FINAL REPORT

Clinico-economic study of the JACO robotic arm for powered wheelchair users with upper-extremity disabilities

To justify reimbursement to third party payers

Presented To

By
DATA 4 ACTIONS

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Disclaimer

This study has been sponsored by Kinova Canada. All data analysis and reporting have been performed by Data 4 Actions Inc. It should be mentioned that due to rounding of results, some tables might not reach a sum of 100% or the exact number in the tables. The linked data in the excel spreadsheet represents the accurate data that generated the results in the tables. However, if the reader wishes to obtain the accurate rounding result, the precise data are available through a Kinova Canada representative.

All prices listed in this report are representative of fees and cost at the time of the study and are in Canadian dollars (CAD).

Also, the masculine form is used to simplify the text. No discrimination is intended.

SUMMARY

Accomplishment of many activities of daily living (ADL) require proper control and usage of the upper extremities. Multiple factors, such as illness or accidents, may cause impairment in upper-body movements and have detrimental effect on ADL. Often wheelchair bound, people suffering from upper extremity weaknesses are habitually dependent on external help for achieving activities such as feeding, self-care and leisure. Many technical aids devoted to compensate upper limb impairment may be found on the market. However, many are limited in terms of functionality and very few studies have demonstrated their efficacy or their potential economic benefits.

The JACO arm is a novel robotic manipulator designed to compensate for upper limb impairment. Controlled by the user, it is installed on the wheelchair and may extend its reach to almost one meter, may lift most objects of daily routine and is of light but robust construction. As the acquisition cost of the robotic device is high[1], it becomes critical for third party payers to obtain information about the safety, efficacy and economic outcomes of the JACO arm. Hence, the objectives of this study were:

1. To evaluate the efficacy of the JACO arm in terms of accomplishing specific motor tasks normally performed with upper extremities;

2. To evaluate the economic benefits of JACO in terms of a potential reduction in the costs associated with the performance of upper-extremity tasks.

The results presented in this report were derived from a multi-center, clinico-economic, institutional ethics committee approved trial. The participants were recruited between June 2009 and January 2010 through the *Centre de réadaptation Constance Lethbridge* and the *Institut de réadaptation en déficience physique du Québec*. The trial progression included the completion of two forms and the assessment of two experiments with the JACO arm. The forms collected data pertaining to participants' socio-demographic profile, physical ability, muscular condition, level of autonomy and perception of the JACO arm before and after the trial. Questions relating to the contribution of caregivers and level of satisfaction with the robotic manipulator were also assessed. The two experiments with the JACO arm consisted of the accomplishment of 16 basic movements and 6 ADL-related tasks.

The results showed a global appreciation of the participants experience with the JACO arm. Over 90% of the participants thought of the device as a good looking, significant assistive aid to manipulation and easy to adapt to one's residual capacities. More than half thought it could help reduce stress and anxiety.

As the robotic manipulator is multi-functional, the easiness of its use was important to validate. All the participants achieved to performed the given movements and tasks. Almost all of the participants could perform them in less than 2 attempts. Furthermore, 94% of the participants found it very easy to accomplish the give tasks. The average number of attempts needed to accomplish JACO's 16 basic movements was 1,36 and 1,25 for accomplishing the 6 ADL-related tasks. All participants declared to be satisfied with the ease of use of the standard

[1] Contract price of 30 000 $.

joystick and over 90% felt the JACO arm was a safe device. The literature highlights that safety issues are critical for users and third party payers when choosing a technical aid. Hence it should be highlighted that no incident occurred during the trial. Also, more than 90% of the participants perceived that JACO was safe for the user and the people nearby.

Over and above the latter results, JACO was proven to be an efficacious technical aid to manipulation for enhancing the participant's autonomy for accomplishing basic ADL-related tasks. With the JACO arm, participants could achieve those tasks that were considered very important and 97% thought the JACO arm could allow them to take up abandoned projects.

The economic model underlying assumptions assessed that, on average, 42% of the attendants and natural caregiver time could be saved if participants had a JACO arm. On average, attendants supply 3,19 hours of daily caregiving time (excluding traveling time) and thus the model forecasts that JACO could enable to save 1,33 hours, generating a mean annual savings of 12 095$ per user, according to the base-case scenario. When the societal perspective is considered, a mean annual savings of 27 575 $ is expected. A societal cost saving may be inferred when considering the reduction of the attendant's and natural caregiver's care time in addition to the risk reduction of being transferred in a specialized cost center.

Various sensibility analysis were made around the principal parameters (fees, care hours, risk of being transferred to a specialized care center and JACO's price) in order to give different perspective on time to return on investment (RoI) of the JACO arm. For the base-case scenario, the economic model predicts that, on average, the time to RoI of a JACO arm is of 1,4 to 4,7 years with a contract price of 30 000 $. Considering the product's lifetime to be around 7 years, this represents an average cost saving of 55 657 $ per user depending on the different time saving assumptions and scenarios.

The time to RoI may drop to less than two years when patients transfer in a specialized care center is avoided. As the study results are mainly based on participants' expectations, future study will soon be underway to correlate the different findings. Future works include a long-term clinical evaluation of the JACO arm in the participants' natural environment.

