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SYSTEMS REFERENCE DELIVERABLE

colour inside

Economic evaluation of active assisted living services – Part 2: Example of use – Monitoring patients with chronic diseases

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ECONOMIC EVALUATION OF ACTIVE ASSISTED LIVING SERVICES –

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FOREWORD

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IEC SRD 63234-2, which is a Systems Reference Deliverable, has been prepared by IEC systems committee Active Assisted Living.

The text of this Systems Reference Deliverable is based on the following documents:

Draft SRD	Report on voting
SyC AAL/154/DTS	SyC AAL/166/RVDTS

Full information on the voting for the approval of this Systems Reference Deliverable can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC SRD 63234 series, published under the general title *Economic evaluation of active assisted living services*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Under the "Triple Aim" [1][1] concept (now "Quadruple Aim"[2]), a well defined, inclusive set of objectives for new interventions leading to improvements in the local and national healthcare systems consists of the following:

- improving the health of the population;
- improving the patients' (e.g. AAL care recipients) experience of care,
- lowering (or holding constant) the per-capita cost of care to the healthcare system to ensure sustainability; and
- (the recently added fourth aim) improving the work life of healthcare providers (e.g. healthcare professionals and AAL formal carers), clinicians, and other staff.

Economic evaluations of proposed new healthcare services and technologies involve the assessment of the costs and effects of any interventions in the healthcare system and provide input into the economic sustainability objective above. Where there are important health outcomes that can be evaluated in monetary terms, a cost-benefit analysis can be undertaken as a 'non-reference case analysis' (Alternate Scenario analysis) with details provided on the derivation of the monetary value of the health outcomes. Appropriate economic evaluations will provide evidence to address the financial considerations of proposed new interventions along with the impact on health outcomes.

To achieve the Quadruple Aim objectives, all new technology-supported homecare or Active Assisted Living (AAL) services (such as remote monitoring of patient physiological measurements, in-home medication adherence monitoring and management, as well as mobility aids and emergency reporting services) should be evaluated to ensure they not only improve the quality of the patients' lives but also provide economic benefits greater than the cost of providing the service. Without financial benefits that exceed the cost of the service to the health system funder, or at the very least an economically neutral situation while improving patient outcomes over usual care pathways, the services will not be sustainable – or the healthcare services funder must be prepared to knowingly increase its cost per patient supported by the healthcare system to achieve the population health outcomes.

Furthermore, health system funders may be presented with a choice of options for investment in new or expanded services. In order to compare options from a financial costs and benefits perspective (as well as their health outcomes), economic evaluations of the options will provide an equal basis for comparison of the options.

The evaluation example has been structured to provide example data for a Reference Scenario (the current means of providing care to patients with chronic diseases, the target patient population) and compare this against an Alternate Scenario (the healthcare intervention using the AAL physiological measurement and monitoring service) for the economic comparison. Standard economic measures including Return on Investment, Net Present Value, and Payback Period of the investment are estimated.

[1] Numbers in square brackets refer to the Bibliography.

ECONOMIC EVALUATION OF ACTIVE ASSISTED LIVING SERVICES –

Part 2: Example of use – Monitoring patients with chronic diseases

1 Scope

IEC SRD 63234-1 provides a descriptive framework and template for the economic evaluation of the implementation of technology-supported home healthcare, wellness or AAL services. This part of IEC SRD 62234 provides an example of the use of the framework, specifically analysis and economic evaluation of the implementation of technology-supported, remote, in-home monitoring of patients (AAL care recipients) with chronic diseases.

This analysis is completed from the point of view of the healthcare system/services funder (e.g. the government in a state-sponsored healthcare system or possibly a health management/health insurance company in a privately funded system).

This document is structured like IEC SRD 63234-1, to provide a means of capturing data for the Reference Scenario (the current means of providing care, also known as 'usual care', to the target population of members of the population with one or more chronic diseases living at home), compared against an Alternate Scenario (the deployment of an AAL service which provides remote patient monitoring). Standard economic measures have been estimated (using an electronic spreadsheet) including Return on Investment (ROI), Net Present Value (NPV), and Payback Period of the investment.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
AAL service
action or function of an AAL system creating an added value for customers

EXAMPLE 1 Configuration and maintenance of AAL systems.

EXAMPLE 2 Assistant systems to support the home and living environment.

[SOURCE: IEC 60050-871:2018, 871-01-04]

3.1.2
AAL user
person who uses or benefits from, or uses and benefits from, AAL devices, systems or services

[SOURCE: IEC 60050-871:2018, 871-02-05]

3.1.3
AAL care recipient
person who receives and consumes AAL care services

3.1.4
AAL informal carer
person who provides informal (or lay) services to the AAL care recipient

3.1.5
AAL formal carer
person who provides personal or homemaking services to the AAL care recipient

3.1.6
AAL system
<AAL services> set of interrelated elements in a defined context as a whole and separated from the environment

Note 1 to entry: A system is generally defined with the view of achieving a given objective, e.g. by performing a definite function.

Note 2 to entry: Elements of a system can be natural or man-made material objects, as well as modes of thinking and the results thereof (e.g. forms of organization, mathematical methods, programming languages).

