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Departamento de Economía Financiera, Contabilidad y Dirección de Operaciones

Efecto de tecnologías sanitarias en la gestión hospitalaria y su aceptación por parte del personal sanitario

Memoria para optar al grado de doctora
presentada por:

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Memoria que presenta María Mercedes Romero Alonso para aspirar al Grado de Doctora

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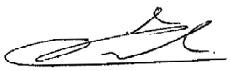

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INTRODUCCIÓN

El sistema de salud no es tan seguro como debería y podría ser. La identificación de los posibles riesgos relacionados con la atención hospitalaria es crucial para el sistema de salud, debido a sus graves repercusiones en la salud de los pacientes. Otros factores como los aspectos económicos y jurídicos, así como la confianza en el sistema, también se han visto afectados por estos riesgos.

El interés por los riesgos relacionados con los errores de la salud no es algo nuevo. Numerosos estudios se han llevado a cabo para cuantificar estos errores. Schimmel (2003) señaló que aproximadamente el 20% de los pacientes admitidos en un hospital universitario sufrió algún tipo de iatrogénesis, una quinta parte de los cuales había dado lugar a complicaciones graves. Steel et al (1981) elevaron esta cifra a un 36%, una cuarta parte de los cuales eran graves. En ambos estudios, el principal riesgo se debió a los errores de medicación. Los errores de medicación son la principal causa de errores producidos en la asistencia sanitaria que afectan a los pacientes (Bates 2007; Leape et al 1991). A lo largo del tiempo se han llevado a cabo diversos estudios en diferentes países, con los resultados de la cuantificación de los errores de medicación en un intervalo aproximado de entre el 4% y el 20% (Baker et al 2004; Brennan et al 1991; Davis et al 2001; Forster et al. 2004; Leape et al 1991; Schioler et al 2001; Thomas et al 2000; Vicente et al 2001; Wilson et al 1995).

Error de medicación puede definirse como cualquier evento prevenible que puede causar o conducir a un uso inapropiado de la medicación o daño al paciente, mientras que el medicamento está en el control del profesional de la salud, el paciente o el consumidor (NCCMERP, 2011). Estos eventos pueden estar relacionados con la práctica profesional, productos para la salud, los procedimientos y los sistemas, que incluyen: la prescripción, el etiquetado del producto, el empaquetamiento, la nomenclatura, la composición, la dosificación, la distribución, la

administración, la educación, la vigilancia y el uso. Así, los errores de medicación pueden tener su origen en una o más de las cuatro etapas secuenciales en la cadena de uso del medicamento: prescripción de la orden médica, transcripción, dispensación o administración (Leape et al. 1995).

Un error de medicación es a menudo, el resultado final de una cadena de eventos desencadenado por el diseño de un sistema defectuoso que, o bien induce a errores o los hace difíciles de detectar (Perrow 1984).

La cadena de uso del medicamento tiene cuatro fases secuenciales que se describen de la siguiente manera:

1. Orden médica. Los médicos seleccionan y prescriben el fármaco correcto y la dosis correcta para el paciente. Los posibles errores en esta etapa se llaman errores de prescripción.

2. Transcripción. Las enfermeras transcriben las diferentes prescripciones médicas en un formulario, solicitando la cantidad de medicamento necesaria para cada unidad del hospital. Errores inexplicables asociados con la transcripción de la orden puede tener lugar durante esta fase.

3. Dispensación. La farmacia dispensa a continuación, los medicamentos solicitados a cada unidad o sección del hospital. Los errores de esta fase se denominan errores de dispensación.

4. Administración. Las enfermeras administran el medicamento prescrito para el paciente en la dosis requerida. Los errores de administración se llevan a cabo durante esta fase.

Como queda reflejado, varias personas intervienen en cada etapa de la cadena de uso del medicamento, por lo que se incrementan los potenciales errores. Los principales errores de medicación se producen

en la etapa de prescripción (56%) y de administración (34%) (Bates et al. 1995; Leape et al. 1995).

Los medicamentos representan la intervención más frecuente en la atención de la salud, pero a pesar de sus beneficios, también conducen a un número estimado de 1.5 millones de eventos adversos y decenas de miles de hospitalizaciones cada año. Aunque algunos no se pueden prevenir teniendo en cuenta lo que se conoce hoy en día, hay muchos tipos, y una de las principales causas son las interacciones fármaco-fármaco (Classen et al. 2011).

Con el fin de mejorar la seguridad del paciente, las causas más frecuentes de error de medicación deben ser identificadas. Por tanto, pueden ser diseñados mecanismos para evitarlos utilizando un enfoque basado en sistemas. Las principales causas de error que se pueden producir en cada etapa de la cadena de uso del medicamento son (Nadzam 1998):

- Errores de prescripción: Falta de información de los efectos adversos del fármaco, falta de información de las patologías y de la historia clínica del paciente y distracciones.

- Errores de transcripción: Letra ilegible, prescripciones ambiguas o incorrectas, fármacos con nombre similar, interrupciones constantes y distracciones.

- Errores de dispensación: Fármacos con nombre similar, fármacos con similar empaquetado o etiquetado y distracciones.

- Errores de administración: Confusiones a la hora de identificar a los pacientes, problemas con los equipos de administración y distracciones.

Los errores de medicación y su conexión con la tecnología de la información

Las mejoras en el sistema de salud deberían estar basadas en la premisa de que "errar es de humanos" (Kohn et al. 2000). Independientemente de la habilidad de un individuo o de su grado de concentración, la naturaleza humana conlleva el cometer errores. Por lo tanto, los sistemas diseñados para prevenir los errores deberían incluir procedimientos creados para detectar y evitar tales errores a través de un enfoque basado en sistemas, en lugar de centrarse en el tradicional "enfoque basado en personas" (Reason 2000).

El enfoque de sistemas se basa en la idea de que los errores pueden prevenirse mediante el diseño de sistemas de trabajo, de tal manera que los errores sean difíciles de cometer. La esencia es centrarse en los procesos no en las personas (Leape 1999). Sin embargo, no siempre es fácil realizar cambios en los sistemas de trabajo. Estos cambios implican normalmente una reingeniería de procesos, dando lugar a cambios organizativos que afectan tanto a la forma de trabajar como al control de la información centralizada. Bajo estas circunstancias, el personal puede rechazar las alteraciones que se produzcan en el sistema de trabajo, ya que son normalmente reacios a cambiar sus rutinas de trabajo, pudiendo ser problemática la sensación de una supervisión o control más estrecho de su trabajo (Anderson 1997; Plotnick 2010). De este modo, los empleados pueden resistirse al cambio debido al miedo a lo desconocido o simplemente a la sensación de desplazamiento.

La tecnología de la información (TI) puede jugar un papel fundamental dentro del enfoque de sistemas. Investigaciones previas han demostrado los beneficios de la TI, además, numerosos estudios empíricos demuestran la relación positiva entre la investigación en tecnología y las mejoras operativas (Bender 1986; Dewan y Ren 2011; Harris y Katz 1991, Huang 2007).

Los continuous control monitoring systems (CCM) amplían el campo del control de procesos. Los sistemas CCM abarcan una amplia gama de tareas de control incluyendo la automatización de las pruebas de control, las valoraciones del riesgo, la evaluación y la documentación de los controles y la gestión y comunicación de la garantía de control de las actividades. El papel de los sistemas de CCM es asegurar que el control interno funciona con eficacia a través de la promoción de buenas operaciones de control (Committee of Sponsoring Organizations of the Treadway Commsission 2009).

Las herramientas de control continuo generalmente evalúan uno o más de los siguientes procesos, provocando una evaluación de los elementos fundamentales en el contexto de una situación específica (Ramamoorti y Dupree 2010):

- Datos de las transacciones: ponen de relieve las excepciones a través de la comparación de las transacciones procesadas (o de los datos maestros) frente a un conjunto de reglas de control predefinidas.

- Condiciones: comparando la línea de base o las expectativas previamente establecidas con aplicaciones reales o configuraciones de los parámetros.

- Cambios: identificación y notificación de los cambios en los recursos críticos, datos o información que permitan la verificación de autorización y/o propiedad.

- Garantizar la información (procesamiento) íntegramente: verificar y controlar con precisión, ver la consistencia y fiabilidad de la información a través del contenido, el proceso, el sistema y el medio (es decir, la integridad de la información).

- Gestión de errores: monitorizar la cantidad y resolver la actividad en las áreas de suspenso, registrar los errores o informes de excepción y gestionar el flujo de trabajo de las excepciones.

Los sistemas de CCM están implicados en diferentes partes del sistema de gestión de la información. Los procesos pueden ser controlados de forma automática a medida que se producen. El objetivo es evitar errores en la generación de la información digital, esquivando el efecto GIGO (Garbage in, Garbage out). Su capacidad de análisis permite el control de todas las operaciones o acciones que tienen lugar en el área de interés. Por tanto, no hay riesgos asociados con grupos de muestras o intervalos de confianza. También se pueden integrar los datos obtenidos de múltiples procesos, mientras se envían mensajes de alerta cuando se detecten anomalías.

Los siguientes pasos comprenden la monitorización continua de un proceso (Nigrini y Johnson 2008):

- Determinar el alcance de la monitorización y los métodos y técnicas a aplicar
- Determinar los controles, los indicadores y las reglas que se han de usar
- Diseñar y documentar el sistema
- Registrar los resultados y preparar los informes de gestión
- Actualizar el sistema para mejorar la capacidad predictora del mismo

Por todo esto, podemos decir que el uso de TI basadas en la filosofía CCM podría ser una alternativa para la prevención de parte de los riesgos inherentes a los procesos predominantemente manuales que actualmente se llevan a cabo en una gran cantidad de hospitales.

Cambios en los sistemas de trabajo a través de la tecnología de la información

Este trabajo se centra en las TI aplicadas en una determinada área de la sanidad, la que corresponde a los medicamentos. En este caso, entre las nuevas tecnologías de la información implementadas en el hospital se encuentran la prescripción electrónica asistida (PEA) y los sistemas automatizados de dispensación de medicamentos (SADME) que en conjunto llamaremos EPAMMS (electronic-prescriptions and automated medication management systems).

El objetivo principal de los EPAMMS es la mejora de la seguridad y la atención recibida a los pacientes. Por otra parte, se han realizado grandes avances en la mejora de la información disponible para ayudar en la gestión del hospital.

Los hospitales están cambiando de los sistemas manuales a los digitales basados en suposiciones sobre el valor de las TI y sistemas de CCM, por ejemplo, que van a mejorar la eficiencia de los servicios o resultados de los pacientes (Keen y Muris 1995). Entre otras innovaciones, la prescripción hecha a mano y los botiquines tradicionales están siendo sustituidos por sistemas electrónicos de prescripción asistida y dispensación automatizada de medicamentos (Sengstack y Gugerty 2004), utilizando procedimientos integrales.

Se ha visto que los errores de medicación pueden reducirse o prevenirse mediante la mejora de la formación, el uso de sistemas informatizados y la participación de los farmacéuticos en el control de las órdenes médicas (Davis 2011).

Los errores de medicación comunes son prevenibles en gran parte con educación y formación y todos los hospitales tienen la tarea de implementar programas de capacitación para prevenir más errores de medicación, mejorando así la seguridad del paciente (Wallymahmed 2011). Sin embargo, la formación con demasiada frecuencia se centra en

intentar prevenir al médico individual de hacer un error particular de nuevo. Es más adecuado centrarse en los factores subyacentes que contribuyen a que tal error se cometa (Crook et al. 2004). En este sentido, los gestores sanitarios tienen por objeto prevenir los errores de medicación a través del uso de las TI y los sistemas CCM (Kohn et al. 2000), mejorando así los protocolos e implicando a los farmacéuticos como parte de un equipo multidisciplinario especializado en fármacos.

La implementación de un sistema electrónico de prescripción asistida es una importante evolución en la forma de prescribir y distribuir los fármacos (Bates 2007). Bajo el nuevo sistema, los médicos no prescriben medicamentos a mano, en su lugar utilizan un programa informático. En vez de generar prescripciones en papel realizan prescripciones electrónicas, haciendo posible establecer nuevos sistemas de control automatizados. Los métodos tradicionales de farmacovigilancia no proporcionan información oportuna sobre la seguridad del fármaco y su eficacia. La vigilancia en tiempo real utilizando sistemas electrónicos de prescripción podría abordar este problema (Eguale et al. 2008).

El médico tiene la información necesaria para llevar a cabo la tarea de forma digital. Hay un acceso inmediato a: la historia farmacoterapéutica de cada paciente y a los datos sobre la dosis máxima, interacciones, duración del tratamiento para cada medicamento, detalles sobre las alergias de cada paciente y las situaciones personales de relevancia. Toda la información está disponible en línea, con sistemas de control automáticos que generan alertas en las siguientes situaciones potenciales: interacciones o incompatibilidades entre los medicamentos prescritos, las interacciones o incompatibilidades con los medicamentos que se toman con anterioridad, y las interacciones entre los medicamentos prescritos y la historia del paciente (alergias, etc).

Por otra parte, las enfermeras en los hospitales son las responsables de administrar los fármacos a los pacientes. Los sistemas automatizados de dispensación están sustituyendo a los botiquines tradicionales de las

unidades. Se trata de un grupo de armarios de control electrónico, gestionados por un software que se conecta a través de diferentes aplicaciones informáticas. Los nuevos botiquines contienen los medicamentos listos para su uso en compartimentos diferentes, con diversos grados de control de acceso. Estos sistemas automatizados de dispensación son colocados en unidades clínicas y están conectados a una consola central. Las enfermeras se identifican en los SADME a través de la huella dactilar o código de acceso personal. Este es otro control, teniendo en cuenta qué persona ha retirado y administrado cada medicación y a qué paciente. Una vez identificado, el empleado selecciona el paciente y la máquina dispensadora suministra la cantidad exacta de medicamentos prescritos por el médico en la prescripción electrónica que fue validada previamente por un farmacéutico.

El primer cambio es la información on line de los pacientes y los medicamentos disponibles para los médicos. La farmacia puede consultar las prescripciones detalladas de los pacientes. Esto hace que sea posible analizar fácilmente los costes de medicamentos, por servicio, paciente y los grupos relacionados con el diagnóstico (GRD), que antes era imposible. Los SADME facilitan un mayor grado de control del inventario de los fármacos. La utilización de los botiquines tradicionales en cada unidad aumentan los costes de los fármacos debido al alto inventario de las existencias necesarias, aumentando el riesgo de vencimiento y deterioro debido a su incorrecta conservación. En el nuevo sistema, la gestión de stock muestra una mejora notable, gracias al mantenimiento del stock exacto en cada dispensador, lo que reduce además las pérdidas de inventario.

El sistema también permite enviar mensajes entre los miembros que utilizan la aplicación y aumentar así el flujo de información. La integración conlleva la mejora del flujo de la información y la reducción de los costes administrativos (Gattiker y Goodhue 2000). Esta integración es importante porque la incapacidad de compartir información a través de los sistemas afecta gravemente a la eficiencia y

la rentabilidad de las organizaciones sanitarias (Grimson et al., 2000). Además, la participación del personal en la gestión podría ser uno de los factores críticos que mejorase el valor intangible del hospital.

OBJETIVOS Y ESTRUCTURA

En este trabajo planteamos como objetivo general analizar el efecto de las tecnologías sanitarias en la gestión hospitalaria y su aceptación por parte del personal sanitario.

Objetivos específicos:

- Examinar los beneficios potenciales que los hospitales pueden obtener de la implementación de TI y sistemas CCM diseñados para apoyar y facilitar el control interno de los procesos, es decir, adoptar las TI como mecanismo de cambio.

- Analizar la aceptación de la prescripción electrónica y los sistemas automatizados de dispensación de medicamentos por parte del personal sanitario (personal médico y enfermería) identificando los factores influyentes. Entendemos que la identificación de estos factores daría la oportunidad de explorar qué acciones se podrían llevar a cabo para la adopción por parte de futuros usuarios.

- Analizar como los adoptantes tempranos se diferencian de los tardíos para el mismo conjunto de variables con el fin de entender mejor el momento de adoptar la decisión. Trataremos de encontrar nuevos factores que permitan hacer una discriminación efectiva entre los adoptantes tempranos y los tardíos.

- Ampliar el número de factores observados que puedan influir en la actitud hacia el uso de una nueva tecnología en un hospital por parte del personal de enfermería. Intentaremos entender las relaciones entre las variables externas propuestas y la actitud de los usuarios.

Para conseguir los objetivos anteriormente mencionados, estructuramos el trabajo en cuatro capítulos.

El capítulo 1, "Implementación de la tecnología de la información y los sistemas de control continuo en los hospitales para prevenir los errores de medicación", describe cómo los hospitales se están alejando de los tradicionales sistemas basados en papel y se centran en el diseño de nuevos métodos que reduzcan los errores utilizando TI y los sistemas de CCM para catalizar el proceso de reingeniería. Para llevar a cabo este objetivo se realiza un estudio de caso.

El capítulo 2, "Aceptación de la prescripción electrónica y los sistemas automatizados de dispensación de medicamentos en hospitales: una extensión del modelo de aceptación de tecnología", identifica cuáles son los factores que hacen al personal sanitario aceptar o no una nueva tecnología. Para llevar a cabo el objetivo se utiliza el Modelo de Aceptación de Tecnología (TAM) que analiza la aceptación de los usuarios de una determinada TI.

El capítulo 3, "Aceptación de las innovaciones en tecnología de la información en hospitales: diferencias entre adoptantes tempranos y tardíos", analiza cuáles son los factores que permiten discriminar de forma efectiva a los adoptantes tempranos de los tardíos, a través del modelo de aceptación de la tecnología y de la teoría de difusión de la innovación.

El capítulo 4, "Actitud del personal de enfermería hacia el uso de los sistemas automatizados de dispensación de medicamentos: una extensión del modelo de aceptación de la tecnología", profundiza en los factores que influyen en la aceptación de esta tecnología en el personal de enfermería. Para llevar a cabo este objetivo utilizamos TAM.

RESUMEN CAPÍTULO 1

En este capítulo describiremos el cambio en los sistemas de trabajo en un hospital a consecuencia de la implementación de una nueva tecnología de la información, a saber: la PEA y los SADME, utilizando los sistemas de CCM.

Objetivo

Examinar los posibles beneficios que los hospitales pueden obtener de la implementación de TI y el CCM de los sistemas diseñados para apoyar y facilitar los procesos de control interno, es decir, la adopción de las TI como mecanismo de cambio.

Metodología

Para llevar a cabo el estudio hemos realizado un estudio de caso. La metodología del estudio de caso se recomienda como un medio de aumentar el contacto entre la investigación y la realidad empresarial (Huq y Martin 2006; Stefanou y Revanoglou 2006) y es muy apropiado en las primeras etapas de la investigación de un fenómeno (Eisenhardt 1989). Además, el estudio de caso ha sido recomendado como la metodología de investigación ideal para lograr una mejor comprensión de fenómenos complejos (Flynn et al 1990; McCutcheon y Meredith, 1993), tal y como es el diseño e implementación de nuevos procesos y sistemas de control en los hospitales.

Las instituciones de salud son complejas y multifuncionales, y manejan una gran cantidad de información que requiere sofisticados sistemas integrados de gestión de la información (Stefanou y Revanoglu 2006), esto hace posible analizar el papel de los diferentes usuarios. La mayoría de las organizaciones sanitarias producen una gran cantidad de documentos que se utilizan para soportar una variedad de procesos dentro de estas organizaciones (Ribeiro-Neto, Laender y Luciano, 2001), siendo un interesante campo de investigación (Jamal et al. 2009).

Debido a la naturaleza descriptiva de este estudio, la selección del hospital no ha sido al azar, sino intencionada (Eisenhardt, 1989). Este estudio de caso longitudinal se llevó a cabo en el Hospital Infanta Elena (HIE). HIE es un hospital público creado en 1985. Ofrece cobertura médica a unas 200.000 personas ubicadas en 17 ciudades diferentes. En el HIE la gestión de la información se considera una de las piedras angulares, y la incorporación de la TI es esencial para poder manejar la información adecuadamente. Esto es cierto no sólo en los niveles estratégicos y tácticos para apoyo a las decisiones, sino también a nivel operativo, para facilitar la actividad clínica diaria. La alta dirección ha mostrado interés en la búsqueda de soluciones eficaces para prevenir errores de medicación.

Tradicionalmente, en el HIE la prescripción y la dispensación se realizaban de forma manual sin ningún soporte tecnológico. Una revisión del Servicio de Farmacia pone de manifiesto que los procedimientos de trabajo pueden ser mejorados para evitar ciertos errores de medicación, y que era importante incluir controles más generalizados para la detección de estos errores cuando tienen lugar. Con el apoyo de los directivos, en abril de 2007 comenzó un proyecto de implementación de TI y del sistema CCM con dos grandes ejes:

1- La modificación del proceso de trabajo mediante el uso de TI, por lo que es difícil cometer errores en la medicación, y

2- La introducción de mecanismos de control que utilizan sistemas orientados a CCM por lo que es posible detectar y corregir los errores de medicación que se producen.

El proyecto tuvo una duración de cuatro años a partir de 2007. Estos cambios implicaron la reingeniería de procesos, dando lugar a cambios organizativos que han afectado a la forma en la que se realiza el trabajo. Este estudio analiza el papel de la TI como catalizador del diseño de sistemas de trabajo. También se analiza la aplicación de los sistemas

para detectar y corregir los errores de medicación antes de que se produzca el daño, con especial atención al enfoque del nuevo sistema en la reducción de riesgos.

Resultados

En primer lugar haremos un breve resumen de cómo era el sistema de trabajo anterior a la implantación de las nuevas tecnologías:

- El médico escribía a mano las prescripciones incluyendo símbolos y abreviaturas, con la dosis requerida y forma de administración. La documentación de apoyo era en papel, teniendo que comprobar manualmente la información que le interesaba para la prescripción.

- La enfermera realizaba la transcripción de las órdenes manuscritas a un formulario donde indicaba la cantidad global de medicamentos que necesita en su unidad, para hacer frente a las prescripciones médicas.

- La dispensación la realizaba la farmacia a partir de los formularios enviados por enfermería, sin saber qué medicamentos ni qué dosis se administraba a cada paciente. Se distribuían de forma global y se almacenaban en pequeños armarios que había en cada unidad.

- La administración la realizaba enfermería según las instrucciones dadas en la orden médica. La enfermera cogía los medicamentos de forma manual del almacén de su unidad. Para que la administración fuera adecuada a la prescripción la enfermera debía hacer recuento diario de medicamentos y confrontrar la hoja de prescripción con su hoja de enfermería.

El paso de un sistema de trabajo a otro se ha realizado de forma progresiva para evitar al máximo las resistencias al cambio por parte del personal, para ello el Hospital puso en marcha una Comisión de Asesores y Expertos que guiaron el proceso de implantación.

En segundo lugar haremos un resumen de cómo es el sistema de trabajo actual:

- El médico realiza una prescripción electrónica por paciente. Para ello cuenta con toda la información necesaria ya que tiene acceso a través de la intranet a todo lo relativo a la historia farmacoterapéutica del paciente. Esto ayuda a la estandarización de las prescripciones siguiendo protocolos establecidos.