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ABBREVIATIONS

Abbreviation	Description
Absol	Absolutely
ADL	Activities of daily living
Att	Attendant
CG	Caregiver
CRCL	Centre de Réadaptation Constance Lethbridge
CRF	Case report form
CSST	Commission de la santé et de la sécurité du travail
ECU	Electronic Control Unit
ICF	International Classification of Function
IRDPQ	Institut de réadaptation en déficience physique du Québec
JACO	The robotic arm JACO
LTA	A long time ago
MMT	Manual Muscle Testing
MSSS	Ministère de la Santé et des services sociaux
NA	Not applicable
NI	No impact
PACEC	Programme des aides au contrôle de l'environnement et à la communication
PATM	Programme des aides techniques à la mobilité
PT	Participant
QoL	Quality of life
SA	Sensitivity analysis
SAAQ	Société de l'assurance automobile du Québec
Sp. Ctr	Specialized center
TA	Technical aid
W/WO	With or without
WHO	World Health Organization
Yes TA	Yes with technical aid

1) INTRODUCTION

Proper control and usage of the upper extremities is fundamental to the natural accomplishment of many activities of daily living (ADL), such as feeding, self-care and leisure. The *International Classification of Function* (ICF) of the World Health Organization (WHO) defines mobility of the hand and arms, as well as the ability to manipulate and move objects, as important components of activity and participation (WHO 2001). Impairments in upper extremity movements may occur as a consequence of conditions such as neuromuscular diseases, spinal cord injuries or other diseases. These impairments often have a detrimental effect on ADL (Garber and Gregorio 1990; Parker, Robb et al. 2005; Sison-Williamson, Bagley et al. 2007; Atkins, Baumgarten et al. 2008). In addition, the same individuals may often be wheelchair bound, which may cause additional difficulties in terms of upper extremity activities due to environmental barriers (Garber and Gregorio 1990; Newton, Kirby et al. 2002; Holliday, Mihailidis et al. 2005; Rudman, Hebert et al. 2006). Because of the presence of obstacles such as furniture, and of the restricted position in the wheelchair, reaching for objects can become increasingly difficult. Indeed, in a survey of 89 wheelchair users and 52 health care professionals, the ability to reach adequately for objects was rated as the most important concern related to wheelchair use (Holliday, Mihailidis et al. 2005). The ability to properly position the wheelchair in order to perform upper extremity activities is also an important component of the Wheelchair Skills Training Program developed by Kirby et al (Kirby 2008).

ASSISTIVE DEVICES FOR UPPER EXTREMITIES ACTIVITIES

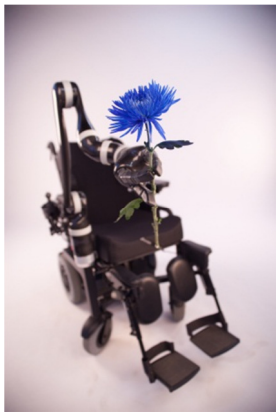
Presently, there exists a significant amount of assistive devices that can compensate for a loss of mobility in the upper extremities. However, these existing aids may be limited in terms of functionality. Most technical aids are only designed to accomplish specific tasks for ADL. Simple tools include “reachers”, a grasping device mounted on a rod that can extend the reach distance (Chen, Mann et al. 1998). Mobile arm support systems are more complex orthotic and spring systems that provide flexible support against gravity (Yasuda, Bowman et al. 1986; Atkins, Baumgarten et al. 2008). In general, few studies have demonstrated the efficacy of technical aids for upper extremity function (Garber and Gregorio 1990; Atkins, Baumgarten et al. 2008).

ROBOTIC ASSISTIVE DEVICES

A novel approach for the development of assistive devices, by allowing more functionality, can be provided through robotics; where the latter may provide a widespread modernized approach for the need of users with reduced mobility in the upper extremities. These include robotic arms that can be controlled through a joystick and that may be fixed either on a table, the user’s wheelchair or to a mobile base; please refer to Appendix 1 for a summary of robotic devices, either developed or under development. Some of these robotic arms are commercialized; however data in the literature is scarce, if not non-existent, about their use by the disabled population. At the time of the study, two studies were published about the efficiency of robotics in rehabilitation. These studies concern the Manus arm (Exact Dynamics, Netherlands), a joystick-controlled, and six degree-of-freedom robotic arm that has many comparable features to the JACO arm. One of these studies consisted of a survey of 21 users of the Manus arm. It demonstrated greater participation in activities of daily living, compared to a non-user group with similar levels of disabilities (Römer, Stuyt et al. 2005). The other one consisted of a survey of 200 potential users, where it identified the perceived requirements of robotic devices. These

included ease of use, reliability, cost and ability to perform various ADL functions such as reaching for objects, eating, self-care and leisure (Stanger, Anglin et al. 1994). It is possible that failure to achieve an acceptable level in one or more of these requirements has led to an under-utilization of robotic assistive devices.

JACO ARM SYSTEM



The JACO arm is a light-weight, technical assistance robot which was designed to compensate for the loss of arm movements. It is composed of six inter-linked segments or axes (degrees of freedom) the last of which is a three-fingered hand. Through the joystick controller, the user can move the robot's hand in three-dimensional space, while the robot maintains the orientation of the hand according to the position given. In a second mode of control, the user can modify the orientation of the hand, but keeping the hand centered at the same point in space. Finally, the user can grasp or release with the hand, using either two or three fingers. A button is used to switch between modes of control. The robotic arm JACO can be fixed to the electric wheelchair or to a table (refer to the Appendix 2 for an exhaustive description of the characteristics of JACO). However, for the JACO arm to be used by everyone, it is important for the controller to be adapted to one's physical abilities. The universal adapter, recently developed by Kinova Canada, enables the user to control the JACO arm system via its wheelchair's controller. The universal adapter is linked to the wheelchair's electrical control unit (ECU) and to the JACO arm system. However, it should be noted that for this clinico-economic trial, a standard joystick was used; as the universal adapter was under development at the time of the study.