Note 3 to entry: The system is considered to be separated from the environment and the other external systems by an imaginary surface, which cuts the links between them and the system.

Note 4 to entry: The term "system" should be qualified when it is not clear from the context to what it refers, e.g. control system, colorimetric system, system of units, transmission system.

[SOURCE: IEC 60050-151:2001, 151-11-27, modified – The domain "<AAL services>" has been added. In the definition, "in a defined context" has been deleted.]

3.1.7
remote monitoring
condition monitoring and monitoring of persons from a distance by using telecommunication

[SOURCE: IEC 60050-871:2018, 871-04-27]

3.2 Abbreviated terms

AAL Active Assisted Living
ED emergency department
CMC centralized monitoring centre
CSF critical success factors
NPV Net Present Value
ROI Return on Investment

4 General

4.1 Document objective

While this document is a theoretical example, this evaluation uses real data as input to the greatest extent possible. For example, costs of several technical components are based on those available to a health service provider organization in the Ottawa, ON, Canada area at the time of writing. Furthermore, examples of healthcare system benefits are taken from documented research studies and costs from Canadian measured averages; however, not all of these data elements came from a single study example.

All costs and benefits in this example are in Canadian dollars (C$), but parallel examples using other currencies, and local costs and benefits may be created following this example.

4.2 Economic evaluation process overview

4.2.1 Alternate versus Reference Scenario

The economic evaluation process is a comparison of a Reference Scenario against an Alternate Scenario, the AAL service or technology intervention, using a cashflow analysis over an appropriate time period.

The Reference Scenario (also commonly referred to as a "base case" or "base scenario") is typically the current means of providing healthcare or health services, often known as "usual care", to the target patient population: members of the population living with one or more chronic diseases such as Chronic Obstructive Pulmonary Disorder (COPD) or Diabetes Mellitus ('diabetes') still living in their own homes.

The Alternate Scenario describes AAL service or technology, the specific intervention or benefits it hopes to achieve, and outlines the impacts on the delivery of healthcare. The Alternate Scenario proposed is to augment the traditional healthcare services with in-home monitoring of patient physiological signs (e.g. blood pressure, heart rate, blood oxygen levels, weight, etc.) as appropriate for the condition. The assumption, based on evidence from a number of smaller pilot projects, is that this AAL Service will prevent worsening of the conditions and reduce the number of hospital emergency department visits and in-patient admissions that would otherwise result, saving the overall health system costs.

4.2.2 Time period for analysis

This analysis uses a five-year time period. Major components of the equipment (hardware, software, etc.) requiring upfront investment have an expected lifecycle of at least five years and extending the study beyond this would require consideration of replacement costs which would generally replicate the analysis for an ensuing five years.

4.2.3 The cost of money

This cashflow analysis assumes the "cost of money" (or time value of money) is 4,25 % based on interest rates currently in place to large organizations (the US and Canadian 10 year government bond rates are roughly 2 % to 3,5 % at the time of writing).

4.2.4 The economic or financial indicators

The financial analysis will present the following indicators:

- Return on Investment (ROI) – the gain or loss generated by an investment relative to the amount of money invested (typically expressed as a percentage);
- Net Present Value (NPV) – the difference between the discounted future cash flows from an investment and the original investment amount;
- Payback Period – the length of time to recoup the initial investment in a project, product development or service implementation.

Jumping to the bottom line early, the proposed AAL Service, remote patient monitoring, exhibits a positive ROI and NPV based on the assumptions and estimates made in this analysis.

4.2.5 Multiple Alternate Scenarios

Two Alternate Scenarios are analysed and evaluated. The first assumes growth to 10 000 patients annually, while the second is a larger deployment assuming a total of 100 000 patients when in full operation to see if there are significant impacts due to economies of scale.

4.2.6 Risks and critical success factors

While this evaluation uses evidence-based inputs in the economic model to the greatest extent possible, using estimates based on the results of a number of remote patient monitoring pilot studies, as a forward-looking model there remains an amount of uncertainty in future outcomes. Therefore, critical success factors (CSFs) in the implementation of the service are also identified.

4.3 Document structure – the example

This document is structured following IEC SRD 63234-1, as a step-by-step means of completing the evaluation process outlined in IEC SRD 63234-1 (even matching clause and subclause headings as far as is applicable) and coming to a set of conclusions and recommendations about the proposed remote patient monitoring service.

Clause 5 presents a summary overview or abstract (sometimes known as an Executive Summary) of the remote patient monitoring, its analysis and recommendations.

Clause 6 provides a detailed descriptive overview of the remote patient monitoring AAL Service.

Clause 7 completes the financial analysis templates, gathering the information required for both the Reference Scenario and the Alternate Scenarios.

Clause 8 calculates and displays the economic and financial indicators.

Clause 9 describes CSFs in more detail and proposes a set of considerations for implementation of a full remote monitoring service for patients with chronic diseases.

Lastly, Clause 10 presents final considerations and recommendations that would be made as a result of the non-economic and financial evaluations.

5 Overview of the analysis and results of a remote patient monitoring service

Table 1 provides an overview of the proposed remote patient monitoring AAL Service, the existing care problem being addressed, and a short description of the expected benefits and financial impact. More detailed information is developed and presented in Clauses 6 to 9.