- La transcripción es una fase que se elimina del proceso, ya que la hoja de administración se obtiene de forma electrónica y automática después de que el médico realice la prescripción. Así se eliminan los riesgos potenciales de esta fase.

- El farmacéutico valida todas las prescripciones por paciente y está al tanto de toda la farmacoterapia de los pacientes de forma individual. La dispensación se realiza a través de los SADME. Usando las e-prescripciones el farmacéutico lleva a cabo una serie de controles para minimizar los errores potenciales. El sistema permite enviar mensajes a los médicos y/o enfermería con los errores detectados en la prescripción para que no lleguen, en última instancia, al paciente.

- La enfermera retira la medicación de los SADME de forma individual para cada paciente. El acceso a los SADME se establece a través de huella dactilar. Estos SADME permiten establecer controles electrónicos tanto de los stocks como de la conservación y los movimientos de retirada/devolución realizados en los medicamentos.

La modificación de los procesos de trabajo mediante el uso de TI para reducir los errores de medicación, y la introducción de nuevos mecanismos de control usando sistemas CCM, permite detectar y corregir los errores de medicación que se producen.

Al ser los errores de medicación la principal causa de errores ocasionados por la asistencia sanitaria, se hace necesario implantar tecnologías que intenten a través de sistemas de control y monitorización minimizar las repercusiones que puedan tener tanto a nivel de costo como de seguridad de los pacientes. Podemos decir que los sistemas de prescripción electrónica asistida y de dispensación automatizada de medicamentos tienen un gran potencial para reducir los errores asociados con la ilegibilidad, así como con el uso inapropiado de medicamentos y la dosificación.

En este sentido el papel de la TI y los sistemas CCM se pueden clasificar en tres categorías:

- Automatización: reemplazando actividades manuales por procesos automatizados.
- Información: proporcionando información sobre las actividades de negocio
- Transformación: redefiniendo los procesos de negocio (reingeniería de procesos)

Para poder realizar todo el proyecto ha sido fundamental contar con el apoyo de la Dirección del centro y establecer un sistema de trabajo asesorado por una Comisión de Expertos. La resistencia al cambio por parte del personal sanitario se considera un riesgo principal. Sin embargo, esto fue minimizado debido a dos factores: la implicación continua de la Dirección y la formación continua impartida a los implicados.

RESUMEN CAPÍTULO 2

Una vez que se ha analizado el proceso de implementación de las nuevas tecnologías se nos hace necesario conocer la aceptación por parte del personal sanitario respecto de éstas. En este capítulo presentamos los resultados de un trabajo empírico sobre aceptación de sistemas PEA y SADME.

Objetivo

Analizar la aceptación de PEA y SADME por parte del personal de salud (médicos y de enfermería), identificación los factores que influyen. La comprensión de estos factores proporciona la oportunidad de explorar las acciones que podrían llevarse a cabo para impulsar la adopción de estos sistemas por los potenciales usuarios.

Metodología

Para analizar la aceptación de los individuos a los nuevos sistemas implantados empleamos TAM. TAM aborda la cuestión de cómo los usuarios aceptan y utilizan una tecnología (Teo y Noyes 2011). Varios trabajos han demostrado la utilidad de TAM para analizar el comportamiento del usuario, así como la intención de usar una amplia gama de TI (Chin y Gopal, 1995; Igbaria et al, 1996; Gefen y Straub, 1997; Hu et al 1999.; Chau y Hu 2002).

Para este trabajo se han establecido 11 hipótesis que relacionan 7 constructos: intención de uso, facilidad de uso percibida, utilidad percibida, compatibilidad percibida, riesgos percibidos, formación y utilidad percibida para mejorar los sistemas de control.

El análisis se ha realizado con la técnica de los mínimos cuadrados parciales (PLS), que mide las relaciones existentes entre los 7 constructos y los diferentes ítems. Cada ítem se mide utilizando la escala de Likert de 7 puntos donde 1 es muy en desacuerdo y 7 es muy de

acuerdo. Se han recogido un total de 209 encuestas: 91 médicos y 118 enfermeras.

Resultados

El modelo TAM aplicado nos sugiere que existe una relación positiva entre la facilidad percibida de uso y la utilidad percibida (H1). Una posible explicación podría ser el proceso de aprendizaje que se lleva a cabo después de la introducción de la TI. El resultado podría estar basado en el hecho de que los médicos y las enfermeras no utilizaban tradicionalmente las TI para el cuidado del paciente. En cambio, no hay relación entre la facilidad de uso percibida y la intención de uso (H2). Una posible explicación podría ser que la intención de utilizar una nueva TI dependería de factores relacionados con la mejora de la seguridad y no con cuestiones de "usabilidad".

La utilidad percibida si tiene relación positiva y significativa con la intención de utilizar estos sistemas (H3) para el grupo de los médicos. Ésto podría estar relacionado con las diferencias de funciones entre ambos grupos, así los médicos al tener toda la información sobre la historia y la farmacoterapia del paciente de forma inmediata si pueden llegar a percibir que para ellos la implantación de estas nuevas tecnologías suponga una mejora en el desempeño de su trabajo.

Se observa también que hay relación significativa entre la percepción de la compatibilidad de las nuevas TI y la facilidad de uso percibida (H5), así como entre la percepción de la compatibilidad y la utilidad percibida (H4), estas relaciones indican que si se percibe incompatibilidad entre las tareas que los diferentes grupos tienen que realizar y la nueva TI, el nuevo sistema puede ser difícil de usar o incluso inútil.

Como aportaciones de este trabajo está la incorporación del constructo ''utilidad percibida para mejorar los sistemas de control'', habiendo relación significativa entre la utilidad percibida de los nuevos

sistemas para prevenir errores de medicación y la intención de usarlos (H7).

Aunque los usuarios a menudo son reacios a ser controlados, nuestros resultados muestran que cuando los mecanismos de control están diseñados para mejorar la seguridad del paciente, son bien recibidos por los profesionales sanitarios.

No hay relación significativa entre la utilidad percibida para mejorar los sistemas de control y la utilidad percibida para mejorar el rendimiento del usuario (H6).

Hemos encontrado relación significativa entre la formación y la utilidad percibida (H8) y entre la formación y la facilidad de uso percibida (H9). La formación es un punto fundamental para lograr la aplicación efectiva de TI en los hospitales.

Los resultados indican que el riesgo percibido tiene una relación significativa con la facilidad de uso percibida (H11). Los usuarios que perciben un alto riesgo por la pérdida de datos o fallos del sistema no las encuentran fáciles de usar.

RESUMEN CAPÍTULO 3

Planteamos ahora un trabajo sobre cómo afecta el ser adoptante temprano o tardío en la aceptación de las nuevas tecnologías de la información para ver la importancia que tiene el contar con mayoría de adoptantes tempranos en la fase de implementación de una nueva TI.

Objetivo

Analizar las diferencias entre los adoptantes tempranos y los tardíos para el mismo grupo de variables para entender mejor el momento de la decisión de adoptar. Intentamos además encontrar nuevos factores que permitan una discriminación efectiva entre ambos grupos.

Metodología

Vamos a utilizar dos teorías: la Teoría de Difusión de la Innovación (IDT) y el Modelo de Aceptación de Tecnología (TAM).

IDT se centra en el estudio de la difusión de la innovación entre individuos (Roger 1983). En ésta, los adoptantes tempranos están abiertos a los cambios y no temen los riesgos, son los que juegan el papel más importante al inicio de la puesta en marcha de una nueva TI por su compromiso profesional y sus motivaciones, en cambio, los adoptantes tardíos son escépticos y más lentos al cambio.

TAM, en este sentido, tiene como premisa básica que los usuarios que aceptan de mayor grado las nuevas TI están más dispuestos a hacer cambios en sus rutinas de trabajo y a usar su tiempo en esforzarse y empezar a usarlas lo antes posible.

Las hipótesis propuestas y los constructos utilizados según TAM y IDT son:

- Para ver la respuesta afectiva y de conducta se han utilizados los constructos intención de uso, para la hipótesis H1 y actitud hacia el uso, para la hipótesis H2.

- Para ver la respuesta cognitiva se ha utilizado el constructo facilidad de uso percibida, para la hipótesis H3 y la utilidad percibida, para la hipótesis H4.

- En cuanto a los estímulos externos se han utilizado 4 constructos. La resistencia al cambio, para medir la hipótesis H5; el riesgo percibido, para la hipótesis H6; los efectos percibidos en los sistemas de control, para la hipótesis H7 y la incompatibilidad percibida, para la hipótesis H8.

Según el cronograma de la implantación, los adoptantes tempranos son los usuarios que se iniciaron en la fase 1 (principios de 2007 hasta mitad de 2008) y los adoptantes tardíos son los que se iniciaron en la fase 2 (principios 2009 hasta mitad 2010).

Los datos se han extraído de un cuestionario validado recogido en mayo de 2011 y fueron aceptados 209 de las cuales, 108 se han identificado como adoptantes tempranos y 101 tardíos. Este cuestionario tiene varios ítems para cada constructo y dan respuesta a las hipótesis propuestas.

Resultados

Los resultados obtenidos son los siguientes

- Los adoptantes tempranos están más dispuestos a usar la TI con tanta frecuencia como sea necesario.

- Los adoptantes tempranos piensan que las TI son una buena idea y están encantados de usarlas.

- Los adoptantes tempranos no están tan preocupados de cómo usar una nueva TI.
- Los adoptantes tempranos basan más su decisión de uso de la nueva TI en la utilidad percibida, ya que ven muy positivo los beneficios potenciales que les puede aportar.
- Los adoptantes tempranos tienen menos resistencia al cambio que los tardíos.
- Los adoptantes tempranos perciben menos riesgos en el uso de las nuevas TI.
- Los adoptantes tempranos encuentran que los sistemas de control incorporados con la nueva TI implantada, les hace mejorar y reducir y prevenir los errores en la asistencia sanitaria.
- Los adoptantes tempranos perciben menos incompatibilidad que los tardíos y está dispuestos a adquirir nuevas habilidades para poder usar esas nuevas TI.

RESUMEN CAPÍTULO 4

La implantación de nuevas TI relacionadas con la seguridad de los medicamentos hacen a enfermería tomar un papel clave en el proceso de puesta en marcha y posterior uso de los SADME. Enfermería se encargará, con estas nuevas tecnologías, de la retirada de la medicación de los SADME acorde a la prescripción electrónica realizada por el médico, y a su posterior administración.

Objetivo

Analizar la actitud del personal de enfermería hacia el uso de los SADME e identificar factores que puedan influir para poder llevar a cabo acciones que impulsen su uso en futuros usuarios.

Metodología

Hemos utilizado el Modelo de Aceptación de Tecnología (TAM), usado ya anteriormente, en el contexto de los SADME y además identificamos nuevas variables externas que afectan a los constructos utilidad percibida, facilidad de uso percibida y actitud hacia el uso.

El instrumento de medida es un cuestionario validado medido por ítems que siguen la escala de Likert de 7 puntos. La recogida se realizó en mayo de 2011 con un total de 118 encuestas válidas para el personal de enfermería. El análisis de datos los realizamos por el método de los mínimos cuadrados (PLS), mediante el que se desarrolla un modelo que representa las relaciones entre los 6 constructos propuestos medidos por los diferentes ítems.

Resultados

Con la metodología utilizada se obtienen los siguientes resultados:

Hay una relación significativa entre la facilidad de uso percibida, la utilidad percibida y la actitud hacia el uso.

Hay una relación significativa positiva entre la facilidad de uso percibida y el nivel de experiencia. En cambio, no hay relación entre el nivel de experiencia y la utilidad percibida.

Hay relación significativa entre el riesgo percibido y la facilidad de uso percibida, de forma que los usuarios que perciben un alto riesgo de pérdida de datos o de fallos en el sistema no encuentran facilidad de uso con los SADME. En cambio no hay relación significativa entre el riesgo percibido y la utilidad percibida.

La variable externa formación tiene una relación positiva y significativa con la facilidad de uso percibida y con la utilidad percibida. Por ello, es de especial interés que los gestores del hospital focalicen el procedimiento de implantación en la formación, explicando los beneficios que ofrecen la nueva tecnología y la potencial disminución en los errores de medicación.

CAPÍTULO 1

Deploying information technology and continuous control monitoring systems in hospitals to prevent medication errors

Abstract

The serious repercussions of health care errors on patient safety have led hospitals to deploy information technology and continuous control monitoring systems to prevent them. Hospitals are moving away from traditional paper-based systems and focusing on designing new systems that prevent errors, using information technologies to catalyze the process reengineering. This paper presents a case study analyzing the effect of computerized physician order entry and automated unit-based medication storage and distribution systems on the drug ordering and delivery process.

Conclusions point out that information technology and continuous control monitoring systems have led to significant process re-engineering in the sequential stages of the drug ordering and delivery system. The new systems have also provided the opportunity to improve information available. This is an exploratory case study and the conclusions drawn from it offer possible routes for future research in this field.

1. Introduction

The health care system is not as safe as it should and could be. The identification of possible risks related to hospital care is crucial to the health care system, due to the serious repercussions on the patient health. Other factors, such as economic and legal aspects, as well as trust in the system, have also been affected by these risks.

This interest in the risks related to health care errors is not something new. Numerous studies have been carried out to quantify these errors. Schimmel (2003) notes that approximately 20% of patients admitted to a university hospital suffer some sort of

iatrogenesis[1], a fifth of which result in serious complications. Steel et al. (1981) raises this figure to 36%, one quarter of which are serious. In both studies, the main risk was due to medication errors. Many studies have taken place over time in different countries, with results quantifying health care errors in an approximate interval of between 4-20% (Baker et al. 2004; Brennan et al. 1991; Davis et al. 2001; Forster et al. 2004; Leape et al. 1991; Schioler et al. 2001; Thomas et al. 2000; Vincent et al. 2001; Wilson et al. 1995).

Improvements in the health care system should be based upon the premise that "to err is human" (Kohn et al. 2000). Regardless of an individual's ability or degree of concentration, it is human nature to commit errors. Therefore, systems designed to prevent errors might include procedures created to detect and avoid such mistakes, through a systems approach, rather than focusing on the traditional "people approach" (Reason 2000).

The systems approach is based on the idea that errors can be prevented by designing work systems so that errors are difficult to make. This is the essence of the systems approach to error reduction: focus on the processes, not on the people (Leape 1999).

However, it is not always easy to make changes to work systems. These changes normally involve process re-engineering, resulting in organizational changes which affect both the way work is done and how centralized information is controlled. Under these circumstances, personnel can reject alterations in the work system, as they are normally reluctant to change their work routines, and feel that closer supervision might be problematical (Anderson 1997; Plotnick 2010). Thus, employees can resist change, due to fear of the unknown or simply due to the sensation of displacement that some members of the organization will feel.

[1] Iatrogenesis refers to the inadvertent adverse effects or complications caused by or resulting from medical treatment or advice.

Information technology (IT) can play a fundamental role within the scope of the systems approach. Prior research has shown that the benefits of IT and a number of empirical studies demonstrate the positive relationship between the investment in technology and operational improvements (Bender 1986; Dewan and Ren 2011, Harris and Katz 1991, Huang 2007).

The main objective of this paper is to examine the potential benefits that hospitals can obtain from implementing IT and continuous control monitoring (CCM) systems designed to support and facilitate internal control processes, i.e., the adoption of IT as a form of change mechanism (Ward et al. 2000). Therefore, a case study is presented to analyze how IT tools can be used for designing work systems so that medication errors are difficult to make, thereby increasing patient safety.

2. Medication errors and CCM systems

Medication mistakes are the leading type of health care errors affecting patients (Bates 2007; Leape et al. 1991). A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use (NCCMERP 2011).

Medication errors may originate in one or more of four sequential stages in the drug ordering and delivery system as shown in Figure 1 (Leape at al. 1995).

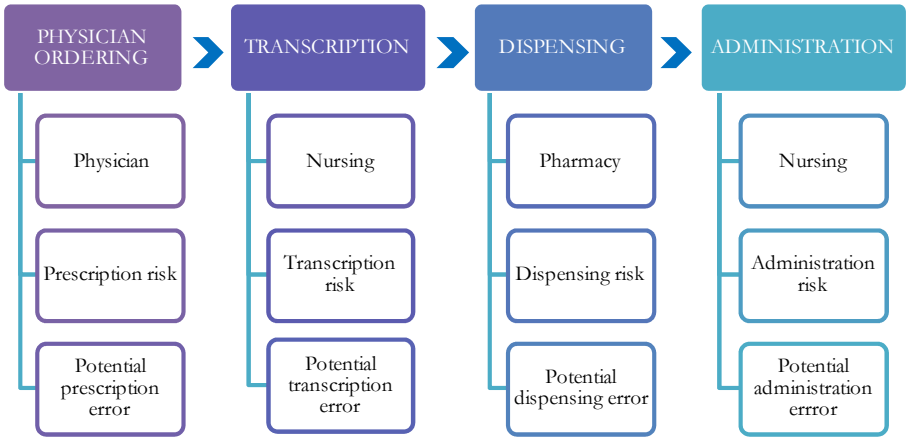

Figure 1. Sequential stages in the drug ordering and delivery system

Several people intervene during each stage of the drug ordering and delivery system, thereby increasing the potential risk at each stage. However, medication errors mainly take place during the physician ordering and administration stages (Bates et al. 1995; Leape et al. 1995) (Figure 2).

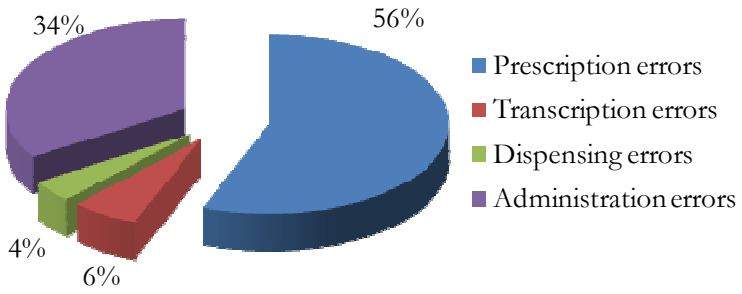

Figure 2. Errors by stages of drug ordering and delivery system

In order to improve patient safety, the most frequent causes of medication error should be identified. Thus, mechanisms can be designed to prevent them using a systems approach. Table 1

summarizes the major errors made by proximal cause and stage of drug ordering and delivery (ISMP 2000; Nadzam 1998).

Medication errors	Proximal cause
Prescription errors	– Lack of information on adverse effects of drugs – Lack of information on patient pathologies and medical history – Distractions
Transcription errors	– Illegible, incorrect, or ambiguous medical prescriptions – Drugs with similar names – Constant interruptions or distractions – Distractions
Dispensing errors	– Drugs with similar names – Drugs with similar packaging or labeling – Distractions
Administration errors	– Confusion in identifying patients – Problems in administration equipment – Distractions

Table 1. Medication errors by proximal causes and stages of drug ordering and delivery

CCM systems expand the scope of control processes. CCM systems encompass a range of control monitoring tasks, including the automation of routine control tests, enhanced risk assessments, evaluation and documentation of controls, and managing and communicating control assurance activities. The role of CCM systems is to ensure that internal control continues to operate effectively by promoting good control operations, and enhancing the process of assessing the design and operation of controls (COSO 2009).

Monitoring tools generally evaluate one or more of the following, prompting an assessment about the underlying elements of the situation-specific context (Ramamoorti and Dupree 2010):

- Transaction data: highlighting exceptions through comparisons of processed transactions (or master data) against a set of pre-defined control rules.

- Conditions: comparing baseline or previously established expectations with actual applications or parameter configurations.

- Changes: identifying and reporting changes to critical resources, data or information allowing verification of authorization and/or propriety.

- Ensuring information (processing) integrity: verifying and monitoring the accuracy, consistency and reliability of information across content, process, system and environment (i.e., information integrity).

- Error management: monitoring the volume and resolution of activity in suspense areas, error logs or exception reports and the management of the workflow of control exceptions.

CCM systems are involved in different parts of the information management system (Figure 3). Processes can automatically be controlled as they occur, with the necessary degree of unbundling. The objective is to prevent errors in generating digital information, sidestepping the GIGO effect (Garbage In, Garbage Out).

Its analysis capability enables control of all transactions or actions taking place in the area of interest. Therefore, there are no risks associated with sample sets or confidence intervals. They can also integrate data collected from multiple processes, while sending alert messages when anomalies are detected.

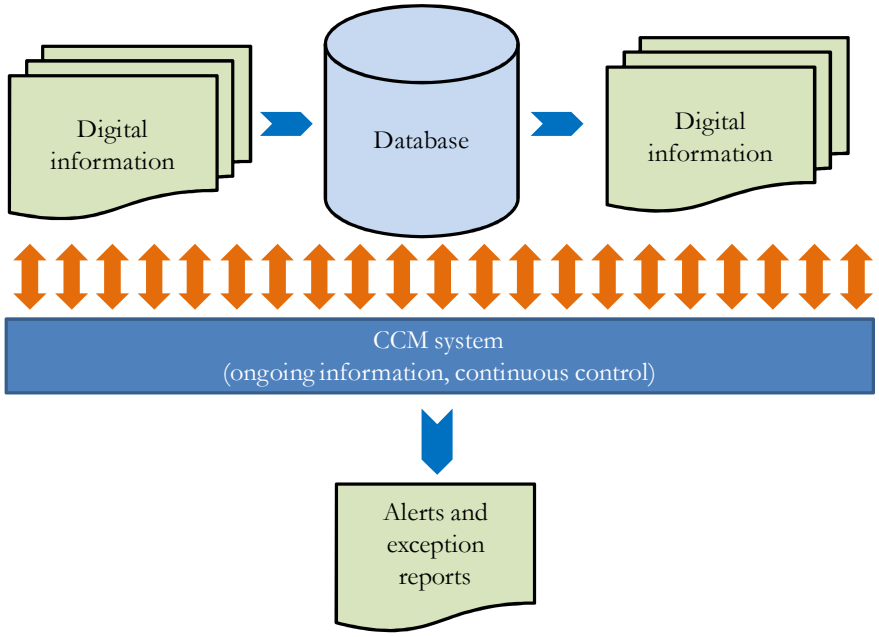

Figure 3. Continuous control monitoring systems

The following steps comprise the continuous monitoring application (Nigrini and Johnson 2008): determine the scope of the monitoring and the methods and techniques to be applied; determine the controls, indicators, and rules to be used; design and document the system; record the findings and prepare management reports; and update the system to improve the predictive ability of the system.

The use of IT systems based on the CCM philosophy could be an alternative for partially preventing the risks inherent to predominantly manual processes, which currently take place in a great deal of hospitals.

3. The case study

3.1. Methodology

Contrary to other empirical research methods, case studies make it possible to analyze contemporary phenomena in their true context, when the demarcations between the two are not so clear, and when multiple evidence sources are used (Yin 1994). Case study methodology is recommended as a means of increasing the contact between research and the reality of the business world (Huq and Martin 2006; Stefanou and Revanoglou 2006) and is highly appropriate in the early stages of research of a phenomenon (Eisenhardt 1989). Further, the case study has been recommended as the ideal research methodology for gaining a better understanding of complex phenomena (Flynn et al. 1990; McCutcheon and Meredith 1993), and the design and implementation of new processes and control systems in hospitals is a complex task which cannot be fully understood on its own.