In terms of expected functionality, JACO (Appendix 2) can be compared with the Manus arm (Römer et al., 2005). The main differences between the two may be mostly engineering-maintenance, software applications, weights, functionalities and price-oriented. The price of the Manus arm (28 000 € or 45 000 $) is significantly higher than that of JACO's contract price (30 000 $), making JACO a somewhat more accessible technology for the user. Some important physical characteristics such as weight and base size are important when differencing Manus to JACO. The Manus arm has a large base fixed to the exterior of the wheelchair, extending its width by approximately 10-12 centimetres. By comparison, JACO does not extend the width of the wheelchair. Architectural barriers such as doorways and narrow corridors have a detrimental impact on accessibility and on the quality of life of wheelchair users (Pierce 1998; Hoenig, Landerman et al. 2003; Morrison, George et al. 2008). Increasing the effective width of a wheelchair may exacerbate these negative effects. The Manus arm system weighs a total of 15 kg, has a radius of 0.8 m and can lift objects of up to 1.5 kg (Dynamics 2010). By comparison, JACO has a weight of 6 kg can reach approximately 1 m in all directions and can lift objects of up to 1.5 kg.

Thus, it is believed that the JACO arm was able to increase the performance of ADL in individuals with physical disabilities, without adding barriers to wheelchair mobility.

ECONOMIC ISSUES

It is well recognized that the economic cost of disabilities is high. Studies on disabilities performed in the United States (Trupin and Yelin 1999; Anderson and Vogel 2002; Dutta, Gervey et al. 2008) and in Australia (Rowell and Connelly 2008) found that approximately two-thirds of working-age adults with disabilities were not employed and that nearly 80% of them wanted to work (Trupin and Yelin 1999).

In Quebec, as in other occidental countries, the contribution of family and loved ones as natural caregivers has become a topic of interest for decision-makers, researchers and families (Camirand and Aubin 2004). This interest lies within the consensus of the advantages of maintaining persons in their natural environment. In a context where resources are limited, governments are interested to promote assistance to families and communities to minimize the risk of exhausting the caregivers; as the latter could generate new conditions that could increase the burden to the public healthcare or the institutionalization of persons with loss of autonomy.

In Canada, 75-90% of homecare is assured by certain members of the family, mostly women (Le Goff 2002). In 1996, almost 3 million Canadian provided unpaid care. As more than half needed to adjust their employment, approximately 1.2 $ million were lost in current and future income (Fast and Keating 2001). The economic burden of caregiving to economic activity can be due to the following: loss of income due to resigning from a job, reduced number of worked hours, unexpected leave of absence, or lateness.

However, the economic benefits of using assistive technology, in terms of employment or decreased need for care, are largely unknown. Very few studies have addressed these issues (Warren 1993; Andrich and Caracciolo 2007) and the benefits of using devices to improve upper extremity function are also unknown. This information is crucial in order that key stakeholders (e.g., users, clinicians, public and third party payers) may take appropriate decisions related to the prescription and purchasing of assistive devices (Andrich and Caracciolo 2007). According to Römer et al. (2005), the potential relevance of a robotic arm can be defined as the degree of cost-savings that can be reached by the procurement of the rehabilitation robot on the total cost of care of the user. The total cost of care includes the cost of labour of personal assistance, as well as, the cost of technical aids that could be replaced by a single rehabilitation robot. Besides these direct economic benefits, a rehabilitation robot can potentially save costs at a larger economic scale. Thus, a second aim of the present project was to document the potential economic benefits of using the JACO arm.

2) OBJECTIVES AND EXPECTED OUTCOMES

The issue at stake was to document and understand the added value of the JACO arm for powered wheelchairs users, in terms of increased autonomy in their daily living activities. The study results are expected to provide valuable data for key stakeholders, such as individuals with disabilities, their family and caregivers, as well as public and private third party payers.

This is a key issue in the current context where attendants and natural caregivers suffer a shortage of resource while demand for their services is increasing. This shortage of resource increases the risk of powered wheelchair users to leave their homes and be transferred to costly specialized centers as to receive basic care for their ADL-needs.

Another issue to be studied is the expected response of stakeholders in terms of perceived efficacy, safety of use, efficient alternative and impact on the well-being of targeted users. In other words, are powered wheelchair users with upper extremity disability looking for a solution to increase their level of autonomy and could the JACO arm fulfill such need?

The general objective of this study was to demonstrate that JACO is a relevant and efficient alternative for increasing the autonomy of individuals with upper extremity disabilities. The specific objectives were:

1. To evaluate the efficacy of JACO in terms of accomplishing specific motor tasks normally performed with the upper extremities

2. To evaluate the economic benefits of JACO in terms of a potential reduction in the costs associated with the performance of upper-extremity tasks.