Table 1 – Overview of the remote patient monitoring AAL Service

Element	Description of entry
Title	Remote Monitoring of Patients with Chronic Diseases
Summary	This document provides and analysis of an AAL Service that provides in-home, remote monitoring for patients of four chronic diseases: Congestive Heart Failure (CHF) Hypertension (high blood pressure) Chronic Obstructive Pulmonary Disorder (COPD) Diabetes mellitus

<table>
<tr><th>Element</th><th>Description of entry</th></tr>
<tr><td>Current need or existing problem addressed</td><td>Patients with Chronic Diseases are a major user of the healthcare systems around world. Frequent trips to the Emergency Department (ED), use of emergency transport services, and in-patient hospitalizations brought on by exacerbations of individual Patients' diseases are expensive and a drain on the healthcare system.

For example, in Canada alone in 2010, the economic impact of chronic disease in Canada was estimated to be about C$190 billion or about 42 % of healthcare costs [3]. Furthermore, the issue is on the rise owing to the aging population. While 16,5 % of Canada's population was over the age of 65 in 2017, this proportion is expected to grow to 24,2 % by 2041, in just over 20 years [4]. This will significantly increase the incidence of chronic diseases in the population.</td></tr>
<tr><td>Target Population – Overview</td><td>The target AAL care recipient (patient) population will:
• have one or more of the monitored chronic conditions (CHF, Hypertension, COPD, Diabetes);
• have had three ED visits, or two ED visits and one hospitalization, or two hospitalizations in the six months prior to beginning the remote patient monitoring programme.

The estimated total population in Canada is about 11 million. (This may be high due to double counting of patients with multiple co-morbidities.) Two scenarios are considered later in this document: the first assumes that the healthcare system wishes to achieve a monitoring volume of 10 000 patients, the second 100 000 patients, during the study period.</td></tr>
<tr><td>AAL service description (intervention scenario)</td><td>The intervention will be to provide remote monitoring of patients in their homes as appropriate to the disease. Technology is provided to the AAL care recipient:
• intelligent biometric measurement devices such as blood pressure cuffs, pulse measurement, weight scale, pulse oximeter, spirometer, and/or glucometer, all Bluetooth®[a]-equipped to transfer the measurements. These devices are appropriate to the individual patients' conditions.
• an in-home 'gateway' device such as a tablet to walk the patients through the measurement and transfer of data and the upload of the measurements to the AAL application. The tablet may also provide other functionality such as two-way videoconferencing.

A home visit is made to the patient to configure the remote monitoring equipment and gateway and also to provide basic or more advanced education to the patient in the self-management of their conditions.

The measurements are collected over the internet by a centralized monitoring centre, directly into the Remote Patient Monitoring application. Here the data is continuously analysed against each patient's expected range of normal readings and an 'Alert' is displayed to a healthcare professional (or another AAL formal carer) assumed to be a Registered Nurse in this example) at the centralized monitoring centre and displayed back to the patient via the tablet. If deemed appropriate, the healthcare professional will contact the patient or dispatch a homecare nurse to visit the patient to suggest changes to the patients' activities, diet, medications, etc.</td></tr>
<tr><td>Expected benefits</td><td>By early detection of changes in the AAL care recipient's conditions through the analysis and alerting of the central monitoring software, it is anticipated that:
• there will be a reduction in visits to the ED across the monitored patient population;
• there will be a reduction of in-patient admissions and/or a reduction in the average length of stay of patients in the monitored population as compared to
– their own use of the healthcare system prior to beginning the monitoring service;
– non-monitored patients of comparable conditions and acuity levels.
• there may also be a decrease in nurse home visit time.</td></tr>
<tr><td>Financial impact</td><td>The financial indicators of the lower volume deployment scenario are as follows:
<table><tr><th>Indicator</th><th>Value</th></tr><tr><td>Return on Investment (ROI)</td><td>147 %</td></tr><tr><td>Net Present Value (NPV)</td><td>C$110 390 935</td></tr><tr><td>Payback Period</td><td>175 days (or 0,48 years)</td></tr></table></td></tr>
</table>

Element	Description of entry	
	Total One-Time Investment	HW: $ 30 896 SW: $ 5 000 000 Team: $ 360 000 Total: $ 5 390 896 Year 1 staffing costs Monitoring Centre staff: $2 625 375 IT Support: $26 254
Conclusion and recommendation(s)	Conclusions from the financial analysis are: • The remote patient monitoring AAL Service is financially sustainable. • The implementation should decrease the total costs of the healthcare system. • There are also non-economic benefits (e.g. patient quality of life) that are in addition to the positive financial benefits of the AAL Service implementation. • The overall risk level of achieving the economics is rated as "medium". Based on the economic evaluation captured herein, the analysis team recommends the initiation of detailed service design and hardware and software build/procurement but with a controlled expansion of the AAL Service. The effect on hospitalizations (specifically in-patient days) before and after deployment of the service should be monitored closely and a follow-up financial evaluation should be conducted based on a better real-world AAL care recipient population.	
[a] Bluetooth is a registered trademark of Bluetooth SIG, Inc. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named.		