Healthcare institutions are complex, multi-functional, information-intensive organizations requiring sophisticated integrated management information systems (Stefanou and Revanoglu 2006), making it therefore possible to analyze the role of different users. Most medical organizations produce an abundance of medical documents that are used to support a variety of processes within these organizations (Ribeiro-Neto et al. 2001). The analysis of IT used in healthcare organizations is a very interesting field of research (Jamal et al. 2009). For instance, Handel et al. (2011) present a research agenda addressing the major questions that are posed by the introduction of IT into emergency department care; these questions relate to interoperability, patient flow and integration into clinical work, real-time decision support, handoffs, safety-critical computing, and the interaction between IT and clinical workflows.

Due to the informational nature of this study, the selection of the hospital to be studied was not random, but specific in nature (Eisenhardt 1989). This longitudinal case study was carried out in the Infanta Elena Hospital (hereinafter IEH), due to its public nature, including autonomous administration as well as economic management departments. IEH is a Spanish hospital created in 1985. It provides health care coverage to an estimated 200,000 individuals located in 17 different towns. Its installations include over 40 doctor's offices, 9 operation rooms, and 320 beds, with a full-time staff of 1,100 including physicians, as well as healthcare and other employees.

The IEH understands that information management is one cornerstone of system operation, and that the incorporation of IT is essential in order to handle the information adequately. This is true not only at the strategic and tactical levels for decision support, but also at the operating level, to facilitate the daily clinical activity. Top management has shown an interest in seeking efficient solutions to prevent medication errors.

Traditionally, at the IEH, the drug ordering and delivery process was handled manually, with no IT support. A review of the pharmacy service indicated that working procedures might be improved to prevent certain medication errors, and that it was important to include more widespread controls to detect these mistakes when they take place. With managers' support, in April of 2007 a project began deploying IT and CCM systems with two major focuses: (1) The modification of work process through the use of IT making it difficult to commit medication errors, and (2) the introduction of control mechanisms using CCM-oriented systems making it possible to detect and correct medication errors as they occur.

The project lasted four years beginning in 2007. These changes involved the process re-engineering, resulting in organizational changes which affected the way work is done. This study analyzes the role of IT

as catalysts of designing work systems. It also analyzes the implementation of systems to detect and correct medication errors before harm occurs, with special attention paid to the new system's focus on risk reduction.

3.2. The "old" system vs. the "new" system

This section presents the main characteristics of both systems and the results obtained by using the new one.

3.2.1 The "old" drug ordering and delivery system

The main characteristic of the previous system is that the entire process took place without IT support. The process was entirely manual, and therefore, potential mistakes were hard to control (Figure 4).

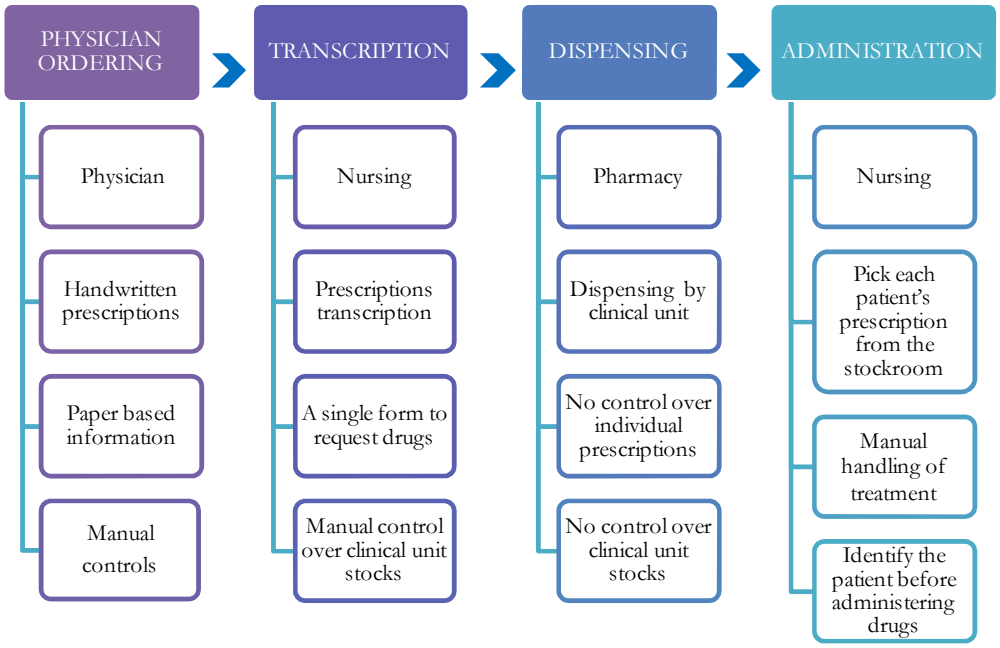

Figure 4. Sequential stages in the old drug ordering and delivery system

Physician ordering

At this stage, physicians wrote out hand-written prescriptions. Thus, each day they wrote their prescriptions, including symbols and abbreviations, featuring the required dosage and administration form. These hand-written prescriptions were given to the nursing staff to continue the process.

During this stage, doctors did not have computerized systems assisting them with detailed information regarding drugs and patients. All supporting documentation was on paper.

Using information at his/her disposal, the physician had to manually verify the following: the lack of possible adverse drug interactions with chronic medication, the correct dosage, and that there were no allergies or other reasons making the prescriptions inadvisable based on the patient's history, etc.

Transcription

The nurses then received the written prescription on their unit, transcribing them onto a single form, requesting the quantity of medicine required from the pharmacy.

The transcription of prescriptions did not add value to the drug ordering and delivery process, and was the source of many potential risks. It was clear that the elimination of handwritten prescriptions and the development of electronic prescribing would reduce these types of medication errors (ISMP 2000).

Grouping the entire unit's prescriptions in one pharmacy request form made it impossible to carry out external controls, and therefore, the risk inherent in the process was greater.

Dispensing

After the nursing staff had sent the drug request form to the pharmacy, it dispensed the requested drugs to each hospital unit/service.

The requests were not broken down according to patients, and therefore, the pharmacy simply filled the prescriptions required without having knowledge regarding which drugs/dosages were to be administrated to each patient.

These drugs were then distributed by hand to each unit, and stored in small cabinets on each unit, with nurses in charge of organizing the drugs in them, as well as dispensing them without any pharmacy supervision.

Administration to the patient

Based on instructions in the doctors' prescriptions, the nursing staff administered the drugs to patients. Nurses collected drugs manually from the unit's stock and administered them to the patients based on the physicians' dosage instructions. This required a hand count so that each patient received exactly the drugs prescribed by his/her doctor. This meant having to make a daily recount of prescription medication, checking the result against the nursing administration sheet. Periodically, nurses requested that certain drugs be replaced so as to have safety stocks.

3.2.2. The "new" drug ordering and delivery system

In April of 2007, a project aiming to prevent medication errors through the use of IT and CCM systems began. Among other innovations, the handwritten prescription and traditional units' cabinets were substituted by computerized physician order entry (CPOE) and

automated unit-based medication storage and distribution systems, all employing integral procedures (Figure 5).

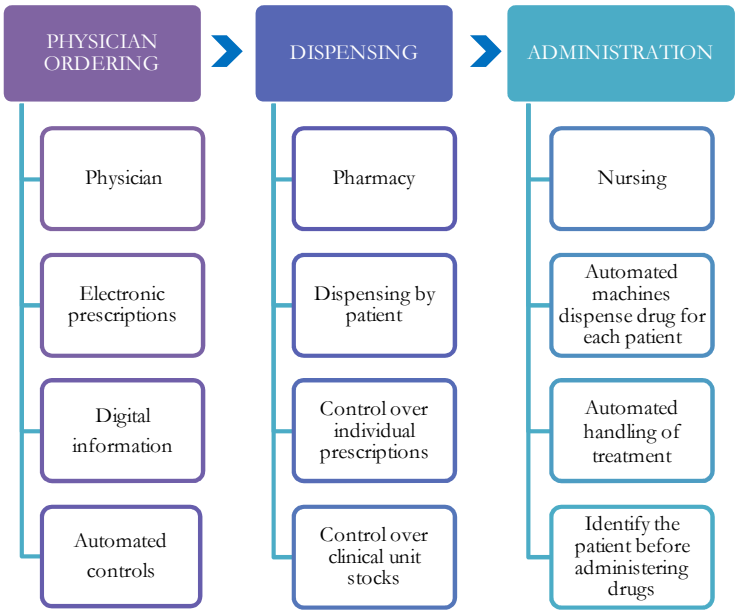

Figure 5. Sequential stages in the new drug ordering and delivery system

Physician ordering

Medication is the most commonly used intervention in health care, yet despite its benefits, it leads to an estimated 1.5 million adverse drug events and tens of thousands of hospital admissions each year. Although some are not preventable given what is known today, many types are, one of which being drug-drug interactions (Classen et al. 2011).

The implementation of CPOE systems was an important shift in the way drugs are ordered and delivered. Under the new system, doctors do not write prescriptions by hand, instead using a CPOE system. To simplify this stage, e-prescription technology was installed in the hospital's intranet so that physicians can log in from any online computer. Instead of generating paper-based prescriptions, e-

prescriptions are produced, making it possible to establish new CCM systems.

Physicians have the necessary information to carry out the task digitally. They have online access to each patient's pharmacological and therapeutic case history, data on maximum dosage, interactions, and duration of treatment for each drug, and details regarding each patient's allergies and relevant personal situations, etc.

Using the CPOE system, all doctors prescribe following the same procedure, thereby increasing the standardization of prescriptions through the use of established protocols.

Furthermore, CCM systems alert of potential situations of interactions/incompatibilities between prescribed drugs, interactions or incompatibility with ones taken previously, and interactions between prescribed drugs and the patient's history (allergies, etc...).

Transcription

Once the physician has sent in the e-prescription, the information is digitally saved into the application so that the pharmacy can gain access. It is therefore unnecessary for nurses to manually transcribe the handwritten prescriptions, with this process disappearing thanks to IT support.

Nurses' roles have changed. They used to spend a great deal of time devoted to bureaucratic tasks such as transcription, to the detriment of time spent on patient care. The nursing staff is thereby freed from activities which do not add value, and which are also the source of potential risks, to focus on the key aspects of their jobs.

Dispensing

Traditional pharmacosurveillance methods do not provide timely information on drug safety and effectiveness. Real-time surveillance using electronic prescribing systems could address this problem (Eguale et al. 2008). Unlike the old pharmacy service system, the new system provides pharmacists with access to e-prescriptions broken down by patients, rather than by hospital unit or service. This represents an important change in the role of pharmacists in the drug ordering and delivery system. Rather than simply dispensing medicine, they become part of a multi-disciplinary team specialized in drugs.

Using each patient's e-prescriptions, pharmacists may carry out additional controls on each of the e-prescriptions. The pharmacist reviews each e-prescription to detect medication errors. If an error is detected, the pharmacist communicates it to the doctor through the same CPOE system.

The drug dispensing procedure has also improved, through the use of automated unit-based medication storage and distribution systems. Previously, the pharmacy supplied each unit with the requested medicine, which was transferred to and administrated from the cabinets on each unit. Now nurses directly withdraw the prescribed medication for the patients using automated unit-based storage and distribution systems located in the hospital units, once the e-prescription has been validated by the pharmacy. Manual dispensing is eliminated and replaced by automated dispensing machines.

Administration to the patient

Nurses still administer drugs to patients. Automated dispensing machines have replaced the cabinets on each unit. Now, these are electronically-controlled cabinets connected through different applications. Their features include a keyboard and tactile screen which

are used for completing all functions: identifying the user (physician, pharmacist, or nurse), selecting the patient, withdrawing and replacing medication, etc. These automated dispensing machines are placed in clinical units and are connected to a central console, which is located within the pharmacy; all the peripheral units are managed through them.

The ID of all users who use the system is always recorded. Nurses identify themselves in the automated unit-based medication storage and distribution systems via fingerprint identification; this is another control, which records which staff member has withdrawn and administrated which medication to which patient. Once identified, the employee selects the patient, and the machine dispenses the exact amount of drugs prescribed by the doctor on the e-prescription that has been previously validated by the pharmacy.

4. Discussion

The medication error dilemma is at the forefront of most hospitals' improvement agendas. The most often cited solution to the problem has been CPOE systems and automated dispensing machines. These systems have significant potential to improve errors associated with illegibility as well as inappropriate drug use and dosing (Sengstack and Gugerty 2004). Hospitals are moving from manual to digital systems based on assumptions about the value of IT and CCM systems: for example, that they will improve the efficiency of services or patient outcomes (Keen and Muris 1995, Levick and O'Brien 2003). Ammenwerth et al. (2008) analyzed the relative risk reduction on medication error and adverse drug events by CPOE systems. Of the 25 studies that analyzed the effects on the medication error rate, 23 showed a significant relative risk reduction of 13% to 99%. Six of the nine studies analyzing the effects on potential adverse drug events showed a significant relative risk reduction of 35% to 98%. Four of the seven studies that analyzed the effect on adverse drug events showed a significant relative risk reduction of 30% to 84%. However, further research might ascertain

whether the actual implementation of computerized physician order entry systems are achieving goals such as improved patient safety (Metzger et al. 2010, Moniz et al. 2011).

This paper is focused in the implementation process and uses a case study to analyze the role of IT and CCM systems in hospitals to prevent medication errors. The strategic role of IT can be classified into three categories (Dehning et al. 2003; Schein 1992; Zuboff 1988). IT can replace human labor in automating business processes. Furthermore, IT can provide information about business activities to senior management and/or provide information about business activities to employees across the firm. Last but not least, IT can also transform the organization and redefine business processes and relationships.

In the IEH case study, important results came to light from each of the stages. These are discussed based on the previous classification.

Automate: Replacing human labor in automating business processes

CPOE systems used during the physician ordering automatically detect possible prescription errors, such as drug interactions or likely side effects considering the patient's history. The transition from paper-based to e-prescriptions allows nurses to focus on tasks unrelated to transcription and requesting drugs from the pharmacy, as this all takes place automatically. CPOE systems have led to advancements in the prevention of prescription and transcription errors, as they affect the proximal causes of this stage of drug ordering and delivery system (Table 1).

Automated unit-based medication storage and distribution systems make it possible to dispense drugs automatically according to e-prescriptions. Previously, there were numerous opportunities for error, since the nurses were expected to interpret and transcribe the prescriptions as well as prepare medication for patients, without any

pharmacy intervention or supervision. Automated unit-based medication storage and distribution systems increase the efficiency of the drug dispensation and administration process, thereby preventing medication errors, while reducing the pharmacist's workload, and guaranteeing the immediate availability of medicine in the nursing units and controlling inventory. The system also alerts when the nursing staff has not withdrawn patient medication.

Inform: Provide information about business activities

IEH's main goal has been the improvement of safety and care provided to patients; also, great strides have been made in improving the information available to assist in managing the hospital. The first change, which was mentioned previously, was the online information on patients and drugs available to doctors.

The pharmacy can consult patients' detailed e-prescriptions. This makes it possible to easily analyze drug costs, breaking them down by service, patient, and diagnosis-related groups (DRG), which was previously impossible.

Automated dispensing machines facilitate a greater degree of control on the drug inventory. The use of traditional cabinets on each unit increase the drug costs due to the high inventory of stocks required, increasing the risk of expiration and deterioration due to their incorrect conservation. In the new system, stock management shows notable improvement thanks to awareness of the exact stock in each dispenser, thereby reducing wasted inventory.

The system also makes it possible to send messages and increase information flow. The integration involves the improved flow of information while reducing administrative costs (Gattiker and Goodhue 2000). This integration is important because the inability to share information across systems seriously affects the efficiency and cost-

effectiveness of healthcare organizations (Grimson et al. 2000). Furthermore, personnel's participation in management could be one of the critical factors affecting intangible hospital value (Lu et al. 2010).

Transform: Redefine business processes

CPOE systems and automated dispensing machines have restructured existing work procedures, affecting the workflow between different professional groups. The system results in the reassignment of tasks and reallocation of areas of expertise in the medication process (Niazkhani et al. 2010). Therefore, the new systems have been catalysts for process reengineering, with redefined tasks of personnel involved in the new drug ordering and delivery system (Figure 6).

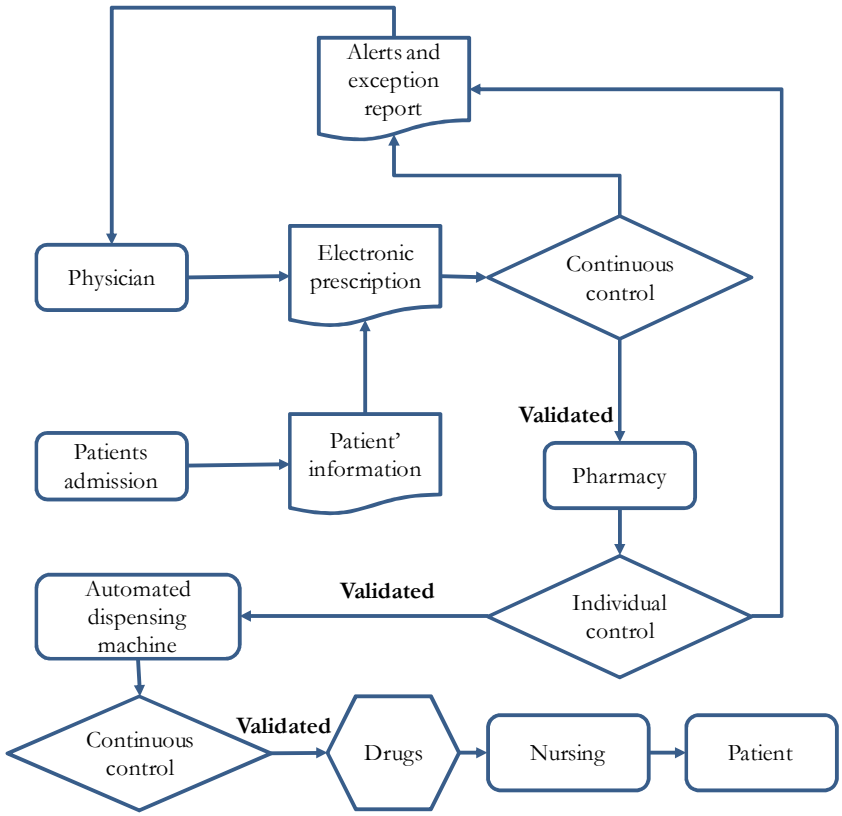

Figure 6. New drug ordering and delivery system: redefined processes

Recognizing that change does not take place easily or all at once, IEH chose not to implement the new system throughout the entire organization simultaneously. It was gradually set up over a four-year period, following a "phased rollout" implementation methodology (Markus et al. 2000). Implementation began in areas perceived as more receptive to change, and then extended to other hospital areas (Figure 7). To avoid problems, during the two weeks following implementation of the new system, both systems remained active. Once these two weeks were up, only the new system remained operative.

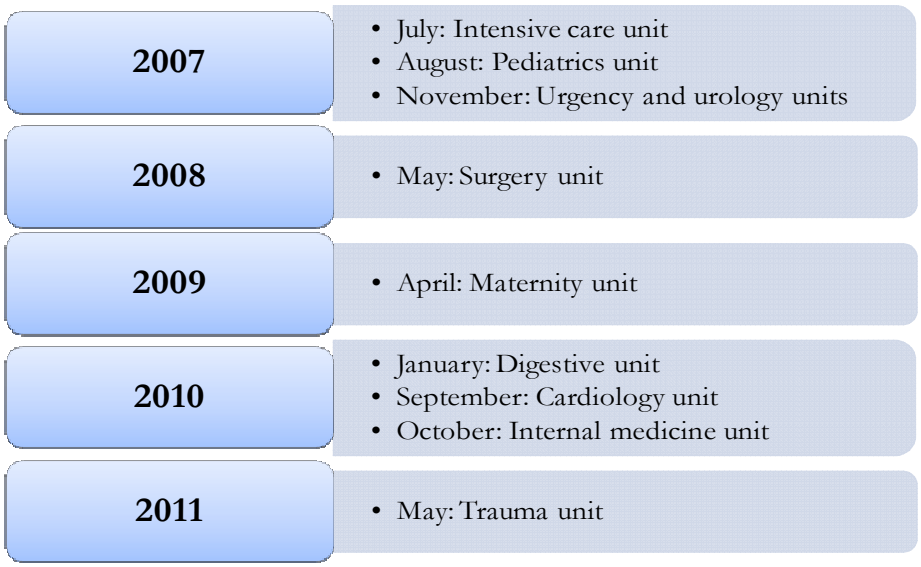

Figure 7. Implementation schedule

Resistance to change was considered a main risk. However, this was minimized due to two factors making a decisive contribution to achieving the set goals: continual involvement of management, and continuous training provided to those involved.

It is even possible that the process might not have been implemented had the top management support been weak. Top management formed an Implementation Committee to ensure a smooth implantation process. The team was comprised of the following members: the Project Manager,

Functional Consultants, and Technical Consultants. The Hospital Administrator stepped in as Project Manager. Functional Consultants included the head of each clinical unit (physicians and nurses), as well as the pharmacy head. The Technical Consultant was an employee from the company hired to carry out the implementation.

The Project Manager's role included analyzing, defining, and designing the entire process. It also included directing the project, securing involvement of all the different groups, while at the same time overseeing the project with an eye to fulfilling deadlines. The Functional Consultants analyzed processes in order to detect which could be automated, while also defining authorization policies for obtaining access to information. The Technical Consultants configured the technical infrastructure in order to set the system up, and also installed and configured software as specified by the Project Manager and Functional Consultants.

This Committee was also in charge of supervising the overall implementation process in each unit. It also designed the training courses to be given to personnel. In May 2007, the company which had been hired to set the system up trained pharmacy personnel on how the CPOE system and automated dispensing machines work. Since that time, the pharmacy staff has given specific training program to doctors and nurses every time another unit is set up with the new system. It is a continuous training course. Once new employees are hired, they are trained on how the system works. The pharmacy communicates system updates (such as new medication protocols, security updates, etc...) to the personnel involved.

Training was not exclusively focused on using the system, but was also focused on the new system's advantages, most of which are related to the patient's increased safety profile. As it was implemented gradually, all areas were able to observe its effect in those areas testing it first. The result was a predisposition of personnel towards using IT and CCM

systems, along with the well-known implications of the reengineering of processes.

In order to convince personnel to adopt IT and CCM systems, top management emphasized the functional benefits of the technology (from reduced paperwork to decreased medication errors). In general, both physicians and nurses seemed positive about CPOE before and after the implementation of this system (van Doormaal et al. 2010). In contrast to other cases (Plotnick 2010), there were positive attitudes toward behavior change, mainly due to the potential of these new technologies to prevent medication errors and reduce the risks associated with patient treatment.