Participants in the proposed study were evaluated in terms of their upper extremity function and ADL skills. They were then requested to experiment the JACO arm for basic operations as well as ADL-related tasks. A questionnaire was produced to obtain their perceived actual need for assistance in ADL, in terms of caregiver time and use of assistive devices. Another questionnaire assessed their appreciation of their experience with the JACO arm, as well as the perceived expected impact that it may have in their ADL. Thus, the study was expected to provide answers to the following questions:

OBJECTIVE 1: EFFICACY OF JACO

- ☑ Can participants succeed in performing each of JACO's movement (basic operation)?
- ☑ Can the participants succeed in performing ADL-related tasks (consecutive combination of JACO's basic operations)?
- ☑ Do participants and evaluators appreciate their experience with JACO?
- ☑ Is JACO easy to use?
- ☑ Is JACO safe for the users, the power wheelchair and caregivers?

OBJECTIVE 2: ECONOMIC BENEFITS OF JACO

- ☑ Does JACO have an expected impact on the level of autonomy of the participants?
- ☑ Is there a medical need of such a device for individuals with upper-extremity disabilities?
- ☑ Is JACO an efficient alternative (cost-consequence, budget impact, time to return on investment)?

Consequently, the study examined the following key elements:

- ☑ Resource utilization and costs incurred by the participants to the public/private healthcare regimen
- ☑ Clinical and non-clinical outcomes of the evaluated device
- ☑ Economic efficiency and budget impact on Canadian third party payers; based on various study horizons and study perspective.

EXPECTED RESULTS

It was expected to show that participants with disabilities involving the upper extremities were able to operate the JACO arm in a variety of tasks with a high success rate (>80-95%, depending on task difficulties). It was expected such results because in pilot studies involving healthy participants, the success rate was close to 100% for the more complex tasks, such as picking up small objects from the floor and pouring water into a glass. Satisfaction with the use of the JACO arm may not be related to the level of impairment, as participants with more severe disabilities may have different expectations, not directly related to their level of performance. Some may find the JACO arm too difficult to operate, while others may be very satisfied to be able to perform new tasks with the help of this assistive device.

JACO's expected high efficacy rate could imply the feasibility of reducing the number of hours for which assistance by a caregiver is required in everyday tasks. The results from the proposed study will enable to generate the economic impact of the JACO arm. It is expected that JACO will generate significant cost savings as an alternative to paid and unpaid assistance. The results should also highlight the level of interest of the participants to seek autonomy for specific ADL-tasks.

From the preference, satisfaction and autonomy level results combined with the safety and efficacy results, recommendations for future trial, training sessions and utilization will be highlighted to optimize JACO's success for users in their natural environment. The efficacy and economic data collected in the present study will also serve as a baseline for a future study, where the use of the JACO arm in daily life will be assessed over a long-term period in the participants' natural daily environment. The effects of this long-term use of the JACO arm in the participants' performance of ADL tasks, satisfaction and in quality of life will be described. Finally, comments from the participants and evaluators may be used to suggest changes and improvements, which may be integrated in a new version of the JACO arm.

FUTURE WORK

The study presents in this report is preliminary to a future project planned to measure the impact of a long-term use of the JACO arm on the performance of ADL and on quality of life in participants' daily environment.

3) METHODOLOGY

STUDY DESIGN

The study design was a prospective multi-center non-comparative clinico-economic trial of the JACO arm.

STUDY SITES

The recruitment of potential participants was performed through formal centers (institutions). Two (2) formal study sites participated to the trial:

- Centre de réadaptation Constance-Lethbridge (CRCL)
- Institut de réadaptation en déficience physique du Québec (IRDPQ)

Two independent investigators, Philippe S. Archambault and François Routhier, took part to the study. Their implication is described in chapter 12) ROLE OF TEAM MEMBERS. Also, team members strived to recruit potential participants in informal centers to complete the data collection form. This effort resulted in a limited number of recruits (n=4). The objective of the informal group was to assess whether the efficacy of performing the movements with JACO when trained in an informal environment would lead to different results as when the participants were trained in a formal study environment.

BETA-TESTS

Prior to initiating the clinico-economic trial, beta-tests were performed to clarify or simplify the data collection forms using a cohort of five (5) healthy participants (not in a wheelchair) and naïve with the use of JACO. This cohort completed all the JACO tasks and questionnaires of Parts 1A and 1B. Based on these data and participants comments, appropriate changes were made to data collection forms, when required.

After completion of this first beta test, a second beta test was accomplished with a second group of 3 wheelchair users following the inclusion criteria of the main study. These participants were recruited through the study sites as described previously. Data was used to verify the clarity and cohesion of the completed data collections forms of Parts 1A and 1B.

In the event that major adjustments would have been needed, an additional beta test would have been performed on two additional participants. As the comments were rather minor (mostly down-sizing some questions), we felt comfortable going to the cohort of wheelchair users. This second group (3 wheelchair users) was recruited through the study sites as described previously. Data was used to verify the clarity and cohesion of the completed data collections forms of Parts 1A and 1B.

EVALUATORS AND INVESTIGATORS KICK-OFF TRAINING

Prior to initiating the clinico-economic trial, a kick-off meeting was undertaken in each study site in order to inform and train the study evaluators about:

- ☑ Study protocol

- ☑ Eligibility criteria
- ☑ Patient consent form
- ☑ Data collection forms (including the participant list, participants coordinates list, Appendix, charts for answer options)

A study manual was prepared for the evaluators to ensure that the study data and actions would be compiled in a homogeneous manner. It should be noted that a procedure (including an adverse event form to complete) was explained in the evaluator's manual, in the occurrence that an adverse event was reported (minor or serious) during the study or that the product encountered engineering issues.

