could be subject of further research.

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