Once the system was set up in all the units, it went into use. The Implementation Committee created a technical support service located in the pharmacy department. This technical support service is in charge of resolving irregularities which arise, as well as making back-ups, analyzing glitches in the system, etc. Whenever a user detects a problem in the system, and is unable to solve it personally, this technical support service is contacted. Personnel trained by the company having installed the system can then proceed to solve any of the problems which might arise. If they are unable to provide a solution, the installing company is contacted in order to do so (it offers a 24-hour help line, 365 days a year).

Following are observations about the steps taken to set up the continuous monitoring application (Nigrini and Johnson 2008). As expressed throughout this paper, the monitoring scope was limited to medication errors inherent in the original drug ordering and delivery system. The main challenge was to establish controls, indicators, and rules that would be used to prevent potential errors. It was necessary to establish safety intervals for each drug/dosage, as well as to define possible interactions with other drugs. This was the first filter, as the system alerts doctors in situations in which prescribed drugs conflicted

with any established rules. Checks are also made to see that there are no incompatibilities between the prescribed drugs and the patient's history. A great deal of time was devoted to the development of this phase, especially in the first units in which it took place. The system was not set up in a generalized fashion until the establishment of a list of rules and controls considered sufficiently consistent, with tests made on the pilot units.

The system is continually updated to improve its preventive ability. When errors surpassing system controls are detected, the causes are analyzed to include new rules or modify those in existence.

5. Concluding remarks

Evidence supporting the recommendations made in the Institute of Medicine report (Kohn et al. 2000) includes research on IT to improve the quality and safety of healthcare sector. Technologies, such as CPOE systems and automated dispensing machines, undoubtedly play a key role, and institutions should be thinking seriously about implementing a number of these (Bates 2007).

The aim of this paper has been to analyze the role of IT as catalysts of designing work routines so that medication errors are difficult to make, using the systems approach. The design and implementation of the CCM systems were also explained.

This primary contribution to this literature is the strategic role that IT and CCM systems have played in hospitals, replacing human labor in automating business processes, providing information about business activities and, fundamentally, redefining business processes and relationships.

The end result has been the implementation of a system preventing errors in the drug ordering and delivery system. The system has also provided the opportunity to improve information available.

Implementation of the new system was not quite as problematic as expected. The low resistance to change was the result of management's firm and constant support of the project, as well as continuous personnel training. Another important issue was that the system was introduced progressively, thereby ensuring a smooth transition process.

CAPÍTULO 2

Acceptance of e-prescriptions and automated medication-management systems in hospitals: an extension of the technology acceptance model

Abstract

The serious repercussions of heath care errors on patient safety have led hospitals to deploy corrective information technologies. Hospitals are moving away from traditional paper-based systems and focusing on designing new methods that reduce errors, using information technology to catalyze the reengineering process.

This paper analyzes the intention of health care personnel (physicians and nursing) to use e-prescriptions and automated medication-management systems (EPAMMS), identifying influencing factors. Understanding these factors provides the opportunity to explore which actions might be carried out to boost adoption by potential users.

The theoretical grounding for this research is the Technology Acceptance Model (TAM). TAM specifies the causal relationships between perceived usefulness, perceived ease of use, and actual usage behavior. The proposed model has seven constructs; we have generated eleven hypotheses from connections among these seven constructs. These constructs include perceived compatibility, perceived usefulness to enhance control systems, training and perceived risks. Our results provide support for a number of relationships in the hypothesized model.

1. Introduction

Improvements in the health care system should be based upon the premise that "to err is human" (Kohn et al., 2000). Regardless of an individual's ability or degree of concentration, it is human nature to commit errors. Therefore, systems designed to prevent errors must include procedures created to detect and avoid such mistakes through a

"systems approach", rather than focusing on the traditional "people approach" (Reason, 2000).

A medication error is often the end result of a chain of events set in motion by faulty system design that either induces errors or makes them difficult to detect (Reason, 1990; Perrow, 1984). Many medical injuries also result from systems failures (Leape, 1994). This interest in the risks related to health care errors is not something new. Numerous studies have been carried out to quantify these errors. Schimmel (1964, 2003) note that approximately 20% of patients admitted to a university hospital suffer some sort of iatrogenesis[2], a fifth of which result in serious complications. Steel et al. (1981) raises this figure to 36%, one quarter of which are serious. In both studies, the main risk was due to medication errors. Many studies have taken place over time in different countries, with results quantifying health care errors in an approximate interval of between 4-20% (Baker et al. 2004; Brennan et al. 1991; Davis et al. 2001; Forster et al. 2004; Leape et al. 1991; Schioler et al. 2001; Thomas et al. 2000; Vincent et al. 2001; Wilson et al. 1995).

Medication mistakes are the leading cause of health care errors affecting patients (Brennan et al. 1991; Leape et al. 1991). Medication errors may originate in one or more of four sequential stages in the drug ordering and delivery system (Leape at al., 1995):

1. Physician ordering. Physicians select and prescribe the correct drug and dosage for the patient. Potential errors during this stage are called prescription errors.

2. Transcription. Nurses transcribe the different medical prescriptions onto a form requesting the quantity of medicine required for each hospital unit from the pharmacy. Unexplained errors associated with the order transcription can take place during this phase. These

[2] Iatrogenesis refers to the inadvertent adverse effects or complications caused by or resulting from medical treatment or advice.

include a variety of omissions, inadvertent cancellations or duplications, and dose transcription errors.

3. Dispensing. The pharmacy then dispenses the requested drugs to each unit or hospital section. Errors here are termed dispensing errors.

4. Administration. The nurses administer the prescribed medicine to the patient in the required dosage. Administration errors take place during this phase.

Information technology (IT) plays a fundamental role in improving the quality of health care service while increasing its efficiency. The strategic role of IT can be classified into three categories (Dehning et al. 2003; Schein, 1992; Zuboff, 1988):

- Automate: Replacing human labor in processes.

- Inform: Provide information about business activities to senior management and/or provide information about business activities to employees across the firm.

- Transform: Fundamentally redefine business and industry processes and relationships.

Hospitals are moving from manual to digital systems based on assumptions about the value of IT and automated-control systems: for example, that they will improve the efficiency of services or patient outcomes (Keen and Muris, 1995). Among other innovations, the handwritten prescription and traditional cabinets are being replaced by electronic assisted prescription systems and automated based-unit medication storage and distribution systems (Sengstack and Gugerty, 2004), all of which using integral procedures (Figure 1).

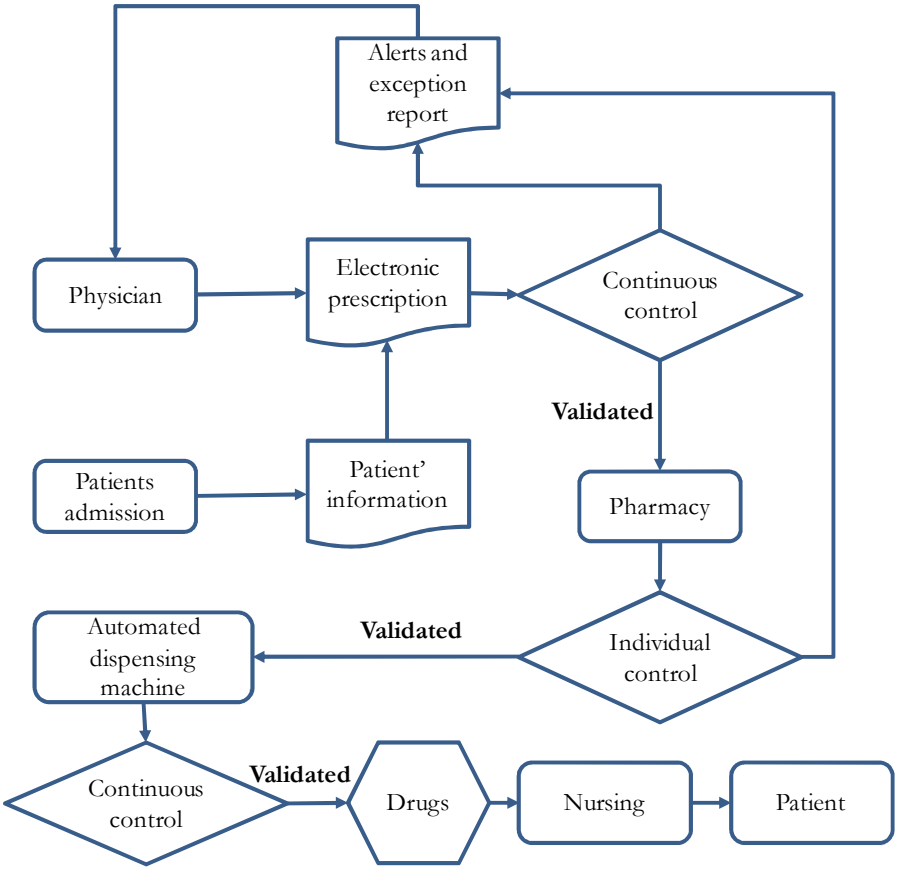

Figure 1. Sequential stages in the electronic drug ordering and delivery system

Medications represent the most common intervention in health care, despite their benefits; they also lead to an estimated 1.5 million adverse drug events and tens of thousands of hospital admissions each year. Although some are not preventable given what is known today, many types are, and one key cause which is preventable is drug-drug interactions (Classen et al., 2011).

Medication errors can be reduced or prevented by improving training, using computerized systems and involving pharmacists in checking drug charts (Davis, 2011). Common medication errors are largely preventable with education and training, and all hospitals are tasked to implement

training programmes to prevent further medication errors thus improving patient safety (Wallymahmed, 2011). The focus of training must be on prevention of errors. However, training too often focuses on trying to prevent the individual physician from making that particular error again. It is most appropriate to focus on the underlying factors that contributed to such an error being committed (Crook et al., 2004). In this regard, healthcare managers aim to prevent medication errors through the use of IT and control systems (Kohn et al., 2000), thus improving protocols and involving pharmacists as part of a multi-disciplinary team specialized in drugs.

The implementation of an electronic assisted prescription system is an important evolution in the way drugs are ordered and delivered (Bates, 2007). Under the new system, doctors do not write prescriptions by hand, instead using a computer program (e-prescriptions). Instead of generating paper-based prescriptions, e-prescriptions are produced, making it possible to establish new automated-control systems. Traditional pharmacosurveillance methods do not provide timely information on drug safety and effectiveness. Real-time surveillance using electronic prescribing systems could address this problem (Eguale et al., 2008).

The physician has the necessary available information to carry out the task digitally. There is immediate online access to:

- Each patient's pharmacological and therapeutic case history.
- Data on maximum dosage, interactions, and duration of treatment for each drug.
- Details regarding each patient's allergies and relevant personal situations.

All information is available online, with automatic control systems generating alerts in the following potential situations:

- Interactions or incompatibilities between prescribed drugs.
- Interactions or incompatibility with drugs taken previously.
- Interactions between prescribed drugs and the patient's history (allergies, etc.).

Nurses, in hospitals, still administer drugs to patients. Automated dispensing machines have replaced traditional cabinets on the units. These are a group of electronically-controlled cabinets, managed by software and connected through different IT applications. The new cabinets contain medication ready for use in different boxes, at varying degrees of access control. These automated dispensing machines are placed in clinical units and are connected to a central console.

Nurses identify themselves in the automated based-unit medication storage and distribution systems via fingerprint identification or personal access code. This is another control, noting which staff member has withdrawn and administered which medication to which patient. Once identified, the employee selects the patient, and the machine dispenses the exact amount of drugs prescribed by the doctor on the e-prescription that was previously validated by the pharmacy.

Ammenwerth et al. (2008) analyzed the relative risk reduction on medication error and adverse drug events by computerized physician order entry systems. Of the 25 studies that analyzed the effects on the medication error rate, 23 showed a significant relative risk reduction of 13% to 99%. Six of the nine studies that analyzed the effects on potential adverse drug events showed a significant relative risk reduction of 35% to 98%. Four of the seven studies that analyzed the effect on adverse drug events showed a significant relative risk reduction of 30% to 84%.

The prime aim of e-prescriptions and automated medication-management systems (EPAMMS) is the improvement of safety and care

provided to patients. Furthermore, great strides have been made in improving the information available to assist in managing the hospital.

The first change is the online information on patients and drugs available to doctors. The pharmacy can consult patients' detailed e-prescriptions. This makes it possible to easily analyze drug costs, breaking them down by service, patient, and diagnosis-related groups (DRG), which was previously impossible. Automated dispensing machines facilitate a greater degree of control on the drug inventory. The use of traditional cabinets on each unit increase the drug costs due to the high inventory of stocks required, increasing the risk of expiration and deterioration due to their incorrect conservation. In the new system, stock management shows notable improvement thanks to awareness of the exact stock in each dispenser, thereby reducing wasted inventory.

The system also makes it possible to send messages and increase information flow. The integration involves the improved flow of information while reducing administrative costs (Gattiker and Goodhue, 2000). This integration is important because the inability to share information across systems seriously affects the efficiency and cost-effectiveness of healthcare organizations (Grimson et al., 2000). Furthermore, personnel's participation in management could be one of the critical factors affecting intangible hospital value.

However, it is not always an easy task to make changes to work systems. These changes normally involve process re-engineering, resulting in organizational changes which affect both the way work is done and the control of centralized information (Niazkhani et al., 2010). Under these circumstances, personnel can reject alterations in the work system, as they are normally reluctant to change their work routines, and feel that closer supervision might be problematic (Anderson, 1997, Plotnick, 2010).

The main objective of this paper is to analyze the acceptance of EPAMMS by health care personnel (physicians and nursing), identifying influencing factors. Understanding these factors provides the opportunity to explore which actions might be carried out to boost adoption by potential users.

Technology Acceptance Model (TAM) (Davis, 1989, 1993) is often used to analyze individuals' acceptance of new technologies (Cornell et al., 2011; Dasgupta et al., 2002). TAM has become established as a robust, powerful and parsimonious model for predicting user acceptance (Hu et al., 1999, Venkatesh and Davis, 2000). Apart from the aforementioned aims, our analysis will validate TAM in the context of EPAMMS while also identifying new external variables which affect the constructs of perceived usefulness, perceived ease of use, and intention to use.

The remainder of the paper proceeds as follows. In the next section, we provide a theoretical background of TAM and posit the hypotheses. We then describe our research methodology and present data analysis and results. We then conclude, discussing implications for future research.

2. Research context and hypotheses

2.1. Technology Acceptance Model

The theoretical grounding for the model is the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975). TRA is based on the concept that beliefs influence attitudes, which then generate behavior, and TAM specifies the causal relationships between systems design features, perceived usefulness, perceived ease of use, attitude toward using, and actual usage behavior (Davis, 1993).

TAM proposes two important determinants to analyze the causes of IT acceptance or rejection: perceived usefulness and perceived ease of

use. Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort (Davis et al., 1989).

TAM addresses the issue of how users accept and use a technology (Teo and Noyes, 2011). Several papers have demostrated the usefulness of TAM for analyzing user behavior regarding, as well as intention to use, a wide range of IT (Chin and Gopal, 1995; Igbary, et al., 1996; Gefen and Straub, 1997; Hu, et al., 1999; Chau and Hu, 2002).

This model has been used to explain intention of use by different IT users, including an analysis of the conditions in which technology is used (Venkatesh, 2000), gender aspects (Gefen and Straub, 1997; Venkatesh and Morris, 2000), and cultural factors (Teo et al., 2008). A number of studies have been carried out in a health care environment (Chau and Hu, 2002; Hu et al., 1999; Thuemmler et al., 2009), often with significant results.

2.2. Hypotheses

TAM arises from the theory that perceived ease of use of a technology affects perceived usefulness. Some studies have confirmed this relationship (Liaw and Huang, 2003; Shang et al., 2005), some have rejected it (Agarwall and Prasad, 1999; Venkatesh and Morris, 2000), and others ignore it (Gefen and Straub, 1997; Liu and Wei, 2003). The intensity and direction of this relationship is not uniform, depending on the degree of innovativeness of the technology (Peffers and Dos Santos, 1996). A technology perceived to be easier to use and/or to have higher usefulness is more likely to be accepted. The first three hypotheses in the proposed model are based on three basic relationships set up in TAM (Davis, 1989; Davis et al., 1989):

H1. Perceived ease of use has a significant effect on the perceived usefulness of EPAMMS.

H2. Perceived ease of use has a significant effect on the intention to use EPAMMS.

H3. Perceived usefulness has a significant effect on the intention to use EPAMMS.

Perceived ease of use and perceived usefulness have traditionally been used as determinants of individual technology adoption (Szajna, 1994; Koufaris, 2002). However, these two variables do not fully reflect users' motivation to adopt EPAMMS. To complete the proposed model, we include four external variables which might be relevant for health care personnel to adopt EPAMMS. These external variables influence users' attitude toward a behavior indirectly by influencing salient beliefs about the consequences of performing the behavior (Fishbein and Ajzen, 1975).

Perceived compatibility

Despite the potential benefits of EPAMMS, resistance to change must be taken into account in order to achieve the desired results. This is a common challenge faced during IT implementation (Jones, 2003; Lippert and Davis 2006). The use of new technologies normally implies changes in the way tasks are carried out, sometimes generating reticence in those involved. Health care personnel are faced with acquiring new skills on a steep learning curve (Thuemmler et al. 2009), which is not always in line with the way they usually work. This can be frustrating for managers; after they have invested in new technologies, they may find these technologies rejected by reticent heath care personnel. We therefore hypothesize:

H4: Perceived compatibility with users´ tasks has a significant effect on perceived usefulness of EPAMMS.

H5: Perceived compatibility with users´ tasks has a significant effect on perceived ease of use of EPAMMS.

Perceived usefulness to enhance control systems

A key benefit of automated control systems is the detection and prevention of errors. Users can modify their intention of use IT because they consider IT is necessary (Klopping and McKinney, 2004). However, users might not only consider EPAMMS useful for improving productivity, but also for detecting and correcting medication errors. Perceived usefulness by health care personnel, and, therefore, intention of use, are closely related to the perceived ability of the new system to enhance control systems. The next hypotheses can be stated:

H6: Perceived usefulness to enhance control systems has a significant effect on perceived usefulness of EPAMMS.

H7: Perceived usefulness to enhance control systems has a significant effect on the intention to use EPAMMS.

Training

Effective innovation implementation often requires significant investments of time and money in start-up, training, and user support (Katherine and Knight, 2005). Training provided to health care personnel can have a significant influence on the perceived ease of use and perceived usefulness of EPAMMS. Training can facilitate learning processes, highlighting the relative advantages of technology in order to improve intention to use (Cooner and Rumelt, 1991; Robinson et al., 2005). One of the most frequently cited barriers to technology use is lack of training (Keil et al., 1995). Consequently, the following hypotheses are stated:

H8: Training has a significant effect on perceived usefulness of EPAMMS.

H9: Training has a significant effect on perceived ease of use of EPAMMS.

Perceived risks

A healthcare system failure can have serious consequences. The perception of possible risks related to EPAMMS could affect user intention to use new technologies. Health care personnel make continuous efforts to reduce risks due to the serious repercussions involved. Legal and economic factors, as well as public trust in the healthcare system, have also been affected by these risks. Therefore, perceived risk could have a significant impact on the user's intention to use new technologies (Cho, 2004). EPAMMS have significant advantages, from reduced paperwork to decreased medication errors. However, the potential for data loss and system failures present serious risks. Consequently, the last hypotheses are:

H10: Perceived risks have a significant effect on perceived usefulness of EPAMMS.

H11: Perceived risks have a significant effect on perceived ease of use of EPAMMS.

The proposed model has seven constructs and eleven hypotheses have been generated from relationships between these constructs (figure 2).

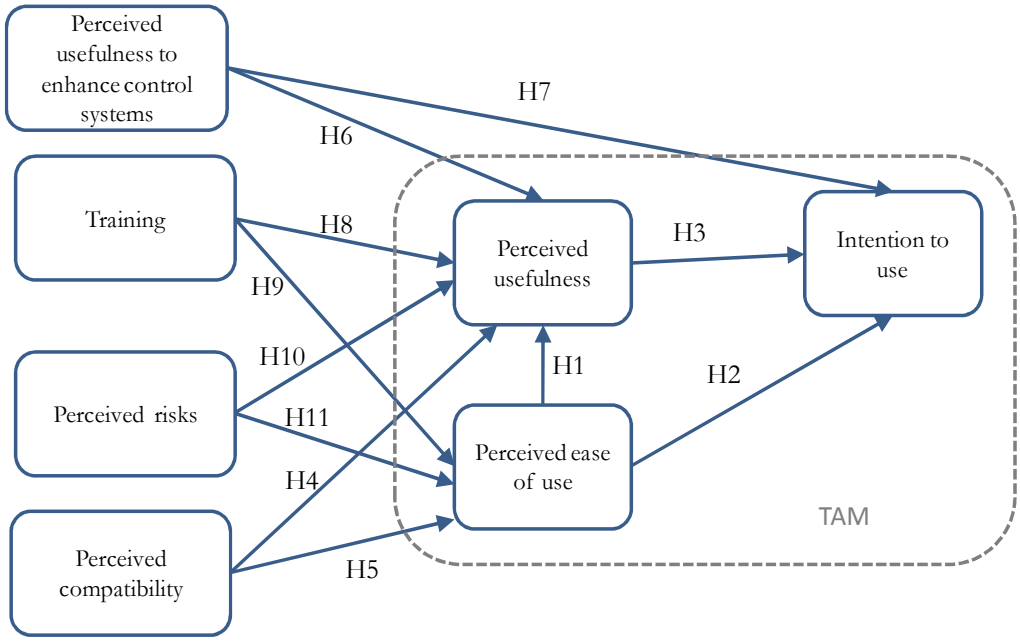

Figure 2. Research model, relations and hypothesis of different constructs

3. Methodology

This research uses regression analysis of latent variables with the Partial Least Squares (PLS) optimization technique to develop a model that represents the relationships among the seven proposed constructs measured by multiple items. PLS is a multivariate technique to test structural models (Wold, 1985), estimating the parameters which minimize the residual variance of the entire model's dependent variables (Hsu et al., 2006). It does not require any parametric conditions (Chin, 1998) and is recommended for small samples with non-normal data (Hulland, 1999). These PLS characteristics are different from those of the Structural Ecuations Models based on covariance analysis, which requires a high sample due to the sensitiveness of the Chi-square test. Basically, the objective of the PLS modeling is predicting dependent variables, latent and manifest, maximizing the explained variance of the dependent variables and minimizing the residual variance of endogenous

variables (Lévy et al, 2009). PLS method is more oriented to the model predictability (Chin and Frye, 2003) and the estimates' stability will be measured by the Student T statistic, issued from a bootstrapping made over random samples.

This study was carried out in the Infanta Elena Hospital (IEH). IEH is a Spanish hospital created in 1985 that provides health care to an estimated 200,000 individuals in 17 different towns. Its installations include over 320 beds, with a full-time staff of 1,100 including physicians, health care and other employees. In Spanish public hospitals, health care personnel are public servants with permanent contracts, so it is very important to analyze their intention to use new technologies because they are in a very strong position to hinder new systems and process re-engineering.