PARTICIPANTS

TERMINOLOGY

A potential participant refers to a person interested to enrol in the study following the understanding of the study brochure.

An eligible participant refers to a person that respects the eligibility criteria, as assessed by the study evaluator.

A participant refers to an eligible participant that signed the informed consent form.

NUMBER OF PARTICIPANTS

The study recruited 34 participants for the clinico-economic trial.

ELIGIBILITY CRITERIA

The clinico-economic study eligibility criteria were:

- ☑ Male or female aged between 18 and 64 years of age
- ☑ Participant in a powered wheelchair
- ☑ Participant was not pregnant
- ☑ Participant could manipulate a joystick
- ☑ Participant was able to understand verbal instructions in French or English
- ☑ Participant had the fine motor control that allowed him to press the buttons used to change the control mode
- ☑ Participant had the abilities that allowed him to learn new joystick uses
- ☑ Participant agreed to read and sign the information and consent form
- ☑ The participant used a powered wheelchair with standard joystick

RECRUITMENT STRATEGY

A list of potential participants was obtained from the clientele of the appropriate service or program at both study sites. At the CRCL, the recruitment was executed through the Technical Aids Service. At IRDPQ, participants were recruited from the *Programme des aides techniques à la mobilité (PATM)* and *Programme des aides au contrôle de l'environnement et à la communication (PACEC).* In each case, an employee of each program first contacted potential participants to inform them about the project and invited them to participate in the study.

ENROLMENT PERIOD

The enrolment period was initially planned to take place from June to August 2009, however it was extended until January 2010.

SOURCE OF DATA

The clinico-economic data was retrieved in a prospective manner through data collection forms. Complementary data to generate the economic model was retrieved through a literature review.

DATA COLLECTION FORMS

The data collection made use of questionnaires developed specifically for the study; including sections with validated questionnaires when relevant. A beta test was performed on an initial sample of participants, to make sure the questions were clear, reliable and understandable (see 'Beta test' section).

The questionnaire development was mainly performed by Data 4 Actions, with a close collaboration of the study investigators (see section 12) ROLE OF TEAM MEMBERS). Kinova's experience with powered wheelchair users with upper body disabilities was also significant during the questionnaire development.

TRIAL PROGRESSION

The study comprised of a single session. The estimated time for the data collection was three hours. In the case where this time period would have been be too tiring for the participant, it would have been possible to complete the data collection over two 1.5-hour sessions. Alternatively, instead of a second visit, it could have been possible to finalize the questionnaires through a telephone interview; however, preferably, once the JACO basic operations and tasks would have been performed before discharging the participant. The detailed progression of the project is described hereunder and summarized in Table 1.

VALIDATION OF ELIGIBILITY CRITERIA

The evaluator validated whether the potential participants profile respected the eligibility criteria established for the study. To become eligible, participants had to respect all established criteria in order to be eligible for participation in the research project.

STUDY AND SIGNATURE OF THE INFORMATION AND INFORMED CONSENT FORM

The evaluator summarized the Information and Informed Consent Form. Thereafter, the eligible participant took the time to read it. All participants agreed to sign the form.

Once the participant respected the eligibility criteria and signed the consent form, the evaluator could then begin the completion of the clinico-economic data collection forms.

COMPLETION OF FORMS - CRF PART 1A

The questionnaire consisted in four distinct parts.

a) The participants' physical profile was performed by the evaluator and assessed the following:

- ☑ Diagnosis (health condition)
- ☑ Ability to move trunk (from front to back)
- ☑ Handedness (dominant side), using the valid and reliable Edinburgh handedness inventory (Oldfield 1971) (Appendix 5).

Table 1: Progression of clinical trial

PART 1A of the study	PART 1B of the study
Validation of the eligibility criteria.	Review on the use of JACO
Study and signature of the Information and Informed Consent Form.	Assessment of 6 tasks
Completion of the form (CRF Part 1A) on: • Physical capacity profile • Muscular condition • Level of autonomy with daily tasks • Perception of JACO before use	Completion of form (CRF Part 1B) on: • Contribution of caregivers (paid and unpaid) • Perception of daily autonomy with JACO after the trial • Level of satisfaction and ease of use of JACO after the experience • Socio-demographic profile.
Training on the safe and effective use of JACO	Information about the complementary study in one's natural environment and signature, if required
Assessment of 16 movements with JACO	
Health break	End of study for the participant

b) The muscular condition section assessed the following:

- ☑ Manual muscle testing (MMT) of the shoulder, elbow and wrist on both sides (Hislop 2007) (Appendix 6). A recent systematic review of the literature indicated that the MMT has good validity and reliability for individuals with neuromuscular dysfunction (Cuthbert and Goodheart 2007).
- ☑ ADL function, using TEMPA (Appendix 7). TEMPA assessed the skill level and time required to perform a variety of uni-manual and bi-manual ADL tasks, such as taking a water jug and pouring a glass of water. Although initially developed for assessment

of ADL in elderly (Desrosiers, Hebert et al. 1995), its validity and reliability has also been demonstrated in other populations, such as adults with multiple sclerosis (Feys, Duportail et al. 2002) and traumatic brain injury (Moseley and Yap 2003).

c) Level of autonomy was assessed using a 5-point Likert scale questionnaire:

- ☑ The participant's perception of his or her ability to perform a variety of ADL tasks, including feeding, self-care and leisure
- ☑ The perceived value of being able to accomplish these tasks independently
- ☑ The current use of assistive devices to accomplish these tasks

d) The questions concerning JACO's perception before use were asked in order to understand the participants' expectations and impressions relative to their upcoming experience with JACO.