6 Description of the AAL Service or Intervention

Table 2 provides a descriptive overview of the important aspects of the specific intervention (i.e. a remote patient monitoring AAL Service) being considered in the economic evaluation.

Table 2 – Description of the AAL Service

Factor	Details
Healthcare problem addressed	Patients with Chronic Diseases are a major user of the healthcare systems around world. Frequent trips to the Emergency Department (ED), use of emergency transport services, and in-patient hospitalizations brought on by exacerbations of individual Patients' diseases are expensive and a drain on the healthcare system. In Canada alone in 2010, the economic impact of chronic disease in Canada was estimated to be about C$190 billion or about 42 % of healthcare costs [3]. Furthermore, Congestive Heart Failure (CHF) is the leading cause of hospitalization in Canada. Lastly, the issue is on the rise due to the aging population. While 16,5 % of Canada's population was over the age of 65 in 2017, this proportion is expected to grow to 24,2 % by 2041, in just over 20 years [4]. This will significantly increase the incidence of chronic diseases in the population. This analysis will look at in-home remote monitoring for patients of four chronic diseases: • Congestive Heart Failure (CHF); • Hypertension (high blood pressure); • Chronic Obstructive Pulmonary Disorder (COPD); • Diabetes mellitus.

Factor	Details
Patient population – Description	The patient population will: • have one or more of the monitored chronic conditions (CHF, Hypertension, COPD, Diabetes); • have had three ED visits, or two ED visits and one hospitalization, or two hospitalizations in the six months prior to beginning the remote patient monitoring programme; • be of sufficient age and capable of carrying out instructions as directed; and • not have any mental or behavioural issues that would prevent them from following their specific care plan.
Reference Scenario	"Usual care" for this population is defined as the common care approaches in place today: • Patients visit their family/primary care physicians on a regular three- or six-month check-up cycle. • At these sessions, biometric measurements are taken, an assessment of the progress of the patient's diseases is completed, and any changes in treatment/care plan are provided. • If a patient's condition suddenly worsens, they will either go to the Emergency Department (ED) or call an ambulance to be taken to the ED. • If the exacerbation is serious enough, some percentage of the patients will be admitted to hospital for in-patient treatment. The length of stay in the hospital will be dependent on the disease and the extent of the exacerbation of the condition. • In some instances, untreated exacerbations can lead to even more significant medical problems requiring treatment. For example, untreated venous leg ulcers on the part of chronic Diabetes patients may lead to the need to amputate a limb.
Intervention/AAL Service description to be evaluated	The intervention will be to provide remote monitoring of AAL care recipients in their homes as appropriate to the specific disease(s). According to Pare et al.[5], remote patient monitoring "is the remote transmission (by patients) and collection (by healthcare professionals) of physiological and biological data (such as vital signs and symptoms) and behavioral data (such as compliance with medication and activity level) for the purposes of patient monitoring, data interpretation and clinical decision making." Technology is provided to the patient: • Intelligent biometric measurement devices such as a blood pressure cuff, pulse measurement, weight scale, pulse oximeter, spirometer, and/or glucometer, all Bluetooth®-equipped to transfer the measurements. These devices are appropriate to the individual patients' conditions. • An in-home 'gateway' device such as a tablet to walk the patients through the measurement and transfer of data to the central monitoring system. The tablet may also provide other functionality such as two-way videoconferencing for healthcare professional consultations. A home visit is made to the patient to configure the remote monitoring equipment and gateway and also to provide basic or more advanced education to the patient in the self-management of their conditions. The measurements are collected over the internet by a centralized monitoring centre (CMC), directly into the AAL Remote Patient Monitoring application. Here the data is continuously analysed against each patient's expected range of normal readings and an 'Alert' is displayed to a healthcare professional (or another AAL formal carer), assumed to be a Registered Nurse in this example, at the centralized monitoring centre and displayed back to the patient via the tablet. If deemed appropriate, the Clinician will contact the patient or dispatch a homecare nurse to visit the patient. Results of the interventions are captured in notes plus any additional measurements taken on-site. A record of measurements and any required nursing interventions are provided to the patients' primary care physicians on a regular basis (e.g. monthly) so they are available when the regular visits are made.

Factor	Details
Description of Expected Benefits	By early detection of changes in the patient's conditions through the analysis and alerting of the central monitoring software, the clinical staff at the remote monitoring centre may intervene to suggest changes to the patients' activities, diet, medications, etc. In so doing, it is anticipated that: • there will be a reduction in visits to the ED across the monitored patient population; • there will be a reduction of in-patient admissions and/or a reduction in the average length of stay of patients in the monitored population as compared to – their own use of the healthcare system prior to beginning the monitoring service; – non-monitored patients of comparable conditions and acuity levels. • there may also be a decrease in nurse home visit time OR an offsetting increase in home care nursing visit time due to an increased number of interventions. The above healthcare system benefits have been successfully documented in several research studies although to different degrees and across widely varied patient populations and details of the interventions. Lastly, there is anticipated to be an increase in the patient's self-reported Quality of Life, however these do not influence the economic evaluation directly (possibly indirectly as seen in lower health system utilization).
Patient population – Overall Size	For the purposes of this example of Canada's 36,7 million population (from the Canadian Government's website): • population with diagnosed diabetes (8,1 %) ≈ 2 973 000; • population with heart failure (3,7 %) ≈ 1 358 000; • population with ischemic heart disease (8,5 %) over age 20 ≈ 3 120 000; • population with COPD (9,9 %) ≈ 3 633 000. Estimated total patient population of about 11 million. This may be high due to double counting of patients with multiple co-morbidities.
Patient population – Addressed by the Intervention	Alternate Scenario A - assume that the healthcare system wishes to achieve a monitoring rate of 10 000 patients over the age of 65 in a steady state, roughly 0,1 % of the potential patient population. This percentage of the population has symptoms of sufficient acuity to meet the hospital target described above. The age of 65 is assumed as current study results often focus on this patient population. Alternate Scenario B – We will consider monitoring ramping up to 100 000 total patients and continuing to monitor for five years. This is the target population for the AAL Service.
Length of evaluation	The evaluation assumes a five-year period, consistent with an estimated end of equipment life of the main monitoring centre equipment.