The IEH understands that information management is one cornerstone of system operation, and that acquiring technology is essential for adequate information handling. This is true for decision support not only at strategic and tactical levels, but also at the operating level, to facilitate daily clinical activity. Top management has shown an interest in seeking efficient solutions to prevent medication errors. Traditionally, at the IEH, the drug ordering and delivery process was handled manually, with no IT support. A review of the pharmacy service indicated that working procedures might be improved to prevent certain medication errors, and that it was important to include more widespread controls to detect mistakes. With managers' support, in April 2007 a project began deploying IT and continuous control systems with two major focuses:

- The modification of work processes through the use of IT to reduce medication errors.

- The introduction of new control mechanisms using continuous and automated control systems making it possible to detect and correct medication errors as they occur.

The project lasted four years beginning in 2007. These changes involved the re-engineering of processes, resulting in organizational changes which affected the way work is done. This study took place among hospital physicians and nurses. Data were collected in May of 2011, with a total of 209 valid replies received. Of these, 91 were physicians and 118 nurses.

The questionnaire has several items related to each of the constructs included in the model. The survey items were measured using a seven-point Likert scale. All items ranged from 1 (strongly disagree) to 7 (strongly agree). Theoretical constructs were operationalized using validated items from prior research. Perceived ease of use, perceived usefulness and intention to use EPAMMS were measured using items adapted from Davis (1989, 1993), Davis et al. (1989) and Mathieson (1991). The measurement of "Perceived compatibility" was adapted from Dasgupta et al. (1999) and Moore and Benbasat (1991). "Training" and "Perceived risks" items' measures are based on Carr et al. (2010). Items for "Perceived usefulness to enhance control systems" were specifically developed for this research.

4. Data analysis and results

Data analysis took place via a two-stage methodology, in which the measurement model first was developed and evaluated separately from the full structural equation model (Gerbing and Anderson, 1988). The first step involved establishing individual reliability for each item, followed by determining the convergent and discriminate validity of the constructs.

Individual item reliability was determined via loadings or correlations between the item and the construct. The convergent validity of each construct is acceptable for a loading higher than 0.505 (Falk and Miler, 1992). Table 1 indicates the loading for each item. All variables complied with established conditions.

Construct	Indicador	Mean	Standard deviation	Loading
Perceived usefulness to enhance control systems (PUC)	PUC1. EPAMMS can enhance medication errors controls.	5.301435	1.605294	0.8153
	PUC2. EPAMMS improve the quality of control activities.	5.043062	1.591160	0.9149
	PUC3. EPAMMS enable to develop continuous control systems.	4.923445	1.472137	0.9254
Training (T)	T1. The kind of training provided to me about EPAMMS was complete.	3.540670	1.729140	0.8797
	T2. My level of understanding about EPAMMS was substantially improved after going through the training program.	4.114833	1.619063	0.9277
	T3. The training gave me confidence in EPAMMS.	3.990431	1.740332	0.9174
Perceived risks (PR)	PR1. There is a significant potential for loss data with EPAMMS.	3.894737	1.759158	0.7457
	PR2. There is a significant risk of potential failure to using EPAMMS.	4.234450	1.885563	0.9039
	PR3. Using EPAMMS is not completely sure.	4.488038	1.909264	0.9011

Perceived compatibility (PC)	FC1. Using EPAMMS is not completely compatible with my current situation.	4.215311	1.828344	0.8319
	FC2. I think that using EPAMMS do not fit well with the way I like to work.	4.124402	1.874379	0.9067
	FC3. Using EPAMMS is not compatible with aspects of my work.	3.473684	1.921670	0.7286
Perceived usefulness (PU)	PUE1. Using EPAMMS improve my job performance.	3.205742	1.852951	0.9291
	PUE2. EPAMMS support critical aspect of my job.	3.009569	1.706860	0.9469
	PUE3. Using EPAMMS allows me to accomplish more work than would otherwise be possible.	2.578947	1.636347	0.8948
Perceived ease of use (PEU)	PEU1. I often become confused when I use EPAMMS. (*)	4.507177	1.978538	0.8831
	PEU2. I make errors frequently when using EPAMMS. (*)	4.110048	1.863708	0.8723
	PEU3. Interacting with EPAMMS is often frustrating. (*)	4.397129	1.863153	0.8162
Intention to use (IU)	IU1. I will use EPAMMS in my patient care and management if it is available in my department.	4.866029	1.868577	0.9450

	IU2. I will use EPAMMS to provide health-care services to patients as often as needed.	4.966507	1.838119	0.9437
	IU3. To the extent possible, I would use EPAMMS to do different things, clinical or nonclinical.	4.311005	1.795808	0.8481

Table 1. Items descriptive and loading (*) Reverse scaled items

The reliability of a measure is that part containing no purely random error (Carmines and Zeller, 1979). The reliability of a research instrument concerns the extent to which the instrument yields the same results on repeated trials (Roca *et al.*, 2009). To verify the realibility of each indicator, the Cronbach coefficient alpha (Cronbach, 1970) and the composite reliabilities coefficient (Werts et al., 1974) were utilized, each ranging from 0 (no homogeneity) to 1 (maximun homogeneity). Both parameters are taken into account, as the first considers the contribution made by each indicator to the construct, while the second takes the respective item's loading into account. Table 2 indicates the values of each coefficient. Composite reliabilities are over the minimun acceptable limit of 0.70 (Gefen et al., 2000; Nunnally, 1978). The Cronbach coefficient alpha levels are also shown in Table 2. They were all above 0.70, which is recommended for confirmatory research (Churchill, 1979).

Construct	Composite Reliability	AVE	Cronbach Alpha
Perceived usefulness to enhance control systems (PUC)	0.916584	0.786061	0.861794
Training (T)	0.934076	0.825340	0.894199
Perceived risks (PR)	0.888677	0.728341	0.814729
Perceived compatibility (PC)	0.864374	0.681646	0.761006
Perceived usefulness (PU)	0.945877	0.853558	0.913431
Perceived ease of use (PEU)	0.892902	0.735614	0.820331
Intention to use (IU)	0.937763	0.834298	0.900022

Table 2. Composite reliability, AVE and Cronbach coefficient alpha

Convergent validity represents the common variance between the indicators and their construct. It is measured by the Average Variance Extracted (AVE), and the acceptable thereshold should be above 0.50 (Fornell and Larker, 1981). Table 2 presents the AVE scores achieved for each of the seven constructs in the model, all of which surpass the minimun desirable value.

To confirm the discriminant validity among constructs, the AVE square root must be superior to the correlation between constructs (Fornell and Larker, 1981). Table 3 indicates the square roots of the AVE (along the diagonal) and the correlation between constructs. It suggests adequate discriminant validitiy of the measurements.

	PUC	T	PR	PC	PU	PEU	IU
PUC	***0.864***						
T	0.223	***0.897***					
PR	-0.013	0.073	***0.832***				
PC	-0.178	-0.303	0.343	***0.817***			
PU	0.272	0.434	-0.189	-0.533	***0.936***		
PEU	-0.161	-0.211	0.539	0.645	-0.456	***0.827***	
IU	0.457	0.162	0.042	-0.270	0.256	-0.214	***0.896***

Table 3. Discriminant validity of constructs

In order to complete the analysis of the convergent and discriminant validity of the measurements, the factor structure matrix of loadings and cross-loadings is analyzed (Table 4). Items measuring the same construct indicate distinctly higher factor loadings on a single construct than on other constructs. This is also an indication of the convergent and discriminant validity of the measurement.

	PUC	T	PR	PC	PU	PEU	IU
PUC1	**0.8153**	0.1960	-0.0091	-0.1181	0.1517	-0.1963	0.2992
PUC2	**0.9149**	0.1895	-0.0382	-0.0726	0.1808	-0.1724	0.3566
PUC3	**0.9254**	0.2609	-0.1006	-0.2083	0.2315	-0.2036	0.3978
T1	0.1117	**0.8796**	-0.0475	-0.2552	0.4117	-0.2186	0.2159
T2	0.2614	**0.9277**	0.0095	-0.2509	0.4079	-0.1763	0.3005
T3	0.2792	**0.9174**	-0.0986	-0.3589	0.5276	-0.3395	0.3394
PR1	-0.0029	0.0004	**0.7457**	0.2893	-0.1585	0.3918	-0.0658
PR2	-0.0808	-0.0588	**0.9039**	0.3903	-0.2945	0.5487	-0.1721
PR3	-0.0573	-0.0735	**0.9011**	0.4391	-0.2819	0.5559	-0.0922
PC1	-0.0898	-0.3286	0.4028	**0.8319**	-0.4242	0.4989	-0.2259
PC2	-0.1616	-0.2844	0.4082	**0.9067**	-0.5455	0.5906	-0.2591
PC3	-0.1254	-0.1915	0.2807	**0.7286**	-0.4096	0.4683	-0.4060
PU1	0.1902	0.4817	-0.2740	-0.5390	**0.9291**	-0.4624	0.3589
PU2	0.2519	0.5035	-0.3221	-0.5705	**0.9469**	-0.5362	0.4016

PU3	0.1425	0.3995	-0.2109	-0.4331	**0.8948**	-0.4207	0.2871
PEU1	-0.1982	-0.2629	0.5542	0.5336	-0.4393	**0.8831**	-0.2464
PEU2	-0.1852	-0.1704	0.5483	0.4587	-0.3468	**0.8723**	-0.2656
PEU3	-0.1682	-0.2803	0.4278	0.6215	-0.5269	**0.8162**	-0.2107
IU1	0.4000	0.3007	-0.1272	-0.3305	0.3446	-0.2781	**0.9450**
IU2	0.3876	0.2876	-0.1075	-0.3327	0.3313	-0.2587	**0.9437**
IU3	0.3037	0.2883	-0.1326	-0.3021	0.3762	-0.2278	**0.8481**

Table 4. Factor structure matrix of loadings and cross-loadings

After individual item reliability and convergent and discriminate construct validity have been established, the structural model is examined. To test H1 through H11, a PLS analysis was performed. Regression coefficients are based on a bootstrapping of 500 samples (Efron and Gong, 1983) and not on samples estimator. It permits the generalization of the results and the computation of the t-value for each hypothesis (Lévy et al., 2009). The results are presented in Figure 3, and Table 5 summarizes the relationships between the different constructs. The predictive capability of the model is satisfactory because all R-Squares are higher than 0.10 (Falk and Miller, 1992).

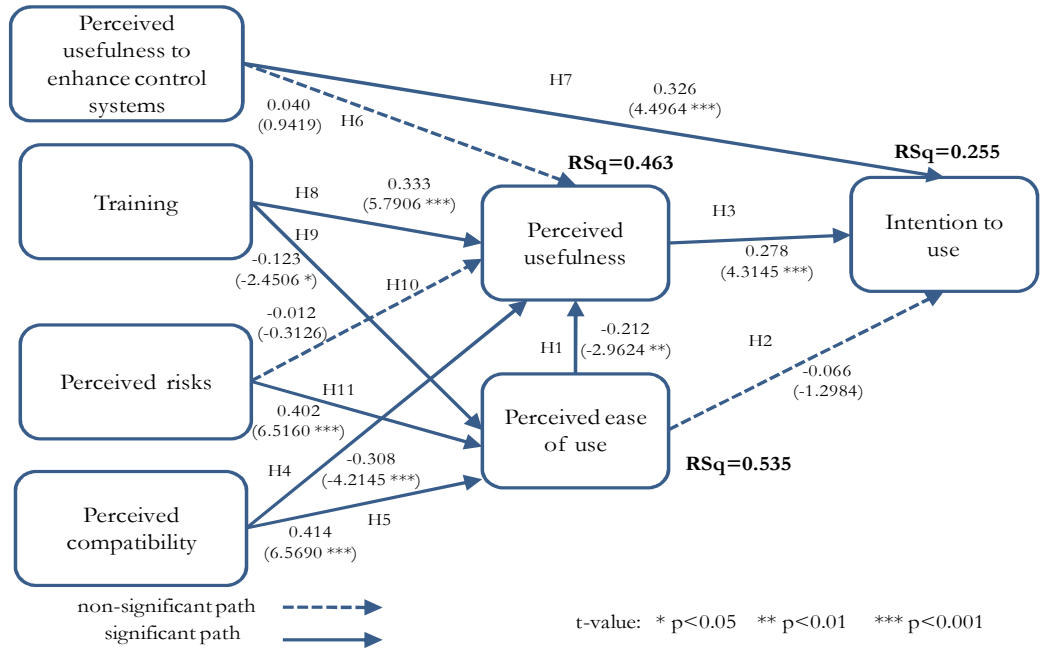

Figure 3. Results of testing model

Hypothesis	Path	Standardized path coefficient	t-value	Supported?	Construct	R-Squared
H1	PEU→PU	-0.212	-2.9624	Yes, p<0.01	Perceived usefulness	0.463
H4	PC→PU	-0.308	-4.2145	Yes, p<0.001		
H6	PUC→PU	0.040	0.9419	No		
H8	T→PU	0.333	5.7906	Yes, p<0.001		
H10	PR→PU	-0.012	-0.3126	No		
H5	PC→PEU	0.414	6.569	Yes, p<0.001	Perceived easy of use	0.535
H9	T→PEU	-0.123	-2.4506	Yes, p<0.05		
H11	PR→PEU	0.402	6.5160	Yes, p<0.001		
H2	PEU→IU	-0.066	-1.2984	No	Intention to use	0.255
H3	PU→IU	0.278	4.3145	Yes, p<0.001		
H7	PUC→IU	0.326	4.4964	Yes, p<0.001		

Table 5. Summary of test results for the structural model

The proposed model has been tested with a sample of 209 users of the EPAMMS. Of these 209 users, 91 were physicians and 118 nurses. The roles of these user groups are somewhat differentiated. Physicians are introducing the e-prescriptions in the system. E-prescriptions are the input to the system and include all information about what drugs must be administrated to the patients. On the other hand, nurses receive drugs from the automated medication-management systems and administer the prescribed medicine to the patients in the required dosage. Thus, we could expect some differences in factors which might influence intention to use this system if we test the research model for each group separately.

To identify potential differences, the model has been tested for physicians and for nurses separately. Group 1 includes physicians, while Group 2 includes nurses. Results are presented in Table 6.

	Group 1 (n=91)			Group 2 (n=118)			Difference	t-value	Supported?
	Path	t-value	Supported?	Path	t-value	Supported?			
H1	-0.268	-2.100	Yes, p<0.05	-0.169	-2.142	Yes, p<0.05	-0.099	0.618	No
H2	-0.024	-0.365	No	-0.103	-1.380	No	0.079	-0.798	No
H3	0.433	4.873	Yes, p<0.001	0.096	1.505	No	0.337	-2.930	Yes, p<0.01
H4	-0.270	-2.593	Yes, p<0.01	-0.315	-3.401	Yes, p<0.001	0.045	-0.315	No
H5	0.272	2.520	Yes, p<0.05	0.488	7.418	Yes, p<0.001	-0.216	1.599	No
H6	-0.051	-0.913	No	0.127	1.740	No	-0.178	1.984	Yes, p<0.05
H7	0.273	2.677	Yes, p<0.01	0.414	4.833	Yes, p<0.001	-0.141	1.025	No
H8	0.398	4.665	Yes, p<0.001	0.275	3.646	Yes, p<0.001	0.123	-1.052	No
H9	-0.152	-2.171	Yes, p<0.05	-0.092	-1.782	No	-0.060	0.658	No
H10	0.005	0.061	No	-0.009	-0.191	No	0.014	-0.137	No
H11	0.471	4.696	Yes, p<0.001	0.378	4.852	Yes, p<0.001	0.093	-0.702	No

Table 6. Physicians versus nursing: T-tests

5. Discussion

TAM suggests that there is a significant positive relationship between perceived ease of use and perceived usefulness. Based on our research model, this hypothesis (H1, $p<0.01$) is supported. A possible explanation might be the learning process which takes place after IT introduction (Peffers and Dos Santos, 1996). The result might be based on the fact that physicians and nurses do not traditionally use IT in patient care.

Results do not support the relationship between perceived ease of use and the intention of use (H2). A possible explanation might be that health care personnel do not consider usability as an important reason to use a technology. The serious implications of their actions for patients and the great responsibility they assume could mean that intention to use a technology might depend on factors related to improving security or productivity and not on usability issues.

Similary to the literature, results indicate that perceived usefulness has a positive and significant relationship with intention to use EPAMMS (H3, $p<0.001$). Although this relationship is significant when we analyze the whole sample, if we segregate the test by group (physicians and nurses), results are only significant in the physicians group. The reason could be that the roles of these two groups are somewhat different. Physicians have immediate online access to information about each patient's history, interactions between drugs, and so on. Therefore, they believe the new systems can enhance job performance, increasing intention to use. Nurses perceive that the new system simply involves greater control over the dispensation stage, but does not affect the care provided to patients, so for this group of users perceived usefulness is not a determinant factor of the intention to use. Physicians apparently tend to be pragmatic in their technology acceptance decisions, appearing to focus on usefulness in technology assessment.

That is, a physician is likely to accept (or use) a technology when it is considered to be useful to his or her practice (Chau and Hu, 2002).

We noted a significant relationship between perceived compatibility of EPAMMS and perceived ease of use was noted (H5, $p<0.001$). Thus, the fit between users' tasks and the new system might further contribute to perceived ease of use. Also, a significant relationship between perceived compatibility and perceived usefulness was found (H4, $p<0.001$). These two significant relationships highlight the role of perceived compatibility on intention to use a technology and they are notable for health care technology developers. During the development and implementation process of health care technologies, technology developers and implementation teams might adapt systems to the new work environment, in order to ensure a good fit. If physicians or nurses perceive incompatibility between the tasks to be performed and the EPAMMS, they might find the new system difficult to use and/or useless.

One of the contributions of this research is to incorporate the construct "perceived usefulness to enhance control systems" to explain the intention to use IT. The perceived usefulness of EPAMMS to prevent medication errors has a significant relationship with the intention to use them (H7, $p<0.001$), both for physicians and nurses. This relationship implies that IT-enabled prevention of medical errors increases perceived value. Contrary to other cases (Plotnick, 2010), we found positive attitudes toward behavior change, mainly due to the potential of these new technologies to prevent medication errors and reduce the risks associated with patient treatment.

Although people are often reluctant to be controlled, our results show that when control mechanisms are designed to improve patient safety, they are well received by health care personnel. Moreover, if results for each group separately are analyzed, this is the only factor

that holds a significant relationship with the nurses' intention to use the system.

Should hospital managers choose to support IT implementation, they should stress its usefulness for health care personnel in order to improve control systems and prevent potential errors. Hospitals can take appropriate steps to positively influence this perceived usefulness.

On the other hand, we found no significant relationship between perceived usefulness to enhance control systems and perceived usefulness to enhance the user's performance (H6). This relationship is not significant for either the whole sample or for each group (physicians and nurses) separately. However, the perception of each group is different and they present significant differences in the direction of this relationship (Table 6). The direction of this relationship is possitive for physicians and negative for nurses.

Hypotheses 8 and 9 are concerned with the relationship between training, perceived usefulness and perceived ease of use. One mechanism for influencing intention to use EPAMMS is through training. We found that training positively influences perceived usefulness (H8, $p<0.001$) and perceived ease of use (H9, $p<0.05$). Training is critical to achieving effective IT implementation in hospitals. These significant relatonships show that training has increased both the perceived ease of use and the perceived usefulness of EPAMMS. Therefore, hospital managers should focus training not only on system use, but also on system usefulness. To convince physicians and nurses to adopt these systems, hospital administrators should emphasize the functional benefits of the technology from reduced paperwork to decreased medication errors.

The test results clearly suggest that perceived risk has a significant relationship with perceived ease of use (H11, $p<0.001$). Users who perceive high risks for losing data or system failures do not find them easy to use. Contrary to other cases (Carr et al., 2010), the relationship

between perceived risks and perceived usefulness (H10) is not supported by the test results summarized in Tables 5 and 6.

6. Concluding remarks

Hospitals are undergoing significant changes, mainly due to IT applications within the health care process. Within this framework, the use of EPAMMS helps prevent medication errors, and improve quality of service while increasing efficiency. This study analyzes physicians' and nurses' intention to use this technology, identifying influencing factors. Understanding these factors offers opportunities to explore which actions might be carried out to increase its use and, therefore, to improve the patients safety.

TAM has been extended in this study, through the addition of four external variables (perceived compatibility, perceived usefulness to enhance control systems, training, and perceived risks) in the context of EPAMMS. The findings above suggest that TAM is a valid model, which can be used to predict the intention of use by physicians and nurses of these systems.

Improving the perceived compatibility of these systems by health care personnel is a central issue. In addition, results show that perceived risks are related to the difficulty of its usage. Trainig processes might not only explain system use but also illustrate the ability of the system to enhance job performance and control systems.

Finally, perceived usefulness to enhance control systems has a significant relationship with intention to use EPAMMS. This demonstraes a significant concern regarding the effects of medication errors on patient safety. Therefore, they welcome automated control mechanisms that prevent these risks.

This study validates existing research results involving different technologies, users, and/or organizational contexts. There is notably

little research on what forces effectively influence successful technology implementation at hospitals. Therefore, this research integrates the appropriate information systems literature in order to enhance the knowledge of healthcare technology from the users' perspective. A further theoretical contribution is the development and validation of survey measures for the constructs examined in this study, particularly for the constructs "perceived compatibility", "perceived usefulness to enhance control systems" and "perceived risks". In a situation where theory is advanced, it is essential to involve the creation and validation of new measures, and such efforts are considered an important contribution to scientific practice in the information systems field (Straub et al, 2004). These measures can be utilized to examine other emerging technologies within the context of healthcare organizations.

In addition to the theoretical contribution, the research model suggests important practical implications for EPAMMS acceptance and develops an understanding about how to improve intention to use them in hospitals. This research can be used to direct hospitals toward successful paths for supporting IT implementation. In this regard, the following recommendations to hospitals based on our findings could be pointed out. During the development and implementation process of health care technologies, technology developers and implementation teams might adapt systems to the new work environment, in order to ensure a good fit. Achieving the participation, collaboration and acceptance of all the members of the organization is, without doubt, one key factor for the successful implementation of a new technology. Therefore, during the implementation process, interdepartamental collaboration and communication should be reinforced. Top managers, project managers and software suppliers should have a positive attitude to reduce the perceive incompatibility between the tasks to be performed and the EPAMMS because if physicians or nurses perceive

this incompatibility, they might find the new system difficult to use and/or useless.

Training is also a very important issue. Top managers should design training programs focussed on boosting the acceptance of this technology by physicians and nurses. This training programs should have common contents for physicians and nurses, but also specific contents for each one. The training programs should include training focuses on reducing perceived risk of EPAMMS and how to handle the system. However, specific contents are required. Training of physicians should include the value of this system to enhance his or her job performance and to improve control systems. On the other hand, training of nurses should highlight the ability of EPAMMS to enhance control systems because this seems to be the only factor that holds a significant relationship with the nurses' intention to use the system.