TRAINING ON THE SAFE AND EFFECTIVE USE OF JACO

Training was provided on the safe and effective use of JACO (approximately 15 minutes). During this preliminary training, participants were explained the various functions of JACO and received an explanation on the exercises to be performed with the device. Finally, they were presented with the objects and checklists to be used during the exercises, in order to help them learn.

To allow participants to familiarize themselves with the controls, a period of approximately 10 minutes was allocated to let them test the functionality with the aid of the evaluator.

ASSESSMENT OF 16 MOVEMENTS WITH JACO

The evaluator asked participants to perform specific exercises as prescribed in Part 1A of the CRF (case report form). Those exercises refer to basic operation of the JACO arm described in Appendix 9 and questionnaire. This included specific exercises to explore each possible movement of the robotic device: movements of the JACO arm to touch targets located left, right, up and down; rotating the hand of the JACO arm; pushing objects; activating the grasp function; placing the JACO arm in its retracted position.

Participants had to succeed each exercise twice. The number of attempts necessary to succeed was recorded. Finally, participants assessed the perceived difficulty level (from 1-3), based on the expected amount of fine control needed.

HEALTH BREAK

Once the execution of these exercises was completed, the participant was invited to take a break. Kinova offered a health snack to all participants.

REVIEW ON THE USE OF JACO

During this part, JACO functions were reviewed. Then, the participants were given an explanation of the exercises to be performed with JACO. Finally, the materials to be used during the exercises were presented.

To allow the participants to be comfortable with the controls, a period of approximately 10 minutes was allocated to allow them to test the functionality with the aid of the evaluator.

ASSESSMENT OF 6 TASKS

The ability of participants to accomplish specific ADL-related tasks was evaluated in a series of exercises. Participants performed a series of ADL-related tasks identified in the course of a study involving another rehabilitation robot. These include picking up objects of various sizes (glass, cereal box, grocery bag) located on a table, on a shelf or on the ground, as well as finer tasks such as turning on a light switch, pressing keys on a keyboard and pouring a glass of water (see questionnaire for details). In the event that a participant encountered difficulties to perform the ADL-movements, the evaluator documented those tasks that required practice or coaching.

Participants had to succeed each exercise twice. The number of attempts necessary to succeed was recorded. Finally, participants assessed the perceived difficulty, satisfaction and importance of performing each of the exercise, using a 5-point scale.

It is important to note that in this study, all participants manipulated the JACO robotic arm using the same sequence of commands, which were provided and supervised by the evaluators, as indicated in the case report form. This procedure was to ensure that the study process was homogeneous across all the study centers and evaluators when participants were asked to execute a given task. Also, this was coherent with the objective of the study which was to demonstrate the ability of being able to perform JACO's movements (efficacy) rather than the participants' ability to remember the commands to execute when they are on their own.

COMPLETION OF FORM - CRF PART 1B

After completing the exercises with JACO's movements, participants' were sounded to assess their satisfaction, preferences and ease of use from their experience with the robotic arm JACO. This was evaluated using a 5-point Likert scale and served to gather feedback about possible improvements in the JACO arm or its controls. A new questionnaire was given to the participants where the various parts concerned:

- ☑ Support and contribution of attendants and natural caregivers during their daily activities
- ☑ Perception of their potential level of autonomy using a technical aid such as JACO
- ☑ Perception of life with JACO after the trial
- ☑ General level of satisfaction and preferences following the experience with the JACO robotic arm.

During this part, participants were asked:

- ☑ To estimate the quantity of caregiver time they require for ADL tasks such as eating, preparing meals, self-care, etc (number of hours per day).
- ☑ To estimate the degree by which the JACO arm may help them accomplish the same ADL tasks independently (5-point Likert scale).
- ☑ Questions pertaining to their socio-demographic profile including: family situation, employment and education level, as well as the nature of their disabilities (see questionnaire for details).

INFORMATION ABOUT COMPLEMENTARY STUDY

The evaluator informed the participant about a complementary study evaluating the capacities of JACO to perform daily tasks in their natural environment. The participant received a form stating their interest or refusal to be included in the database of potential participants for this future study. The participant was not obliged to sign or respond to this form: their response could be put off until a future time. Any person accepting to be included in the database may, at any time, have his name withdrawn from the list. In addition, agreement to be included in the database of potential participants did not in any way indicate an agreement to participate in the study.

EVALUATOR'S SATISTACTION

In addition to the participants' evaluations, once the evaluators was informed that the study site was being closed (end of recruitment), they were also surveyed on their satisfaction, preferences and ease of use of the robotic arm JACO.

4) DATA ANALYSIS METHOD

SAMPLE DESCRIPTION

The sample was described (mean, median, standard deviation, min, max, etc.) based on socio-demographic data, physical participant profile, upper-extremity function, and perceived level of autonomy.