7 The non-financial benefits of the AAL service

7.1 Overview

This Clause 7 captures a description of the non-financial benefits provided by the remote patient monitoring AAL Service.

7.2 Improving the health of the population

The positive effects on the health of the broader population will be directly dependent on the significance of the positive effects on those for whom the AAL Service will be deployed, the AAL care recipients. A non-exhaustive list of potential population health benefits includes

- longer lifespan of the AAL care recipients;
- improved quality of life for a number of years for the AAL care recipients including positive effects on the AAL recipients' families;
- managing the chronic diseases will lead to a reduction of acute incidents;

- with fewer patients coming to hospitals or other clinics for treatment there will be a (likely small) reduction in the number of safety incidents or hospital acquired infections, resulting in improved patient safety;
- with a reduction in the need to treat chronic disease exacerbations, the healthcare system resources will be able to apply more time to treating acute conditions caused through accident or other disease;
- this reduction in chronic disease patients visiting hospital emergency departments will result in lower crowding and improved wait times for ED treatment or assessment and admission to hospital.

NOTE Reduced usage of healthcare services by the AAL care recipients has been noted here, but resulting reduced costs are identified in Clause 8.

7.3 Improving the patient experience with healthcare

The evaluation team should assess and describe the potential positive effects on the experience of the AAL care recipients, as well their caregivers, family members or other AAL informal carers. The following is a non-exhaustive list of potential population health benefits.

- Reduced usage of healthcare services by the AAL care recipient means they have more time for personal activities.
- Lower overall usage of the healthcare system by chronic disease patients could result in improved ability to access services and reduced wait times to receive healthcare when it is required by the AAL care recipient.
- This service could eliminate (at least reduce) the need to travel to receive medical care (for example, by now receiving care in their home rather than in a healthcare clinic or hospital).
- Reduced length of stay in hospital results in faster return to work or other personal life activities for the care recipients.
- Being able to see the results of their own actions (for example, what and how much they eat) will give the AAL care recipients a better understanding of how they should be managing their own condition and better overall quality of life.
- Strain on the care recipients' family members, AAL informal carers, is reduced because of better confidence that their family member's chronic conditions are being managed properly and that assistance will readily be provided through the remote patient monitoring service.

Improved patient (AAL care recipient) and family (AAL informal carers) experience with the healthcare system has been demonstrated through patient experience surveys conducted in pilot studies mentioned in this document.

7.4 Improving the work life of healthcare workers

There has been little evidence of benefits to the working life of healthcare professionals or AAL formal carers demonstrated or documented in the pilot studies that have been conducted.

One anecdotal piece of evidence was that healthcare professionals felt that they were more able to focus on patients who truly needed help (an impending or actual healthcare episode requiring treatment), rather than conducting repetitive tests. This led to a higher feeling of job satisfaction.

8 The financial/sustainability analysis

8.1 The financial analysis cost data

This Clause 8 provides aspects for consideration in the development of the Scenario costs, both Reference Scenario and the Alternate Scenario, for the AAL Service under consideration, remote patient monitoring of patients living with one or more chronic diseases. These costs include aspects of healthcare services delivery to this patient population and in the Alternate

Scenario include the costs of the AAL technology and service implementation as well as the lower healthcare delivery costs.

8.2 Reference Scenario costs

Table 3 describes the costs of the current healthcare delivery processes for the treatment of patients with chronic diseases. Many assumptions and sources of the information below for both the Base Case and more importantly the Alternate scenario costs are averaged input from four research studies [5][6][7][8].

Average per day costs are taken from Canadian National statistics quoted from the CIHI Patient Cost Estimator 2012 as referenced in [7]. Three studies were referenced from [7] (the fourth study in that paper was a duplicate of [5]) for a total of six separate studies; however, only four studies reported on the effects of the patient monitoring on ED visits.

Mean values were used from all studies and the occurrence values are scaled up to reflect per patient, per year, cost basis.