Although the results can be considered mostly statistically significant, there are several limitations to this study. First, selft-reports are used to measure behavior. Self-reports may create selft-generated validity and thus inflated causal linkages (Feldman and Lynch, 1988). Second, users' responses may not be actual perceptions, but rather the subject's report of their perception. Third, although the sample size was quite large compared to sample sizes of other TAM studies, and representative, it consisted of Spanish users only. This has an effect on the generalization of the findings. Forth, data used in this paper are derived from a questionnaire administered at a single point in time. Therefore, variables are not measured over time.

Further research might investigate the importance of influences such as individual and national differences, prior experience, and the role of technology in hospitals as predictors of perceived ease of use and usefulness. It would be also interesting to analyze this problem in the light of other theories such as social exchange theory or social network theory. Future research should examine the findings of the current

work in a context where usage can be measured in order to add additional credibility to the model. Furthermore, the same variables could be measured over time to capture the dinamic of the research model.

CAPÍTULO 3

The acceptance of information technology innovations in hospitals: differences between early and late adopters

Abstract

The increasing maturity of information technologies in hospitals and their infrastructure development is improving the quality and efficiency of healthcare services. In these circunstances, an investigation of the diffusion of information technologies in this context would provide some insight into adopters´ behaviors and further the diffusion of information technologies in the near future. In this paper, an investigation of the diffusion of information technologies innovations in hospitals is conducted. Technology Acceptance Model and Innovation Diffusion Theory have been applied in this research trying to find factors that permit an effective discrimination between early and late adopters. The differences in characteristics between these two categories are assessed and implications based on the research findings are discussed.

1. Introduction

The motivations of individuals to accept new information technologies (IT) persist as an important issue among researchers, theorists and practitioners (Piccoli and Ives, 2005). IT acceptance research has yielded many competing models, each with different sets of acceptance determinants (Venkatesh et al., 2003). Among these models, Technology Acceptance Model (Davis, 1989) and the Innovation Diffusion Theory (Rogers, 1983) can be considered valuable and useful for explaining or predicting user acceptance of IT.

Technology Acceptance Model (TAM) specifies the causal relationships between systems design features, perceived usefulness, perceived ease of use, attitude toward using, and actual usage behavior (Davis, 1993). TAM proposes two important determinants to analyze

what causes people to accept or reject IT: perceived usefulness and perceived ease of use. Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. On the other hand, perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort (Davis et al., 1989). TAM addresses the issue of how users accept and use a technology (Teo and Noyes, 2011). Several papers have demonstrated the usefulness of TAM for analyzing user behavior as well as intention of use of a wide range of IT (Chin and Gopal, 1995; Igbary, et al., 1996; Gefen and Straub, 1997; Hu et al., 1999; Chau and Hu, 2002).

Other popular and enduring conceptualization of IT adoption is Rogers' theory. Innovation Diffusion Theory (IDT) focuses on the diffusion of innovations among individuals. Roger (1983) identifies different adopter categories depending on how inclined an individual is to adopt new technologies as compared to other members of the social system. Adopter categories include early and late adopters. Early adopters are open to change. They seek out and embrace innovations, are venturesome and not afraid of risks. Late adopters are slower to adopt new technologies, and tend to be skeptical about innovations.

Early adopters basically play the important role of getting innovations started, and they transmit their beliefs and commitment through their professional networks, mainly by means of inter-personal communication, social interdependence and imitation (Kirton, 2000). Some researchers have applied the rational perspective to gain a better understanding of early adopters' motivations. Under the rational approach, pioneers make their decisions based on information about the innovation and how well it fits with their organizational context and objectives (Fichman, 2004). However, early adopters take important decisions on innovations when their benefits and losses are still not clearly defined (Harrison and Waite, 2006).

The speed of diffusion of a new technology depends not only on the characteristics of the IT itself, but also on the characteristics of the users to whom it is directed (Kavak and Demirsoy, 2009; Teo et al., 2004). Therefore, it is would be interesting to know the characteristics of potential users who make up each adopter category (early or late adopters). It would facilitate the identification of individuals who are the first to try the new IT and could help to accelerate its diffusion process.

In this paper we draw upon IDT and TAM to identify systematic differences between early and late adopters. The main objective of this paper is to analyze how early adopters differ from late adopters for the same set of variables in order to better understand the time of adoption decision. We try to find new factors that permit an effective discrimination between early and late IT adopters. Thus, we extend IDT by characterizing early and late adopters based on constructs found relevant in TAM.

The remainder of the paper proceeds as follows. In the next section, we provide the theoretical background and posit the hypotheses. We then describe our research methodology and present data analysis and results. Finally, we include the discussion section and implications for future research.

2. Theory and hypotheses

IT innovation is usually defined as the adoption of a new technology by individuals or organizations in relation to their technological environment (Becker and Whisler, 1967). However, it has also been defined as the adoption of an IT what is new to the organization adopting it (Aiken and Hage, 1971). Therefore, the IT can be old with regard to other organization so long as the idea has not previously been used by the adopting organization.

Personnel who work within a functional area will tend to be the local experts in that area (Thompson, 1967). They are the most knowledgeable people in the organization regarding new IT and the suitability of technological innovations for use in their task domain (Daft, 1978). Nevertheless, the speed of the innovation process is not always the same. The diffusion of an IT innovation in an organization develops through time at a greater or lesser speed. The speed of adoption of a new IT will depend on the characteristics of potential users, in such a way that potential users will accept it at different moments in time. Thus, we will find individuals who adopt the new technology in the first phase, while others do so later (Roger, 1983).

In order for the diffusion process of an IT innovation to take place, it is necessary that this innovation is adopted by a series of individuals who have what has come to be known as early adopters. Early adopters are relatively quicker in adopting an IT innovation than other members of the same organization (Rogers and Shoemaker, 1971). Early adopters play a very important role during the innovation process because they transmit IT beliefs through the organization. Therefore, the analysis of their behaviour with respect to the acceptance of new IT in order to distinguish between early and late adopters is still a very interested research topic.

Significant progress has been made over the last decades in explaining and predicting user acceptance of IT. In particular, substantial theoretical and empirical support has accumulated in favour of TAM. The basic premise of this model is that the more accepting users are of new IT, the more they are willing to make changes in their practices and use their time and effort to actually start using this technology (Jones et al., 2010).

Basically, TAM specifies the causal relationships between perceived usefulness, perceived ease of use, and actual usage behavior. Moreover, it has been broadly extended through the addition of external variables,

trying to improve the prediction of the intention to use new IT (Seyal and Pijpers, 2004).

IDT suggests that early adopters should have more positive perceptions of using IT innovations than late adopters. Nevertheless, it is important to develop a deeper theoretical understanding of how IT innovations are diffused and accepted (Carayannisa and Turner, 2006), and how early adopters could be identified before the IT innovation process begins. The main objective of this paper is to analyze how both groups differ for the same set of variables in order to better understand the time of adoption decision, and to find new factors that permit an effective discrimination between early and late IT adopters. We will use some theoretical constructs to explain these differences according to the following TAM categories (David, 1993): Affective and behavioral responses, Cognitive response, and External stimulus.

Affective and behavioral responses

TAM is based on attitude paradigm adopted from psychology (Ajzen and Fishbein, 1977), which specifies how to measure the behavior-relevant components of attitudes (Davis, 1993). TAM considers attitude toward using as the degree of evaluative affect that an individual associates with using the IT in his or her job.

The users' affective and behavioral responses toward an innovation depend on the characteristics of the users to whom it is directed. Therefore, we can find some users willing to use new IT and some users which are more reluctant to use them. These basic assumptions of IDT are summarized in the following hypothesis:

H1. Early adopters are more willing to use IT innovations than late adopters

H2. Early adopters' attitude toward IT innovations is more positive than late adopters´ attitude.

Cognitive responses

According to TAM, perceived ease of use and perceived usefulness represent the cognitive response of IT users (Davis, 1993). These two factors have been identified traditionally as important user acceptance criteria (Goodwin, 1987; Hill et al., 1987) and could be really useful to identify early and late adopters during the innovation diffusion process. Early adopters seem to identify the potential benefits of new IT before than late adopters do. Furthermore, early adopters seem to perceive new technologies easier to use than late adopters. Therefore, these two hypotheses are stated:

H3. Early adopters perceive IT innovations easier to use than late adopters do.

H4. Early adopters perceive IT innovations to be more useful than late adopters do.

External stimulus

TAM includes a set of external variables that might influence the attitude toward a behavior indirectly by influencing the salient beliefs about the consequences of performing the behavior (Fishbein and Ajzen, 1975). During the last two decades, TAM has been extended through the consideration of different external variables in the context used to predict user acceptance of a technology. These external stimulus include the conditions in which technology is used (Venkatesh, 2000), gender aspects (Gefen and Straub, 1997; Venkatesh and Morris, 2000), cultural factors (Teo et al., 2008), organizational and environmental contexts (Lian and Lin, 2008), and so on.

According to previous TAM based papers, we have considered four external stimulus in order to discriminate between early and late IT adopters.

Resistance to change

The alignment of the innovation with previous company's business processes is for a long time considered as a critical step of the IT acceptance process (Botta-Genoulaz et al., 2005). IT innovations almost always require business process reengineering, because of the need to adapt the organizational processes to match the capabilities of the new IT (Amoako-Gyampah and Salam, 2004). Potential users may fear that the new system will make their jobs more difficult, reduce their importance, or even cost them their jobs (Yusufa et al., 2006).

Some potential users have a low readiness for change because the purpose is not clear or they are not really involved. However, other potential users are willing to change because they assume that changes are actual opportunities. The next hypothesis can be stated,

H5. Early adopters have less resistance to change than late adopters.

Perceived risk

The perception of possible risks related to innovations could affect user intention to use. Healthcare personnel make continuous efforts to reduce risks due to the serious repercussions involved. Legal and economic factors, as well as public trust in the health care system, have also been affected by these risks. Therefore, perceived risk could have a significant impact on the user's acceptance of IT innovations (Cho, 2004).

The perceived risks could depend on the characteristics of potential users. Some potential users could think that IT innovations would be risky because it would either lead to missing functions or to suboptimizing parts of the organization. However, other potential users could be venturesome and not afraid of risks. The hypothesis will be the following:

H6. Early adopters perceive IT innovations to be less risky than late adopters do.

Perceived effects on control systems

Sometimes, IT innovations capabilities are associated with the centralization of information or the standardization of business processes that usually accompanies it allows improving organizational control systems. Therefore, we could find potential users with positive reactions towards the IT innovation since it implied new and enhanced control mechanisms. On the other hand, other group of potential users would be less worried about control mechanisms and would be reluctant to use these innovations. This factor could be really important in healthcare sector, due to the serious repercussions of healthcare errors on patient safety. Therefore, we hypothesize:

H7: Early adopters perceive more effects in control systems as a result of IT innovations than late adopters.

Perceived incompatibility

Despite the potential benefits of IT innovations, perceived incompatibility must be taken into account in order to achieve the desired results. This is a common challenge faced during IT implementation (Jones, 2003; Lippert and Davis 2006). The use of new IT normally implies changes in the way tasks are carried out, sometimes generating reticence in those involved. Healthcare personnel are faced with acquiring new skills on a steep learning curve (Thuemmler et al. 2009), which is not always in line with the way they usually work. This can be frustrating for managers; after they have invested in new technologies, they may find these technologies rejected by reticent healthcare personnel. We therefore hypothesize:

H8: Early adopters perceive less incompatibility of IT innovations than late adopters do.

	Construct	Hypotheses	Early adopters	Late adopters
Affective and behavioral responses	Intention to use	H1	High	Low
	Attitude toward using	H2	High	Low
Cognitive responses	Perceived ease of use	H3	High	Low
	Perceived usefulness	H4	High	Low
External stimulus	Resistance to change	H5	Low	High
	Perceived risk	H6	Low	High
	Perceived effects on control systems	H7	High	Low
	Perceived incompatibility	H8	Low	High

Table 1. Proposed hypotheses according to TAM and IDT

3. Methodology

Improvements in the healthcare system should be based upon the premise that "to err is human" (Kohn et al., 2000). Regardless of an individual's ability or degree of concentration, it is human nature to commit errors. Therefore, systems designed to prevent errors might

include procedures created to detect and avoid such mistakes, through a systems approach, rather than focusing on the traditional "people approach" (Reason, 2000). The systems approach is based on the idea that errors can be prevented by designing work systems so that errors are difficult to make. This is the essence of the systems approach to error reduction: focus on the processes, not on the people (Leape, 1999).

The implementation of an IT innovation called "computerized physician order entry (hereinafter CPOE) system" is an important evolution in the way drugs are ordered and delivered (Bates, 2007). Under the new system, doctors do not write prescriptions by hand, instead using a computer program (e-prescriptions). Instead of generating paper-based prescriptions, e-prescriptions are produced. The physician has the necessary available information to carry out the task digitally. There is immediate online access to each patient's pharmacological and therapeutic case history; data on maximum dosage, interactions, and duration of treatment for each drug; and details regarding each patient's allergies and relevant personal situations. All information is available online, with automatic control systems generating alerts when interactions or incompatibilities are detected.

Nurses, in hospitals, still administer drugs to patients. Automated dispensing machines have replaced traditional cabinets on the units. These are a group of electronically-controlled cabinets, managed by software and connected through different IT applications. The new cabinets contain medication ready for use in different boxes, at varying degrees of access control. These automated dispensing machines are placed in clinical units and are connected to a central console.

Nurses identify themselves in the automated based-unit medication storage and distribution systems via fingerprint identification or personal access code. This is another control, noting which staff member has withdrawn and administered which medication to which patient. Once identified, the employee selects the patient, and the

machine dispenses the exact amount of drugs prescribed by the doctor on the e-prescription that was previously validated by the pharmacy.

Based on this IT innovation, a field survey was employed to test our hypotheses. This study was carried out in the Infanta Elena Hospital (hereinafter IEH), a Spanish hospital created in 1985 that provides healthcare coverage to an estimated 200,000 individuals located in 17 different towns. Traditionally, at the IEH, the drug ordering and delivery process was handled manually, with no IT support. A review of the pharmacy service indicated that working procedures might be improved to prevent certain medication errors, and that it was important to include more widespread controls to detect these mistakes when they take place. With managers' support, in April of 2007 a project began deploying CPOE systems to detect and correct medication errors as they occur.

The project lasted four years beginning in 2007. Recognizing that change does not take place easily or all at once, IEH chose not to implement the new system throughout the entire organization simultaneously. After an internal communication process, the implementation was set up in two stages. From beginning 2007 to middle 2008, implementation began in areas/users perceived as more receptive to change. Then, it was extended to other hospital areas/users perceived as less receptive to the IT innovation acceptance (Table 2). The first areas were considered as early adopters and the other ones as late adopters.

FIRST STAGE	SECOND STAGE
Early Adopters	*Late Adopters*
Beginning 2007-Middle 2008	Beginning 2009-Middle 2010
Intensive care unit Pediatric unit Urgency and urology units Surgery unit	Maternity unit Digestive unit Cardiology unit Internal medicine unit Trauma unit

Table 2. Implementation schedule

Data were collected in May of 2011, with a total of 209 valid replies received. Of these, 108 were early adopters and 101 late adopters. The questionnaire has several items related to each of the constructs included in the hypotheses. The survey items were measured using a seven-point Likert scale. All items ranged from 1 (strongly disagree) to 7 (strongly agree). Theoretical constructs were operationalized using validated items from prior research. "Perceived ease of use", "perceived usefulness", "attitude" and "intention to use" CPOE were measured using items adapted from Davis (1989, 1993), Davis et al. (1989) and Mathieson (1991).

The measurement of "perceived incompatibility" and "resistance to change" were adapted from Dasgupta et al. (1999) and Moore and Benbasat (1991). "Perceived risks" items' measures are based on Carr et al. (2010). Items for "perceived effects on control systems" were specifically developed for this research.

4. Data analysis and results

Data analysis took place via a two-stage methodology, in which the measurement model first was developed and evaluated (Gerbing and Anderson, 1988). The first step involved establishing individual reliability for each item, followed by determining the convergent and discriminate validity of the constructs.

Individual item reliability was determined via loadings or correlations between the item and the construct. The convergent validity of each construct is acceptable for a loading higher than 0.505 (Falk and Miler, 1992). Table 3 indicates the loading for each item. All variables complied with established conditions.

Construct	Items	Mean	Standard deviation	Loading
Perceived effects on control systems (PEC)	PEC1. IT innovations can enhance the control of healthcare errors.	5.301435	1.605294	0.8367
	PEC2. IT innovations improve the quality of control activities.	5.043062	1.591160	0.8997
	PEC3. IT innovations enable to develop continuous control systems.	4.923445	1.472137	0.9210
Resistance to change (RC)	RC1. Meaningful change innovations are often curtailed.	3.473684	1.921670	0.9244
	RC2. I am reluctant to adopt a new technology.	3.942584	1.920676	0.8161
	RC3. I hesitate to try a new technology.	3.492823	1.911804	0.9246
Perceived risks (PR)	PR1. There is a significant potential for loss data with IT innovations.	3.894737	1.759158	0.9518
	PR2. There is a significant risk of potential failure to using IT innovations.	4.234450	1.885563	0.7611
	PR3. My job have more risks with IT innovations.	3.875598	1.744174	0.9544
Perceived incompatibility (PI)	PI1. Using IT innovations do not fit into my work style.	4.464115	1.826594	0.9034
	PI2. Using IT innovations is not completely compatible with my current situation.	4.215311	1.828344	0.9152

	PI3. I think that using IT innovations do not fit well with the way I like to work.	4.124402	1.874379	0.8850
Perceived usefulness (PU)	PU1. Using IT innovations improve the quality of the work I do.	3.947368	1.795321	0.8856
	PU2. Using IT innovations improve my job performance.	3.205742	1.852951	0.9425
	PU3. IT innovations enable me to accomplish tasks more quickly	3.301435	1.800120	0.9367
Perceived ease of use (PEU)	PEU1. I often become confused when I use IT innovations (*).	4.507177	1.978538	0.8821
	PEU2. I make errors frequently when using IT innovations (*).	4.110048	1.863708	0.8689
	PEU3. Interacting with IT innovations is often frustrating(*).	4.397129	1.863153	0.8200
Attitude toward using (A)	A01. Using IT innovations in patient care and management is a good idea	4.224880	1.816631	0.8894
	A02. Using IT innovations in patient care and management is pleasant	3.464115	1.643725	0.8893
	A03. Using IT innovations is beneficial to my patient care and managemet	3.712919	1.825007	0.9051
Intention to use (IU)	IU1. I will use IT innovations in my patient care and management if it is available in my department.	4.866029	1.868577	0.9412
	IU2. I will use IT innovations to	4.966507	1.838119	0.9389

	provide health-care services to patients as often as needed.			
	IU3. To the extent possible, I would use IT innovations to do different things, clinical or nonclinical.	4.311005	1.795808	0.8571

Table 3. Items descriptive and loading (*) Reverse scaled items

The reliability of a measure is that part containing no purely random error. The reliability of a research instrument concerns the extent to which the instrument yields the same results on repeated trials. To verify the realibility of each indicator, the Cronbach coefficient alpha (Cronbach, 1970) and the composite reliabilities coefficient (Werts et al., 1974) were utilized, each ranging from 0 (no homogeneity) to 1 (maximun homogeneity). Both parameters are taken into account, as the first considers the contribution made by each indicator to the construct, while the second takes the respective item's loading into account. Table 2 indicates the values of each coefficient. Composite reliabilities are over the minimun acceptable limit of 0.70 (Gefen et al., 2000; Nunnally, 1978). The Cronbach coefficient alpha levels are also shown in Table 4. They were all above 0.70, which is recommended for confirmatory research (Churchill, 1979).

Construct	Composite Reliability	AVE	Cronbach Alpha
Perceived effects on control systems (PEC)	0.916617	0.785879	0.861794
Resistance to change (RC)	0.919177	0.791816	0.869241
Perceived risks (PR)	0.921734	0.798645	0.862978
Perceived incompatibility (PI)	0.928473	0.812303	0.884534
Perceived usefulness (PU)	0.944404	0.850000	0.911589
Perceived ease of use (PEU)	0.892689	0.735141	0.820331
Attitude toward using (A)	0.923235	0.800366	0.874112
Intention to use (IU)	0.937674	0.834001	0.900022

Table 4. Composite reliability, AVE and Cronbach coefficient alpha

Convergent validity represents the common variance between the indicators and their construct. It is measured by the Average Variance Extracted (AVE), and the acceptable thereshold should be above 0.50 (Fornell and Larker, 1981). Table 5 presents the AVE scores achieved for each of the eight constructs in the model, all of which surpass the minimun desirable value.

To confirm the discriminant validity among constructs, the AVE square root must be superior to the correlation between constructs (Fornell and Larker, 1981). Table 5 indicates the square roots of the

AVE (along the diagonal) and the correlation between constructs. It suggests adequate discriminant validitiy of the measurements.

	PR	PU	PEC	PI	PEU	RC	A	IU
PR	**0.960**							
PU	-0.238	**0.972**						
PEC	-0.032	0.222	**0.957**					
PI	0.398	-0.542	-0.138	**0.964**				
PEU	0.492	-0.508	-0.217	0.602	**0.945**			
RC	0.283	-0.525	-0.182	0.648	0.587	**0.959**		
A	-0.192	0.727	0.358	-0.511	-0.547	-0.631	**0.961**	
IU	-0.111	0.406	0.398	-0.262	-0.279	-0.422	0.630	**0.968**

Table 5. Discriminant validity of constructs

In order to complete the analysis of the convergent and discriminant validity of the measurements, the factor structure matrix of loadings and cross-loadings is analyzed (Table 6). Items measuring the same construct indicate distinctly higher factor loadings on a single construct than on other constructs. This is also an indication of the convergent and discriminant validity of the measurement.