OBJECTIVE 1: EFFICACY OF THE JACO ARM

Descriptive statistics were used to display averages and standard deviations of the success rate, perceived ease of use and user satisfaction in each of the tasks performed with the JACO arm.

OBJECTIVE 2: POTENTIAL ECONOMIC BENEFITS

A cost is the value of the resources (inputs) consumed by an intervention. The costs that are incurred are: direct medical, direct non-medical and indirect costs (opportunity cost).

- ☑ Direct medical costs are directly related with the intervention itself. These costs are the most simple to determine and to measure (e.g., long-term healthcare facilities, paramedical consultation (attendants)).
- ☑ Direct non-medical costs are directly related to the intervention but are not part of the intervention itself (e.g., other technical aids).
- ☑ Indirect non-medical costs are not directly related to the medical intervention itself, but are repercussions of the illness (e.g., workday days lost by active and non-active workforce).

  The opportunity cost refers to the net economic outcomes foregone when selecting an intervention rather than an alternative. Once a resource has been used, the opportunity to use it for another purpose is lost because this resource cannot be recuperated and transferred to another purpose. Its value in the next best use, which is no longer possible, is called the opportunity cost (Frappier 2003).

Outcomes refer to the effects, advantages, benefits or consequences of the intervention. Outcomes include both direct (e.g., efficacy, compliance) and intangible components (e.g., quality of life, satisfaction, preferences).

An economic evaluation is an analysis that identifies measures, evaluates and compares the various alternatives, in terms of both costs and outcomes. In order to perform the economic model, all three types of costs, i.e. direct medical, direct non-medical and indirect costs, were collected.

The different types of complete economic analysis are: cost-minimization, cost-effectiveness, cost-utility, cost-benefice and cost consequence analysis. It should be noted that the methods used in identifying and measuring costs is similar in all types of economic evaluations. They only differ in the procedure are measured and assess. The economic method selected for this study consists in a cost-consequence analysis. A cost-consequence analysis assesses the

costs and outcomes of the medical device and presents them in a disaggregated form, which avoids the need to represent results as a single index. Cost-consequence considers multiple outcomes independently of the cost. This type of analysis may be attractive to decision makers as it enables the latter to apply their own weighting factors to the various outcomes. In this study, outcomes presented were:

- ☑ efficacy of using the JACO arm (basic and ADL-like tasks),
- ☑ ability to perform activities of daily living,
- ☑ preferences and satisfaction,
- ☑ medical need to increase level of autonomy,
- ☑ utilization of paid and unpaid care givers,
- ☑ quest of autonomy for specific tasks,
- ☑ safety of the JACO arm for user and surroundings,
- ☑ socio-demographic profile of participants to the trial,
- ☑ participants physical abilities.

The static model was built respecting the CCOHTA Pharmacoeconomic guidelines (CCOHTA 1997) to assure methodological soundness (good applied research practice). The purpose of the methods is to help inform programmatic decision-making regarding the appropriateness and availability of health care interventions including drugs and medical devices. The guidelines are useful for directing study design and for providing a template for final reports.

STUDY PERSPECTIVE

To inform decision-makers about the economic impact of reimbursing the JACO arm, an iterative approach was chosen as to enable decision-makers to appreciate the incremental impact of the JACO arm. The following perspectives have been considered:

- ☑ Attendants (w/Att.)
  - This study perspective considers only the impact of JACO on attendants time savings scenarios
- ☑ Attendants + Specialized centers (w/att. + sp. Ctr cost)
  - This study perspective considers the impact of JACO on attendants' time savings scenarios and the reduced risk of transferring participants to a specialized center (weighed value).
- ☑ Societal cost savings
  - This study perspective includes the attendants time savings, the reduced risk of transferring participants to a specialized center (weighed value) and adding the opportunity cost of a natural caregiver tending to the ADL-needs of participants

STUDY TIME HORIZON

The main study time horizon for the economic model was based on a one-year period; as Kinova expects a 7-year product lifetime of JACO. However, as JACO is a new product, we performed sensitivity analyses over this parameter and made scenarios over a 5-year period and a 3-year period.

SENSITIVITY ANALYSIS

Sensitivity analyses were conducted on parameters that could have a significant impact on the final outcome. Different scenarios were assessed to determine the robustness of the study results and to evaluate the outcomes when subgroups were identified. These scenarios were discussed with the investigators and the client. The parameters that were adjusted for the sensitivity analyses were:

- ☑ The reduction of human assistance needed by the participant
- ☑ Hourly cost of an attendant
- ☑ Integrating the risk that some participants could be at high-risk of being transferred to a specialized center, due to a lack of homecare attendants.
- ☑ JACO's lifetime
- ☑ JACO's purchase price
- ☑ Formal participants efficacy vs informal group

DISCOUNTING

No discounting was attributed to the costs for the break-even budget impact to establish the time for return on investment.