Table 3 – Reference Scenario healthcare costs

Cost Factor	Measure	Value
Period for measures	Annual or per month	Annual
In-patient hospitalizations	Number in period	Included below
	Length of stay (LOS) – total or average days	Included below
	Average in-patient days per patient per year	14,47
	Cost per in-patient day	C$935 [7]
	Cost of procedure (e.g. operation)	n/a
Emergency department visits	Number in period (e.g. annual)	3,89 average per patient per year
	Cost per visit (average or total costs)	C$150 [7]
Remote visits or clinician support (if applicable)	Number in period (e.g. annual)	n/a (not applicable)
	Cost per visit (average or total)	n/a
OR (an alternate way to calculate remote visit costs)	Number of Full Time Equivalent Employees (FTE)	n/a
	Cost per FTE (salary, benefits, facilities, support, etc.)	n/a
Home visits (this should be identified for each type of clinician or home care worker impacted.)	Number in period	12
	Cost per visit (time)	C$70 (Ottawa Canada contract rates)
	Travel expenses of clinicians (time and/or cost)	Included in above
Primary care physician visits	Number in period	4
	Cost per visit (average or total)	C$75,00 (Ontario billing)
Specialist physician visits	Number in period	n/a
	Cost per visit (average or total)	n/a
Deferral of admission to long-term care	Number of days deferred	n/a
	Cost per day in long-term care	n/a
Other	None identified	n/a

NOTE It is assumed that in the base scenario, 'usual care' includes one pre-scheduled in-home nursing visit but no regular 'remote visits' by clinicians owing to the Chronic Condition.

8.3 Intervention/Alternate Scenario implementation costs

Table 4 captures the one-time and ongoing operational costs of the intervention/AAL Service or technology deployed for the AAL care recipient population. Identify and quantify those factors as appropriate (not all will be incurred in all service scenarios).

Table 4 – Alternate Scenario AAL service implementation costs

Cost Factor	Item	Value
Central installation	Hardware costs (one time or annual)	C$30 896 one time - 2 × Dell R740 servers[a] - 5 year warranty included in purchase price
	Software costs (development or license purchase costs; one-time)	C$5 000 000
	Annual software support and maintenance	18 % annual software maintenance or C$900 000 per year
	Data network costs (annual)	12 × C$800 = $9 600 per year - 100 MB/s internet access from major provider in the Ottawa area
	IT Operations and Support	1 person per 100 clinical users @ C$96,788 per year per person
	Facility costs (annual)	8,5 % loading on clinician costs (see below)
Service implementation costs	Project Team	6 people for 6 months × C$10 000 per person per month = C$360 000
	Clinician Training	Included in annual costs below
Per AAL care recipient (patient) costs	Number of patients – enrolled annually or per period	Alternate Scenario A: - Ramp up by 2 500 per year to 10 000 total - 10 % churn or 'replacement' patients per year Alternate Scenario B: - Ramp up by 25 000 per year to 100 000 total - 10 % churn of average patients in the year NOTE: 'Churn' requires return, refurbishment and redeployment of the in-home equipment
	Per patient hardware	Based on a particular vendor's information available online at time of writing (any supplier may be used): - BP Cuff C$99,95 - Weight scale C$129,99 - Pulse oximeter C$69,99 (75 % of patients) - Glucose meter (25 % of patients) C$49,99 - Smart thermometer C$119,99 - Mobile tablet device C$599 (32GB cellular ready) Average per patient C$1 013,93
	Per patient Software license	Included in overall software cost
	Installation and set-up costs	Initial Nurse or trainer visit (2 h) C$140,00
	Data network (internet or cellular if provided by funder – per patient or per patient per year)	Data only: C$14,30 per month (Ontario Government rate up to 6 GB per month)
	Support costs (software and hardware maintenance, technical support, etc.)	5 % replacement rate for failed devices after one year warranty expires
	Discharge costs (pick-up and refurbishment of equipment)	C$200 per patient discharged and a replacement patient installed
Other (Describe)		None identified

[a] Dell R740 server is the commercial name of a product supplied by Dell, Inc. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named.

8.4 Intervention/Alternate Scenario health system costs

Table 5 is similar to Table 3 but has been completed to reflect the healthcare services costs for the AAL care recipients (chronic disease patients who are being monitored in their homes). See References [5][6][7][8] for sources of these estimates.

Net reduced healthcare system costs, (overall or per patient) represent the economic benefits of the Remote Patient Service.

Table 5 – Alternate Scenario health system costs

Cost Factor	Measure	Value
Period for measures	Annual (or monthly)	Annual
In-patient hospitalizations	Number in period (e.g. annual)	59 % reduction
	Length of stay (LOS) – total or average days	43 % reduction NOTE: One study showed no reduction, one study showed approx. 86 % reduction.
	Reduction in in-patient days per patient annually	54,5 %
	Cost per in-patient day	No change: C$935
	Cost of procedure (e.g. operation)	n/a
Emergency department visits	Number in period (e.g. annual)	44 % reduction
	Cost per visit (average or total)	No change: C$150
Annual cost of monitoring centre clinicians	Hourly rate (Champlain LHIN)	C$42,54
	Hours/year paid	1820 per year
	Pension and benefits loading	25 %
	Annual loaded cost	C$96,788 per year
Remote visits or clinician support (if applicable)	Number in period (e.g. annual)	50 patients per clinician
	Cost per visit (average or total)	n/a (remote contact included in monitoring centre costs)
OR (an alternate way to calculate remote visit costs)	Number of Full Time Equivalent Employees (FTE)	Alternate Scenario A: – Ramp up to 200 clinicians as patients ramp up Alternate Scenario B: – Ramp up to 2000 clinicians as patients ramp up
	Cost per FTE (salary, benefits, facilities, support, etc.)	C$105015 per year
Home visits (this should be identified for each type of clinician or home care worker impacted.)	Number in period	Increase by average of 32 % or 4 visits per year [a]
	Cost per visit (time)	C$70 (Ottawa Canada Contract rates)
	Travel expenses of clinicians (time and/or cost)	Included in above
Primary care physician visits	Number in period	No change
	Cost per visit (average or total)	No change
Specialist physician visits	Number in period	No change
	Cost per visit (average or total)	No change
Deferral of admission to long-term care	Number of days deferred	n/a
	Cost per day in long-term care	n/a
Other	To be determined	