Items	PR	PU	PEC	PI	PEU	RC	A	IU
PR1	**0.9518**	-0.1772	-0.0061	0.3498	0.3924	0.2009	-0.1235	-0.0664
PR2	**0.7611**	-0.2936	-0.0809	0.3702	0.5477	0.3665	-0.2772	-0.1726
PR3	**0.9544**	-0.1728	-0.0026	0.3480	0.3865	0.1990	-0.1213	-0.0645
PU1	-0.2057	**0.8856**	0.2339	-0.4871	-0.4684	-0.4617	0.6672	0.4353
PU2	-0.2302	**0.9425**	0.1910	-0.4892	-0.4639	-0.4829	0.6853	0.3607
PU3	-0.2219	**0.9367**	0.1919	-0.5220	-0.4739	-0.5053	0.6589	0.3335
PEC1	-0.0326	0.1760	**0.8367**	-0.1005	-0.1964	-0.1387	0.2988	0.2978
PEC2	0.0134	0.1609	**0.8997**	-0.0438	-0.1721	-0.1135	0.2983	0.3552
PEC3	-0.0560	0.2419	**0.9210**	-0.1986	-0.2037	-0.2173	0.3479	0.3974
PI1	0.4086	-0.4493	-0.1067	**0.9034**	0.5244	0.5093	-0.4406	-0.2170
PI2	0.3533	-0.4519	-0.0923	**0.9152**	0.5000	0.5252	-0.3860	-0.2257
PI3	0.3208	-0.5511	-0.1646	**0.8850**	0.5924	0.6955	-0.5373	-0.2605
PEU1	0.4583	-0.4124	-0.1997	0.5273	**0.8821**	0.4763	-0.4756	-0.2463
PEU2	0.4139	-0.3650	-0.1856	0.4164	**0.8689**	0.4345	-0.4058	-0.2664

PEU3	0.3921	-0.5145	-0.1713	0.5860	**0.8200**	0.5823	-0.5124	-0.2094
RC1	0.2091	-0.4504	-0.1277	0.4595	0.4692	**0.9244**	-0.5657	-0.4046
RC2	0.3117	-0.4858	-0.2087	0.7364	0.5953	**0.8161**	-0.5474	-0.3291
RC3	0.2078	-0.4445	-0.1309	0.4670	0.4622	**0.9246**	-0.5573	-0.3965
A1	-0.1902	0.6355	0.3568	-0.4357	-0.4818	-0.6069	**0.8894**	0.5918
A2	-0.1200	0.6602	0.2368	-0.4484	-0.4571	-0.5606	**0.8893**	0.5345
A3	-0.2005	0.6556	0.3604	-0.4858	-0.5263	-0.5254	**0.9051**	0.5639
IU1	-0.1221	0.3640	0.4006	-0.2518	-0.2783	-0.3892	0.5934	**0.9412**
IU2	-0.0734	0.3446	0.3853	-0.2296	-0.2585	-0.4262	0.5532	**0.9389**
IU3	-0.1075	0.4028	0.3023	-0.2352	-0.2270	-0.3415	0.5779	**0.8571**

Table 6. Factor structure matrix of loadings and cross-loadings

After individual item reliability and convergent and discriminate construct validity have been established, the hypotheses are tested. All hypotheses were stated to test expectated differences between "early adopters" and "late adopters". To test H1 throug H8 T-tests were performed.

To create the scales, the means of the items in each scale were used rather than their factor scores. Factor scores may be viewed as being more exact, in that the relative weight of an item in a scale is based on

its loading on the factor (Moore and Benbasat, 1991). In some instances, this approach may be preferable as the scores may perform better than other approaches (Lastovicka and Thamodaran, 1991). Nevertheless, such scores are often less interpretable and generalizable than using simpler approaches such as summing or averaging the items that load highly on the construct (Gorsuch, 1988). For many research purposes, this simpler approach is considered entirely adequate (Tabachnik and Fidell, 1989), and hence was followed in this study. The scores of early adopters versus late adopters were compared using the t-Test. The results are presented in Table 7. As can be seen, the differences between the two groups are significant for all constructs.

	Construct	Early adopters		Late adopters		t-value	Supported?
		Mean	S.D.	Mean	S.D.		
Affective and behavioral responses	Intention to use (H1)	4.867	1.773	4.551	1.927	2.140	Yes, p<0.05
	Attitude toward using (H2)	4.176	1.760	3.399	1.735	5.559	Yes, p<0.001
Cognitive responses	Perceived ease of use(*) (H3)	4.009	1.931	4.690	1.819	-4.535	Yes, p<0.001
	Perceived usefulness (H4)	3.707	1.899	3.248	1.753	3.140	Yes, p<0.01
External stimulus	Resistance to change (H5)	3.414	1.849	3.875	1.983	-3.012	Yes, p<0.01
	Perceived Risk (H6)	3.738	1.764	4.284	1.803	-3.834	Yes, p<0.001
	Perceived effects on control systems (H7)	5.306	1.411	4.858	1.682	3.617	Yes, p<0.001
	Perceived incompatibility (H8)	4.105	1.884	4.442	1.791	-2.294	Yes, p<0.05

Table 7. Results (*) Reverse scaled items

5. Discussion

According to IDT, affective and behavioral responses are quite different in early and late adopters. The results obtained support the theory and show that early adopters are more willing to use IT innovation than late adopters. This relationship is significant (H1, $p<0.05$), so therefore the hypothesis is supported. Early adopters are more willing to use IT innovations as often as needed and to do different things, clinical or nonclinical.

Furthermore, early adopters' attitude toward IT innovations is also more positive than late adopters´ attitude (H2, $p<0.001$). Early adopters think IT innovations are a good idea and are pleased to use them more than late adopters. These results were expected because these differences are the characteristics defining early and late adopters.

Results show that one of the key factors why the implementation process was successfully is that areas perceived as more receptive to change were mainly composed of early adopters. Healthcare personnel with lower affective and behavioral responses toward IT innovations were located in those areas involved in the second implementation stage. Therefore, early adopters played a very important role during the CPOE systems implementation process because they transmitted positive affective and behavioral responses through the IEH, encouraging late adopters to use them.

TAM suggests that cognitive responses determine the affective and behavioral responses. We have tested if there are any differences between cognitive responses of early and late adopters. According to TAM, we used the constructs "perceived ease of use" and "perceived usefulness" to represent the cognitive responses of the users of this IT innovation. Findings show that cognitive responses of early adopters are more positive than late adopters' ones.

The hypothesis that early adopters perceive IT innovations easier to use than late adopters do has been supported (H3 $p<0.001$). One plausible explanation of this finding may be that early adopters usually test IT innovations and they are not worried about how to handle them. Otherwise, late adopters find IT innovations more difficult to use. However, this perception could also be due to that early adopters have more experience than late adopters with the new systems because they began to use them earlier.

Regarding the other hypothesis concerning cognitive responses, a significant relationship between "perceived usefulness" and the adopter category was noted (H4, $p<0.01$). This result could strengthen the rational perspective of early adopters' motivations and could point out that, sometimes, early adopters make their decisions based on information about the perceived usefulness of the IT innovation because they could identify the potential benefits of IT innovations before than late adopters

Four external stimulus have been considered in this study to analyze the characteristics of early and late adopters in the context of healthcare personnel. As hypothesized, resistance to change is not the same in all potential users. Results point out the early adopters have less resistance to change that late adopters (H5, $p<0.01$). Late adopters seem to be reluctant to adopt an IT innovation because they are skeptical about innovations.

Other external stimulus that has been considered in this research is the perceived risk of IT innovations. As stated, early adopters perceive IT innovations to be less risky than late adopters do (H6, $p<0.001$). It could be due to the proclivity of early adopters to take risks. In contrast to early adopters, late adopters find significant risks of potential failure when they are using IT innovations. Therefore, they perceive that they have more risks using IT innovations in their job.

Healthcare errors can be reduced by improving training and using IT innovations to prevent them (Davis, 2011). Common healthcare errors are largely preventable with education and training, and all hospitals are tasked to implement training programmes to improve patient safety (Wallymahmed, 2011). The focus of training must be on prevention of errors. However, training too often focuses on trying to prevent the healthcare personnel from making that particular error again. It could be most appropriate to focus on the underlying factors that contributed to such an error being committed (Crook et al., 2004). In this regard, healthcare managers aim to prevent medication errors through the use of IT innovations (Kohn et al., 2000), thus improving protocols and control systems.

Therefore, perceived effect on control systems is other external stimulus that could help to identify those users who are the first to try the new IT in healthcare sector. Results show that early adopters perceive more effects in control systems as a result of IT innovations than late adopters (H7, $p<0.001$). They find control systems should be improved and that IT innovations could help to reduce and prevent healthcare errors. Thus, they are willing to use IT innovations because they think new IT could improve the quality of control activities and improve patient safety.

The use of IT innovations normally implies changes in the way tasks are carried out, in certain cases creating a feeling of reticence in those involved. The last external stimulus considered in this paper is perceived incompatibility between IT innovations and the way in which healthcare personnel usually work. As hypothesized, we found that early adopters perceive less incompatibility of IT innovations than late adopters do (H8, $p<0.05$). This perception could imply that late adopters are slower to adopt IT innovations because they think that new technologies do not fit into their work style and are not completely compatible with the way they like to work. On the other hand, early adopters seem to be more

flexible and could be willing to acquire new IT skills in order to use these IT innovations.

6. Concluding remarks

This research, which has as its basis acceptance and diffusion literature, provides an interesting perspective about differences between early and late adopters. It analyzes how early adopters differ from late adopters for the same set of variables in order to better understand the time of adoption decision. Understanding these differences offers opportunities to explore which actions might be carried out to accelerate the innovation diffusion process and to improve the implementation process of IT innovations. We have extended the IDT to include constructs derived from the TAM and results provide strong support for the theoretical predictions.

Affective and behavioral responses are quite different between early adopters and late adopters. Early adopters are more willing to use IT innovations and their attitude toward IT innovations is more positive. Cognitive responses also depend on the adopter category. Results show that early adopters perceive IT innovations easier to use and to be more useful than late adopters do.

Furthermore, the perception of external stimulus is not the same for early and late adopters. Four external stimulus have been considered regarding IT innovations: resistance to change, perceived risks, perceived effect on control systems and perceived incompatibility. Early adopters have less resistance to change and perceive IT innovations to be less risky than late adopters. Moreover, they perceive more effects in control systems and less incompatibility as a result of IT innovations than late adopters.

This study validates existing research results involving different technologies, users, and organizational contexts. There is notably little

research on what forces effectively influence the innovation diffusion process at hospitals. Therefore, this research integrates the appropriate information systems literature in order to enhance the knowledge of this process from the users' perspective. A further theoretical contribution is the development and validation of survey measures for the constructs examined in this study, particularly for the constructs "perceived effect on control systems" and "perceived incompatibility". In a situation where theory is advanced, it is essential to involve the creation and validation of new measures, and such efforts are considered an important contribution to scientific practice in the information systems field (Straub et al, 2004). These measures can be utilized to examine other IT innovations within the context of healthcare organizations.

In addition to the theoretical contribution, this research suggests important practical implications and develops an understanding about how to improve the IT innovation process in hospitals. Early adopters play a very important role during the innovation process because they transmit IT beliefs through the organization. Therefore, it is quite important to identify them before deciding how the innovation will be implemented. This paper provides valuable guidelines to identity potential early adopters because these constructs and items could help to know what the adopter category of potential users is.

Although the results can be considered statistically significant in most parts, there are several limitations to this study. First, selft-reports are used to measure behaviour. Self-reports may create selft-generated validity and thus inflated causal linkages (Feldman and Lynch, 1988). Second, users' responses may not be actual perceptions, but rather the subject's report of their perception. Third, although the sample size was quite large compared to sample sizes of other studies, and representative, it consisted of Spanish users only. It has an effect on the generalization of the findings. Forth, data used in this paper are

derived from a questionnaire administered at a single point in time. Therefore, variables are not measured over time.

Further research might investigate the importance of influences such as individual and national differences or prior experience. Furthermore, the same variables could be measured over time to capture the dinamic of the research model. This knowledge could be really useful for improving the IT innovation process.

CAPÍTULO 4

Modeling nurses' attitude toward using automated unit-based medication storage and distribution systems: an extension of the technology acceptance model

Abstract

Heath care errors have got serious repercussions of on patient safety. Therefore, hospitals are focusing on new technologies to reduce errors. This paper analyzes the attitude of nurses toward using automated unit-based medication storage and distribution systems, identifying influencing factors. Understanding these factors provides the opportunity to explore which actions might be carried out to boost adoption by potential users. The theoretical grounding for this research is the Technology Acceptance Model (TAM). TAM specifies the causal relationships between perceived usefulness, perceived ease of use, attitude toward using and actual usage behavior. The proposed model has six constructs; we have generated nine hypotheses from connections among these six constructs. These constructs include perceived risks, experience and training. Our results provide support for a number of relationships in the hypothesized model.

1. Introduction

Medication mistakes are the leading type of healthcare errors affecting patients (Bates 2007; Leape et al. 1991). A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer. Such events may be related to professional practice, healthcare products, procedures and systems, which include prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use.

Medication errors may originate in one or more of four sequential stages in the drug ordering and delivery system (Leape at al. 1995): Physician ordering, transcription, dispensing and administration. Several people intervene during each stage of the drug ordering and delivery system, thereby increasing the potential risk at each stage. However, medication errors mainly take place during the physician ordering and administration stages (Baker et al. 2004, Bates et al. 1995, Forster et al. 2004, Leape et al. 1995).

Hospitals are moving from manual to automated systems based on assumptions about the value of information technology (IT): for example, that they will improve the efficiency of services or patient outcomes (Greenfield, 2008; Keen and Muris, 1995). Among other innovations, the handwritten prescription and traditional cabinets are being replaced by electronic assisted prescription systems and automated based-unit medication storage and distribution systems (Sengstack and Gugerty, 2004), all of which using integral procedures.

The implementation of an electronic assisted prescription system is an important evolution in the way drugs are ordered and delivered (Bates, 2007). Once the physician has prescribed the drugs using the electronic prescription system, the information is digitally saved into the application so that the pharmacy can gain access. It is therefore unnecessary for nurses to manually transcribe the handwritten prescriptions, with this process disappearing thanks to IT support. Nurses' roles change. They use to spend a great deal of time devoted to bureaucratic tasks such as transcription, to the detriment of time spent on patient care. The nursing staff is thereby freed from activities which do not add value, and which are also the source of potential risks, to focus on the key aspects of their jobs.

The drug dispensing procedure would also improve, through the use of automated unit-based medication storage and distribution systems. Nurses directly withdraw the prescribed medication for the patients

using automated unit-based storage and distribution systems located in the hospital units. Manual dispensing is eliminated and replaced by automated dispensing machines.

However, it is not always an easy task to make changes to work systems. These changes normally involve process re-engineering, resulting in organizational changes which affect both the way work is done and the control of centralized information (Niazkhani et al., 2010). The main objective of this paper is to analyze the attitude toward using automated unit-based medication storage and distribution systems by nurses, identifying influencing factors. Understanding these factors provides the opportunity to explore which actions might be carried out to boost adoption by potential users.

Technology Acceptance Model (TAM) (Davis, 1989, 1993) is often used to analyze individuals' acceptance of new technologies (Cornell et al., 2011; Dasgupta et al., 2002). TAM has become established as a robust, powerful and parsimonious model for predicting user acceptance (Hu et al., 1999, Venkatesh and Davis, 2000). Apart from the aforementioned aims, our analysis will validate TAM in the context of automated unit-based medication storage and distribution systems while also identifying new external variables which affect the constructs of perceived usefulness, perceived ease of use, and attitude toward using.

The remainder of the paper proceeds as follows. In the next section, we provide a theoretical background of TAM and posit the hypotheses. We then describe our research methodology and present data analysis and results. Lastly, we conclude, discussing implications for future research.

2. Theoretical background and hypotheses

TAM specifies the causal relationships between systems design features, perceived usefulness, perceived ease of use, attitude toward

using, and actual usage behavior (Davis, 1993). The basic premise of this model is that the more accepting users are of new systems, the more they are willing to make changes in their practices and use their time and effort to actually start using the system (Jones et al., 2010).

TAM proposes two important determinants to analyze what causes people to accept or reject information technology (IT): perceived usefulness and perceived ease of use. Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. On the other hand, perceived ease of use refers to the degree to which a person believes that using a particular system would be free of effort (Davis et al., 1989) (figure 1).

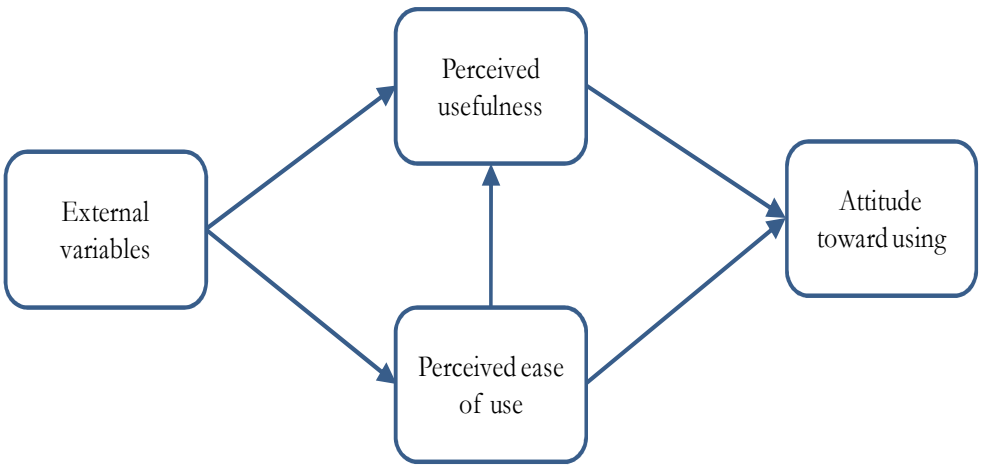

Figure 1. Technology Acceptance Model

TAM addresses the issue of how users accept and use a technology (Teo and Jones, 2011). Several papers have demonstrated the usefulness of TAM for analyzing user behavior as well as intention of use of a wide range of IT (Chin and Gopal, 1995; Igbary et al., 1996; Gefen and Straub, 1997; Hu et al., 1999; Chau and Hu, 2002)..

A number of studies have been carried out in the context of healthcare technology to analyze users' acceptance, often with

significant results. Mc Dowell et al. (2008) examined the effects of nurses' perceptions of ease of use, usefulness, and documentation accuracy on their perceptions of improved quality benefits from information systems. Their findings support that usefulness and documentation accuracy of an information system are highly influential in the nurses' perception of quality benefits from the system. Culler et al. (2011) found that nursing staff acceptance of health information technology is aided by the system's ability to improve patient safety and accessibility of patient information.

Schnall et al. (2011) analyzed the attitudes toward handheld decision support software scale. Zhang et al. (2010) examined the factors of adoption of mobile information technology be homecare nurses. They found that perceived usefulness and perceived ease of use are reasons explaining a significant portion of the intention to use this healthcare technology.

Other factors related with nurses' predisposition to new technology have also been considered. For instance, Kowitlawakul (2011) used TAM to predict nurses' intention to use telemedicine technology. Results showed that the principal factors that influence perceived usefulness are perceived ease of use, support from physicians, and years working in the hospital. Carr et al. (2010) investigated the healthcare organization's intention to use radio frequency identification technology for improving efficiency. Results found indirect relationships between the factors perceived resistance to change, risk, suppliers' support and perceived ease of use with the factor intention to adopt RFID technology in the healthcare organization.

TAM has been tested primarily on technologies that are voluntary. Several researchers have recommended that TAM be revised to address user attitude, intent and behaviour when applied to complex IT in organizational settings where usage is generally considered mandatory (Nah et al., 2004). Nurses do not have the choice to avoid the unit-

based medication storage and distribution systems, regardless of their attitudes about these systems (Sternad et al., 2011). Following to Nah et al. (2004), we analyze nurses' attitudes toward using unit-based medication storage and distribution systems, which refers to nurses' voluntary mental acceptance of the system. Therefore, TAM can be considered valuable and useful for explaining or predicting nurses' attitude toward using automated unit-based medication storage and distribution systems.

The aim of this paper is to extend the number of observed factors which influence attitude toward using new technologies in hospitals. We try to understand the relationships between external variables and users' attitude. Apart from the abovementioned aims, this analysis will validate the TAM in the context of unit-based medication storage and distribution systems in hospitals while also identifying new external variables which affect the constructs of perceived usefulness and ease of use.

Perceived ease of use and perceived usefulness have traditionally been used as determinants of individual technology adoption (Szajna, 1994; Koufaris, 2002). A technology perceived to be easier to use and/or to have higher usefulness is more likely to be accepted. The first three hypotheses in the proposed model are based on three basic relationships set up in TAM (Davis, 1989; Davis et al., 1989):

H1. Perceived ease of use has a significant effect on the perceived usefulness of unit-based medication storage and distribution systems.

H2. Perceived ease of use has a significant effect on the attitude toward using unit-based medication storage and distribution systems.

H3. Perceived usefulness has a significant effect on the on the attitude toward using unit-based medication storage and distribution systems.

However, these two variables do not fully reflect users' motivation to adopt unit-based medication storage and distribution systems. To complete the proposed model, we include three external variables which might be relevant for healthcare personnel. These external variables influence users' attitude toward a behavior indirectly by influencing salient beliefs about the consequences of performing the behavior (Fishbein and Ajzen, 1975).

Experience level

Messineo and DeOllos (2005) found that experience level is the key to the success of the IT. Therefore, experience level of potential users could be one key factor influencing the attitude toward using IT. Jiang et al. (2003) found evidence that experience need to be incorporated in a model to realize its relationship to the systems success. The next hypotheses can be stated:

H4: Experience level has a significant effect on perceived usefulness of using unit-based medication storage and distribution systems.

H5: Experience level has a significant effect on perceived ease of use of using unit-based medication storage and distribution systems.

Perceived risks

A healthcare system failure can have serious consequences. The perception of possible risks related to unit-based medication storage and distribution systems could affect nurses' attitude toward using them (Cho, 2004). We can state these two hypotheses:

H6: Perceived risks have a significant effect on perceived usefulness of unit-based medication storage and distribution systems.

H7: Perceived risks have a significant effect on perceived ease of use of unit-based medication storage and distribution systems.

Training

One of the most frequently cited barriers to technology use is lack of training (Keil et al., 1995). Effective innovation implementation often requires significant investments of time and money in start-up, training, and user support (Katherine and Knight, 2005). Training provided to health care personnel can have a significant influence on the perceived ease of use and perceived usefulness of unit-based medication storage and distribution systems. Consequently, the following hypotheses are stated:

H8: Training has a significant effect on perceived usefulness of unit-based medication storage and distribution systems.

H9: Training has a significant effect on perceived ease of use of unit-based medication storage and distribution systems.

The proposed model has six constructs and nine hypotheses have been generated from relationships between these constructs (figure 2).

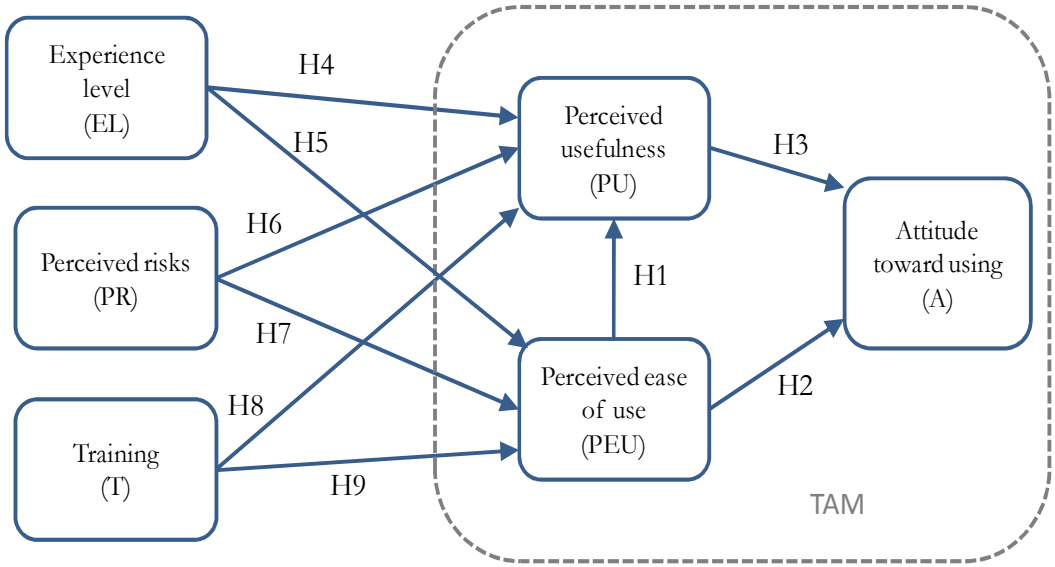

Figure 2. Research model

3. Methodology

A field survey was employed to test our research model. This study was carried out in the Infanta Elena Hospital (hereinafter IEH), a Spanish hospital that provides healthcare coverage to an estimated 200,000 individuals located in 17 different towns. Traditionally, at the IEH, the drug ordering and delivery process was handled manually, with no IT support. With managers' support, in April of 2007 a project began deploying electronic assisted prescription systems and automated based-unit medication storage and distribution systems. The project lasted four years and was finished in 2011.