[a] One study showed a 32 % increase in in-home nursing visits.

9 Cashflow analysis and calculating the financial indicators

9.1 Cash flow analysis: Alternate Scenario A - Ramp up to 10000 patients

Figure 1 below provides the simple cash flow analysis for the calculation of the financial evaluation indicators of Alternate Scenario A, deploying the service to 2500 patients per year up to a total of 10000 AAL care recipients over the study period.

NOTE 1 The capacity for the AAL Service Provider to install equipment is assumed to be 2500 AAL care recipients a year. Therefore, the average number of AAL care recipients (patients) for whom the service is active in the first year is only 1250, so annualized costs (e.g. Internet access and support) have been calculated on this average installed basis. In the second year, with another 1250 installed over the year, the average number of AAL care recipients is 3750 (the 2500 at the previous year end plus the 1250 average installed in the second year).

NOTE 2 Per patient costs of hardware and software in each year are the unit cost of each multiplied by the number of AAL care recipients for whom the service is newly deployed in that year. Hardware costs are $1013,93 with per-patient software costs included.

NOTE 3 The fifth year does not have any newly deployed AAL care recipients.

NOTE 4 Similarly, per-patient annual network costs are based on the annual costs per patient (C$14,30 per month × 12 months) multiplied by the average number of AAL care recipients installed for the year (as per NOTE 1 above).

NOTE 5 Cost avoidance/savings entered in each year in the lower part of the table are the annual savings of hospital inpatient costs, emergency department avoidance cost savings, etc. as determined from the differences in the Reference Scenario in Table 3 and Alternate Scenario Table 5 values above.

Project or Service Financial Evaluation: CHRONIC DISEASE PATIENT MONITORING

Cash Outflows	Year 1 2018	Year 2 2019	Year 3 2020	Year 4 2021	Year 5 2022	Year 6 2023	Year 7 2024	TOTAL
Central - Hardware Costs	$30,896	$0	$0	$0	$0			$30,896
Central - Software Costs	$5,000,000	$900,000	$900,000	$900,000	$900,000			$8,600,000
Central - Network Costs	$9,600	$9,600	$9,600	$9,600	$9,600			$48,000
Service Implementation Team	$360,000							$360,000
Year end patients enrolled	2,500	5,000	7,500	10,000	10,000			
Average patients monitored	1,250	3,750	6,250	8,750	10,000			
Per patient costs - HW	$1,014	$1,014	$1,014	$1,014	$1,014			
Per patient costs - Installation	$140	$140	$140	$140	$140			
Sub-total patient HW & install	$1,442,413	$2,884,825	$2,884,825	$2,884,825				$10,096,888
Per patient costs - Network	$172	$172	$172	$172	$172			
Sub-total patient network	$214,500	$643,500	$1,072,500	$1,501,500	$1,716,000			$5,148,000
Number of patients churn (10%)	125	375	625	875	1,000			
Per patient costs - discharge	$200	$200	$200	$200	$200			
Per patient costs - re-install	$140	$140	$140	$140	$140			
Sub-total patient churn	$42,500	$127,500	$212,500	$297,500	$340,000			$1,020,000
Monitoring Centre Staff	25	75	125	175	200			
Cost per Staff (loaded)	$105,015	$105,015	$105,015	$105,015	$105,015			
Total Monitoring staff cost	$2,625,375	$7,876,124	$13,126,873	$18,377,622	$21,002,996			
IT Operations & Support	$26,254	$78,761	$131,269	$183,776	$210,030			
Total Outflow	-$9,725,283	-$12,441,549	-$18,208,298	-$23,971,047	-$23,968,596	$0	$0	**-$88,312,772**
Ave. In-patient costs-Base	$13,529	$13,529	$13,529	$13,529	$13,529			
Ave. In-patient costs-Alternate	$6,152	$6,152	$6,152	$6,152	$6,152			
Sub-total In-Patient Savings	$9,221,438	$27,664,313	$46,107,188	$64,550,063	$73,771,500			
Ave. ED costs-Base	$410	$410	$410	$410	$410			
Ave. ED costs-Alternate	$230	$230	$230	$230	$230			
Sub-total ED Savings	$225,469	$676,406	$1,127,344	$1,578,281	$1,803,750			
Added Nursing Costs	($350,000)	($1,050,000)	($1,750,000)	($2,450,000)	($2,800,000)			
Cost Avoid./Savings	$9,096,906	$27,290,719	$45,484,531	$63,678,344	$72,775,250	$0	$0	**$218,325,750**
Net Yearly Cashflow	-$628,377	$14,849,170	$27,278,234	$39,707,297	$48,806,654	$0	$0	**$130,012,979**
Net Total Cashflow	-$628,377	$14,220,794	$41,499,027	$81,206,325	$130,012,979			

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Figure 1 – Cash flow analysis table Alternate Scenario A

An electronic spreadsheet was used to perform the cashflow analysis and calculate the economic indicators using the formulas provided in IEC SRD 63234-1.

9.2 Financial indicators for Alternate Scenario A

The key financial indicators which summarize the financial value and investment risk of the AAL Service are described in Table 6.

Table 6 – Financial indicators Alternate Scenario A

Financial Indicator	Value
Return on Investment (ROI)	147 %
Net Present Value (NPV)	C$110 390 935
Payback Period	175 days (or 0,48 years)
Total One-Time Investment	HW: $ 30 896 SW: $ 5,000 000 Team: $ 360 000 Total: $ 5 390 896 Year 1 Monitoring Centre staff: $2 625 375 Year 1 IT Support: $26 254

9.3 Cash flow analysis: Alternate Scenario B - Ramp up to 100 000 patients

Figure 2 provides the simple cash flow analysis for the calculation of the financial evaluation indicators of Alternate Scenario B, deploying the service to 25 000 patients per year up to a total of 100 000 AAL care recipients over the study period. Averages of patients per year and related costs and benefits have been calculated similar to that in Scenario A but using the greater growth factor in patient deployment.

Project or Service Financial Evaluation: CHRONIC DISEASE PATIENT MONITORING

Cash Outflows	Year 1 2018	Year 2 2019	Year 3 2020	Year 4 2021	Year 5 2022	Year 6 2023	Year 7 2024	TOTAL
Central - Hardware Costs	$30,896	$0	$0	$0	$0			$30,896
Central - Software Costs	$5,000,000	$900,000	$900,000	$900,000	$900,000			$8,600,000
Central - Network Costs	$9,600	$9,600	$9,600	$9,600	$9,600			$48,000
Service Implementation Team	$360,000							$360,000
Year end patients enrolled	25,000	50,000	75,000	100,000	100,000			
Average patients monitored	12,500	37,500	62,500	87,500	100,000			
Per patient costs - HW	$1,014	$1,014	$1,014	$1,014	$1,014			
Per patient costs - Installation	$140	$140	$140	$140	$140			
Sub-total patient HW & install	$14,424,125	$28,848,250	$28,848,250	$28,848,250	$0			$100,968,875
Per patient costs - Network	$172	$172	$172	$172	$172			
Sub-total patient network	$2,145,000	$6,435,000	$10,725,000	$15,015,000	$17,160,000			$51,480,000
Number of patients churn (10%)	1,250	3,750	6,250	8,750	10,000			
Per patient costs - discharge	$200	$200	$200	$200	$200			
Per patient costs - re-install	$140	$140	$140	$140	$140			
Sub-total patient churn	$425,000	$1,275,000	$2,125,000	$2,975,000	$3,400,000			$10,200,000
Monitoring Centre Staff	250	750	1,250	1,750	2,000			
Cost per Staff (loaded)	$105,015	$105,015	$105,015	$105,015	$105,015			
Total Monitoring staff cost	$26,253,745	$78,761,235	$131,268,725	$183,776,215	$210,029,960			
IT Operations & Support	$262,538	$787,613	$1,312,688	$1,837,763	$2,100,300			
Total Outflow	-$48,648,366	-$116,229,085	-$173,876,575	-$231,524,065	-$231,499,560	$0	$0	**-$801,777,651**
Ave. In-patient costs-Base	$13,529	$13,529	$13,529	$13,529	$13,529			
Ave. In-patient costs-Alternate	$6,152	$6,152	$6,152	$6,152	$6,152			
Sub-total In-Patient Savings	$92,214,375	$276,643,125	$461,071,875	$645,500,625	$737,715,000			
Ave. ED costs-Base	$410	$410	$410	$410	$410			
Ave. ED costs-Alternate	$230	$230	$230	$230	$230			
Sub-total ED Savings	$2,254,688	$6,764,063	$11,273,438	$15,782,813	$18,037,500			
Added Nursing Costs	($3,500,000)	($10,500,000)	($17,500,000)	($24,500,000)	($28,000,000)			
Cost Avoid./Savings	$90,969,063	$272,907,188	$454,845,313	$636,783,438	$727,752,500	$0	$0	**$2,183,257,500**
Net Yearly Cashflow	$42,320,697	$156,678,103	$280,968,738	$405,259,373	$496,252,940	$0	$0	**$1,381,479,849**
Net Total Cashflow	$42,320,697	$198,998,799	$479,967,537	$885,226,909	$1,381,479,849			

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Figure 2 – Cash flow analysis table Alternate Scenario B

An electronic spreadsheet was used to perform the cashflow analysis and calculate the economic indicators using the formulas provided in IEC SRD 63234-1.