Data were collected among nurses in May of 2011, with a total of 118 valid replies received. The questionnaire has several items related to each of the constructs included in the hypotheses. The survey items were measured using a seven-point Likert scale. All items ranged from 1 (strongly disagree) to 7 (strongly agree). Theoretical constructs were operationalized using validated items from prior research. "Perceived ease of use", "perceived usefulness" and "attitude toward using" were measured using items adapted from Davis (1989, 1993), Davis et al. (1989) and Mathieson (1991). "Training" and "Perceived risks" items' measures are based on Carr et al. (2010). Item for "experience level" was adapted from Messineo and DeOllos (2005).

This research is based on a regression analysis of latent variables using the optimization technique of the Partial Least Squares (PLS) to develop a model that represents the relationships among the six proposed constructs measured by many items. The PLS is a multivariate technique to test structural models (Wold, 1985). The PLS method estimates the model parameters which minimize the residual variance of the whole model dependent variables (Hsu et al., 2006), does not require any parametric conditions, which are com (Chin, 1998) and is recommended for small samples with non-normal data (Hulland, 1999).

These PLS characteristics are different from those of the Structural Ecuations Models based on covariance analysis, which requires a high sample due to the sensitiveness of the Chi-square test. Basically, the objective of the PLS modeling is predicting dependent variables, latent and manifest, maximizing the explained variance of the dependent variables and minimizing the residual variance of endogen variables (Lévy et al, 2009). PLS method is more oriented to the model predictability (Chin and Frye, 2003) and the estimates' stability will be measured by the Student T statistic, issued from a bootstrapping made over random samples.

4. Data analysis and results

Data analysis takes place via a two-stage methodology, in which the measurement model first is developed and evaluated separately from the full structural equation model (Gerbing and Anderson, 1988). The first step involves establishing individual reliability for each item, followed by determining the convergent and discriminate validity of the constructs.

Individual item reliability is determined via loadings or correlations between the item and the construct. The convergent validity of each construct is acceptable for a loading higher than 0.505 (Falk and Miler, 1992). Table 1 indicates the loading for each item. All variables comply with established conditions.

Constructo	Indicador	Mean	Standard deviation	Loading
Experience Level (EL)	EL1. What is your previous profesional experience related with information technologies? (1) None, (2) Less than 5 years, (3) Between 6 and 9 years, (4) Between 10 and 14 years, (5) Between 15 and 19 years, (6) Between 20 and 24 years, (7) More than 25 years.	2.7796	1.2134	1.0000
Perceived risks (PR)	PR1. There is a significant potential for loss data with automated based-unit medication storage and distribution systems.	4.0254	1.7269	0.7199
	PR2. There is a significant risk of potential failure to using automated based-unit medication storage and distribution systems.	4.2118	1.9074	0.9015
	PR3. Using automated based-unit medication storage and distribution systems is not completely sure.	4.6186	1.8807	0.8639
Training (T)	T1. The kind of training provided to me about automated based-unit medication storage and distribution systems was complete.	3.2966	1.6346	0.8297
	T2. My level of understanding about automated based-unit medication storage and distribution systems was substantially improved after going through the training program.	3.9152	1.5556	0.9355
	T3. The training gave me confidence in automated based-unit medication storage and distribution systems.	3.8898	1.6935	0.9205
Perceived usefulness	PUE1. Using automated based-unit medication storage and distribution systems improve my job performance.	2.9745	1.6354	0.9052

(PU)	PUE2. Automated based-unit medication storage and distribution systems support critical aspect of my job.	2.3728	1.5347	0.9656
	PUE3. Using automated based-unit medication storage and distribution systems allows me to accomplish more work than would otherwise be possible.	2.3559	1.4879	0.9567
Perceived ease of use (*) (PEU)	PEU1. I do become confused when I use automated based-unit medication storage and distribution systems.	4.7542	1.9345	0.8466
	PEU2. I do make errors when using automated based-unit medication storage and distribution systems.	4.3474	1.7704	0.8388
	PEU3. Interacting with automated based-unit medication storage and distribution systems is often frustrating.	4.6525	1.7753	0.7936
Attitude toward using (A)	A1. Using automated based-unit medication storage and distribution systems is a good idea	3.7881	1.7582	0.8777
	A2. Using automated based-unit medication storage and distribution systems is pleasant	3.2118	1.5789	0.9237
	A3. Using automated based-unit medication storage and distribution systems is beneficial	3.2288	1.8276	0.9077

Table 1. Items descriptive and loading (*) *Reversed scaled construct*

Reliability makes it possible to measure internal coherence of all the indicatiors in relationship to constructs. To verify the realibility of each indicator, the Cronbach coefficient alpha (Cronbach, 1970) and the composite reliabilities coefficient (Werts et al., 1974) were utilized, each ranging from 0 (no homogeneity) to 1 (maximun homogeneity). Both parameters are taken into account, as the first considers the

contribution made by each indicator to the construct, while the second takes the respective item's loading into account. Table 2 indicates the values of each coefficient. Composite reliabilities are over the minimun acceptable limit of 0.70 (Gefen et al., 2000; Nunnally, 1978). The Cronbach coefficient alpha levels are also shown in Table 2. They were all above 0.70, which is recommended for confirmatory research (Churchill, 1979). The construct "Experience Level" do not need to accomplish this condition. We do not need to measure the internal coherence of this construct becouse it has only one item.

Construct	Composite Reliability	AVE	Cronbach Alpha
Experience Level (EL)	1.0000	1.0000	0.0000
Perceived risks (PR)	0.8700	0.6924	0.7824
Training (T)	0.9244	0.8036	0.8798
Perceived usefulness (PU)	0.9600	0.8889	0.9351
Perceived ease of use (PEU)	0.8661	0.6833	0.7690
Attitude toward using (A)	0.9300	0.8158	0.8840

Table 2. Composite reliability, AVE and Cronbach coefficient alpha

Discriminant validity was assessed by examining whether each item loaded higher on the construct it measured than on any other construct. The factor structure matrix of loadings and cross-loadings (Table 3) indicates that the measurement exhibited reasonable discriminant validity. Items measuring the same construct indicate distinctly higher

factor loadings on a single construct than on other constructs. This is also an indication of the convergent validity of the measurement.

Scale Items	EL	PR	T	PU	PEU	A
EL1	**1.0000**	-0.0564	-0.0258	0.0987	-0.2390	0.2314
PR1	-0.0014	**0.7199**	0.0603	-0.0527	0.3152	0.0341
PR2	-0.0904	**0.9015**	0.0798	-0.2201	0.5375	-0.2213
PR3	-0.0259	**0.8639**	0.0409	-0.0860	0.4521	-0.0826
T1	-0.0357	0.1310	**0.8297**	0.2831	-0.1114	0.2553
T2	-0.0236	0.1478	**0.9355**	0.3816	-0.1094	0.3452
T3	-0.0161	-0.0291	**0.9205**	0.4576	-0.2948	0.4462
PU1	0.0488	-0.1886	0.4643	**0.9052**	-0.3978	0.6318
PU2	0.1225	-0.1280	0.3852	**0.9656**	-0.3794	0.6199
PU3	0.1101	-0.1335	0.3699	**0.9567**	-0.3849	0.6360
PEU1	-0.1361	0.4924	-0.1932	-0.3079	**0.8466**	-0.3957
PEU2	-0.1391	0.5011	-0.0891	-0.2320	**0.8388**	-0.3585
PEU3	-0.3017	0.3549	-0.2279	-0.4576	**0.7936**	-0.4441
A1	0.2383	-0.1518	0.2130	0.5603	-0.4528	**0.8777**

A2	0.2298	-0.0584	0.3849	0.6298	-0.4079	**0.9237**
A3	0.1617	-0.1577	0.4935	0.6184	-0.4610	**0.9077**

Table 3. Factor structure matrix of loadings and cross-loadings

After individual item reliability and convergent and discriminate construct validity have been established, the structural model is examined. To test H1 through H9, a PLS analysis was performed. Regression coefficients are based on bootstrapping samples and not on samples estimator. It permits the generalization of the results and the computation of the t-value for each hypothesis (Lévy et al., 2009). The results are presented in Figure 3, and Table 4 summarizes the relationships between the different constructs. The predictive capability of the model is satisfactory because all R-Squares are higher than 0.10 (Falk and Miller, 1992).

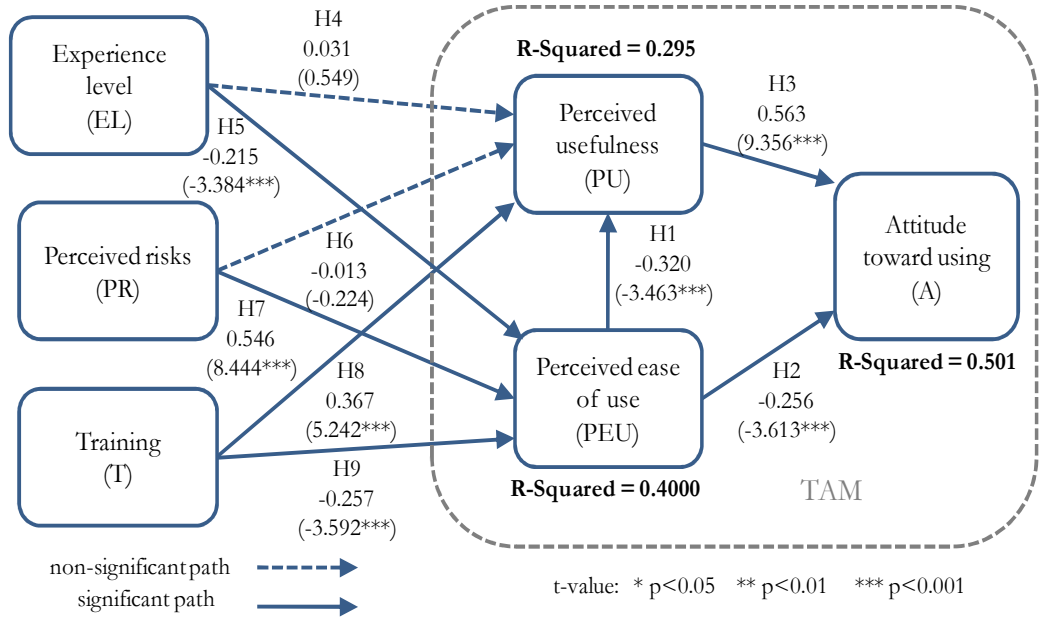

Figure 3. Results

Hypothesis	Path	Standardized path coefficient	t-value	Supported?	Construct	R-Squared
H1	PEU→PU	-0.320	-3.463	Yes, p<0.001	Perceived usefulness	0.295
H4	EL→PU	0.031	0.549	No		
H6	PR→PU	-0.013	-0.224	No		
H8	T→PU	0.367	5.242	Yes, p<0.001		
H5	EL→PEU	-0.215	-3.384	Yes, p<0.001	Perceived easy of use	0.4000
H7	PR→PEU	0.546	8.444	Yes, p<0.001		
H9	T→PEU	-0.257	-3.592	Yes, p<0.001		
H2	PEU→A	-0.256	-3.613	Yes, p<0.001	Attitude toward using	0.501
H3	PU→A	0.563	9.356	Yes, p<0.001		

Table 4. Summary

5. Discussion and conclusions

TAM theory suggests that there is a significant positive relationship between perceived ease of use, perceived usefulness and attitude toward using automated unit-based medication storage and distribution

systems (H1, H2, H3). These paths have been supported in the research model. Therefore, TAM has been validated in this context.

The findings indicate that experience level is positively related to perceived ease of use, giving support for H5. This is also congruent with the findings of Messineo and DeOllos (2005), who found that this external variable is one of the key factors with a significant influence on the attitude toward using new technologies. The relationship between this variable and perceived usefulness (H4) is not supported.

The test results clearly suggest that perceived risk has a significant relationship with perceived ease of use (H7). Users who perceive high risks for losing data or system failures do not find them easy to use. Contrary to other cases (Carr et al., 2010), the relationship between perceived risks and perceived usefulness (H6) is not supported by the test results summarized in Table 5. Sometimes, perceived risks could imply that users do not perceive the usefulness of technology if there is a significant risk of potential failure. However, this relationship is not significant in this research.

Hypotheses 8 and 9 are concerned with the relationship between training, perceived usefulness and perceived ease of use. One mechanism for influencing attitude toward using automated unit-based medication storage and distribution systems is through training. We found that training positively influences perceived usefulness (H8) and perceived ease of use (H9). Training is critical to achieving effective new technology implementation in hospitals. These significant relationships show that training has increased both the perceived ease of use and the perceived usefulness of automated unit-based medication storage and distribution systems. Therefore, hospital managers should focus training not only on system use, but also on system usefulness. To convince nurses to adopt these systems, hospital administrators should emphasize the functional benefits of the technology from reduced paperwork to decreased medication errors.

This research integrates the appropriate information systems literature in order to enhance the knowledge of attitude toward using automated unit-based medication storage and distribution systems from the nurses' perspective. A further theoretical contribution is the development and validation of survey measures for the constructs examined in this study in this context. In a situation where theory is advanced, it is essential to involve the creation and validation of new measures, and such efforts are considered an important contribution to scientific practice in the information systems field (Straub et al., 2004). These measures can be utilized to examine other emerging technologies within the healthcare context.

In addition to the theoretical contribution, the research model suggests important practical implications for attitude toward using automated unit-based medication storage and distribution systems and develops an understanding about how to improve this attitude in hospitals. Reducing the perceived risks of using this technology by nurses is a central issue to get a better attitude toward using them in hospitals. Training is also a very important issue. Top managers should design training programs focused on boosting the acceptance of this technology by nurses. The training programs include training focuses on reducing perceived risk, on highlighting the usefulness of these systems and how to handle them.

Further research might investigate the importance of influences such as individual differences, prior experience, level of educations, and the role of technology in organizations in the context of attitude toward using new technologies in hospitals.

CAPÍTULO 5

1. CONCLUSIONES

Las conclusiones que se presentan en este trabajo son la consecuencia de los objetivos propuestos. En concreto, en este trabajo habíamos establecido un objetivo general y cuatro objetivos específicos.

En cuanto al objetivo específico primero, examinar los beneficios potenciales que los hospitales pueden obtener de la implementación de TI y sistemas CCM diseñados para apoyar y facilitar el control interno de los procesos, sobresalen las siguientes conclusiones:

- Las TI implementadas, a saber, EPAMMS, han actuado como catalizadores del diseño de las rutinas de trabajo para que los errores de medicación sean difíciles de producir, utilizando un enfoque basado en sistemas, todo esto mejora la calidad y la seguridad en el sistema sanitario.

- Contribuimos a la literatura al destacar el papel estratégico que los sistemas informáticos y CCM han jugado en los hospitales, sustituyendo la mano de obra humana a favor de la automatización de los procesos de negocio, proporcionando información sobre las actividades de negocios y, fundamentalmente, la redefinición de los procesos de negocio y las relaciones entre ellos.

- El resultado final ha sido la aplicación de un sistema de prevención de errores en la prescripción y la distribución de medicamentos. El sistema también ha proporcionado la oportunidad de mejorar la información disponible.

- La aplicación del nuevo sistema no ha sido tan problemática como se esperaba. La baja resistencia al cambio fue en parte debida al apoyo constante al proyecto por parte de la dirección, la formación continua del personal y la transición progresiva de una forma de trabajo a otra.

Respecto al segundo objetivo específico, analizar la aceptación de la prescripción electrónica y los sistemas automatizados de dispensación de medicamentos por parte del personal sanitario (personal médico y enfermería) identificando los factores influyentes, destacan las siguientes conclusiones:

- El modelo obtenido puede ser usado para predecir la intención de uso de los usuarios de estos sistemas.

- Entre las conclusiones obtenidas a través del modelo se encuentran que la mejora de la compatibilidad percibida en estos sistemas es un tema central, los riesgos percibidos están relacionados con la dificultad o facilidad de uso, en el proceso de formación no sólo habría que explicar el uso del sistema sino también hacer ver las habilidades que muestra el sistema para mejorar la realización del trabajo y los sistemas de control. La utilidad percibida influye directamente de la intención de utilizar estos sistemas. Esto demuestra una gran preocupación sobre los efectos de los errores de medicación en la seguridad del paciente. Por lo tanto, se puede decir que dan la bienvenida a los mecanismos automáticos de control que reducen estos riesgos.

- Se validan los resultados de otras investigaciones en diferentes tecnologías, usuarios y contexto organizacional.

- Una contribución teórica adicional es el desarrollo y la validación de las medidas empleadas, en particular para los constructos compatibilidad percibida, utilidad percibida para mejorar los sistemas de control, y riesgos percibidos. Estas medidas pueden ser utilizadas para examinar otras tecnologías emergentes en el contexto de las organizaciones de atención de salud.

- Además de la contribución teórica, el modelo de investigación sugiere importantes implicaciones prácticas para la aceptación de

EPAMMS y desarrolla una comprensión acerca de cómo mejorar la intención de utilizarlos en los hospitales. Esta investigación puede ser utilizada por otros hospitales, como apoyo a la implementación de estas nuevas tecnologías. Así, se pueden concretar una serie de recomendaciones a partir de nuestros hallazgos:

- Es prioritario que los gerentes del proyecto y los directivos tengan una actitud positiva para reducir la incompatibilidad percibida entre las tareas a realizar y los sistemas EPAMMS, ya que si no los usuarios potenciales pueden hacerse reacios a su uso.

- La formación es un pilar muy importante que debe estar a la cabeza del proyecto para que así disminuya entre los usuarios potenciales el riesgo percibido por la nueva tecnología.

En relación con el tercer objetivo específico, analizar como los adoptantes tempranos se diferencian de los tardíos para el mismo conjunto de variables con el fin de entender mejor el momento de adoptar la decisión, subrayamos las siguientes conclusiones:

- La comprensión de las diferencias entre los usuarios adoptantes tempranos y los tardíos a la hora de la implementación de una nueva TI nos da la oportunidad de encontrar acciones que puedan acelerar el proceso de difusión de la innovación.

- Hemos ampliado la IDT para incluir constructos derivados de TAM y los resultados han proporcionado un fuerte apoyo a las predicciones teóricas.

- La respuesta afectiva y de conducta es muy diferente entre los adoptantes tempranos y los tardíos. La respuesta cognitiva también va a depender de la categoría de usuario al igual que los cuatro estímulos externos estudiados (resistencia al cambio, riesgos

percibidos, efectos percibidos sobre el sistema de control e incompatibilidad percibida). De forma resumida podemos decir:

- Que los adoptantes tempranos tienen una actitud positiva hacia esa nueva tecnología y están dispuestos a usarla.
- Perciben una mayor facilidad de uso.
- Tienen menos resistencia al cambio.
- Tienen una percepción distinta respecto a los riesgos potenciales y no ven incompatibilidad en el uso de las nuevas tecnologías con su trabajo.
- El hecho de que las nuevas tecnologías lleven incorporados sistemas de control no lo ven como algo negativo, sino como una oportunidad de mejora hacia la realización de un trabajo más seguro.

Por último, en lo referente al cuarto objetivo específico, ampliar el número de factores observados que puedan influir en la actitud hacia el uso de una nueva tecnología en un hospital por parte del personal de enfermería, se pueden señalar la importancia que para este colectivo tiene el hecho de disminuir el riesgo percibido hacia el uso de una TI y un buen programa de formación.

En resumen, como resultado de esta investigación se ha dado respuesta al objetivo general establecido en esta tesis, analizar el efecto de las tecnologías sanitarias en la Gestión Hospitalaria y aceptación por parte del personal sanitario.

Así en cuanto al efecto de las tecnologías sanitarias en la Gestión Hospitalaria podemos decir:

- La implementación de una nueva tecnología lleva consigo un cambio en las rutinas de trabajo y una reingeniería de procesos que debe ser llevado a cabo de forma progresiva para lograr la menor resistencia al cambio por parte de los usuarios.

- Las nuevas tecnologías proporcionan una valiosa información que hay que gestionar adecuadamente y da la oportunidad de implantar sistemas de control que ayuden a la realización del trabajo diario así como, en este caso, a evitar errores de medicación y por tanto a aumentar la seguridad del paciente.

En cuanto a la aceptación por parte del personal sanitario podemos concluir que:

- La formación es una prioridad a la hora de diseñar el proceso de implantación por parte de la alta dirección y gestores del proyecto para el caso que nos ocupa.

- Los adoptantes tempranos tienen una actitud positiva hacia el cambio que implica el nuevo sistema de trabajo y si se gestiona bien el proceso y en la fase inicial de la implantación la mayoría de usuarios son adoptantes tempranos, el proyecto tiene muchas probabilidades de llegar al éxito ya que estos usuarios abren el camino a los adoptantes tardíos.

- Los estímulos externos tales como los riesgos percibidos o la compatibilidad percibida, influyen de forma diferente sobre los constructos utilidad percibida y facilidad de uso percibida, según a qué tipo de usuario nos dirijamos

Respecto a las posibles limitaciones del trabajo, podemos resaltar las siguientes:

- El hecho de contestar cada persona su propia encuesta puede hacerles pensar que se está midiendo el comportamiento a través de sus respuestas, lo que puede inflar las relaciones causales.

- A veces las respuestas pueden no ser percepciones reales sino más bien subjetivas.

- El estudio está hecho en España lo que trae consigo características de personalidad y culturales diferentes a otros países.

- El cuestionario ha sido testado en un solo momento temporal.

2. POSIBLES EXTENSIONES DE LA INVESTIGACIÓN

Las posibles extensiones de la investigación irían orientadas principalmente en las siguientes líneas de trabajo:

- Estudiar cuál sería el coste económico de las nuevas tecnologías implantadas en el ámbito hospitalario y valorar si ha sido eficiente el coste de la TI respecto a los posibles errores de medicación evitados.

- Estudiar la importancia de factores tales como las diferencias individuales, nacionales, la experiencia previa, el nivel de educación y el papel de la tecnología como predictores de la facilidad de uso percibida y la utilidad percibida.

- Analizar el problema desde distintos enfoques teóricos, tanto tecnológicos como organizativos.

- Introducir en los modelos medidas que permitan identificar el comportamiento real de los usuarios y no sólo sus percepciones.

- Medir las mismas variables en distintos momentos para analizar la dinámica del modelo de investigación con el transcurso del tiempo.

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