OTHER EXPLANATORY ANALYSES

The participant's physical profile enabled the description of the participants that actively seek for a solution to increase their level of autonomy. The section evaluating JACO's expectations enabled the assessment of a relationship between the expectations and the level of satisfaction of the participants. The level of expectations enabled us to establish the existence of a placebo effect with those who obtained a high success rate on the movements (Objective 1). The data pertaining to the description of the caregivers (paid and unpaid), the level of importance of the caregiver to perform a task and the perception of life with JACO, combined with the success rate of performing tasks with JACO, enabled to infer the number of potential hours that a paid/unpaid caregiver could be obligated to offer, considering the participant's level of autonomy. This number of hours multiplied by the hourly rate of a paid and unpaid caregiver[2] enabled to infer the average incremental cost/cost saving of JACO. Finally, the relationship between the level of activity on the workforce and the propensity to seek solutions to increase their level autonomy were assessed. These analyses could highlight the trend of JACO's usefulness: ranging from a device to increase the level of autonomy in ADL-tasks to a tool that can enable participants to increase their level of autonomy, beyond ADL-tasks; such as extending their leisure time, increasing their implication in academic or workforce settings.

[2] The Canadian guidelines propose to assign the minimum wage, in a conservative manner, to depict the opportunity cost of unpaid caregivers. Sensitivity analyses could be performed on this value, if required, to assess the variability of the results.

5) STUDY RESULTS

The study results are described following those 8 main categories:

- ☑ Study criteria respect and adverse events
- ☑ Socio-demographic profile
- ☑ Physical profile
- ☑ Studies
- ☑ Workforce
- ☑ The JACO experience
- ☑ Quest for autonomy
- ☑ Evaluator's satisfaction

STUDY CRITERIA RESPECT AND ADVERSE EVENTS

The "study criteria respect and adverse events" section presents global results of study events and contains the following tables:

- ☑ Respect of eligibility criteria
- ☑ Non-completion of the JACO arm exercises
- ☑ Serious adverse event
- ☑ Minor event

Table 2: Respect of eligibility criteria

ELIGIBILITY CRITERIA	
Man or woman aged between 18 and 64 years of age (inclusive)	97%
Participant was in a powered wheelchair	100%
Participant was not pregnant	100%
Participant could manipulate a joystick	97%
Participant had the fine motor control that allowed him to press the buttons used to change the control	97%
Participant had the cognitive abilities that allowed him to learn new joystick uses	100%
Participant agreed to read the information and consent form	100%

Table 2 indicates that the eligibility criteria were almost all respected for every aspects; except for the age group, the manipulation of a joystick and the fine motor control ability. Three participants did not respect the original eligibility criteria.

- One participant, aged of 73 years, was enrolled into the study. As this participant respected all the other inclusion criteria, it was decided not to exclude him or his results from the study.
- Two (2) participants did not have the strength nor the ability to complete JACO's movements and tasks. This fact wasn't noticeable before the study and explains why there were two (2) study drop-outs for the movements and tasks part of the study.

Table 3: Non-completion of the JACO arm exercises

NON-COMPLETION OF THE JACO ARM EXERCISES	Number of events
Number of participants that experience a non-completion of the JACO arm exercises	4
Reason for aborting trial	
Presence of a serious adverse event	0
Presence of a minor event	0
Participant decides to quit	0
Non-compliance to study protocol	0
Incapacity of the participant to press adequately the buttons	1
Incapacity of the participant to use adequately the joystick	1
Cognitive incapacities of the participant	0
Sponsor commanding to stop the trial	0
Investigator commanding to stop the trial	0
Other	
- The JACO arm experienced an engineering issue (the arm stopped working)	3

Table 3 represents the participants' non-completion of the JACO arm exercises. The results indicate that there were 4 participants that had to withdraw prematurely from the study exercises with the JACO arm.

- One participant had limited upper-extremity that incapacitated him to use adequately the buttons and the joystick; as the joystick used for the study was not necessarily identical to the one that participants had on their powered wheelchair.
- Three (3) participants experienced engineering issues with JACO; more specifically, the arm stopped working[3]. The participants completed the study except for the questions specific to the use of JACO.

Table 4: Serious adverse event

SERIOUS ADVERSE EVENTS	Number of events
Related to engineering issues	0
Related to users	0
Related to evaluators	0

[3] Following these events, Kinova handed the study centers an updated version of JACO. Engineering issues did not occur with the updated version.

Table 5: Minor event

NON- ADVERSE EVENTS	Number of events
Related to engineering issues	0
Related with users/evaluators misuse	0

Table 4 and Table 5 indicate that there were no reported adverse events during the clinico-economic trial with the utilization of the JACO arm.

SOCIO-DEMOGRAPHIC PROFILE

The "socio-demographic profile" results were acquired during completion of form CRF-1B. This section presents a global image of the cohort and contains the following tables:

- ☑ General information
- ☑ Number of person living with the participant
- ☑ Level of adaptation of the residence
- ☑ Residence adaptation facilities

Table 6: General information

GENERAL INFORMATION	Mean (std dev)	(n=30-31)
Age	43,6 (14,5)	
Number of children	0,52 (1,03)	
Gender		
Male	68%	
Female	32%	
Civil status		
Single	61%	
Married/Common-law	26%	
Divorced/separated/widow	13%	
Source of income		
Employment	25%	*18%**
CSST	7%	*5%**
Private insurance	11%	*8%**
Family	4%	*3%**
SAAQ	14%	*10%**
Social aid	29%	*20%**
Other	50%	*38%**

*These results indicate the distribution level proportional to the total answers; as participants were required to check all boxes that related to their state.

Table 6 represents the socio-demographic profile of the participants. The results indicate that:

- The majority of study participants were male (68%) and single (61%).
- On average, the participants were aged in their mid-forties; ranging from 18 to 73 years of age. There was one participant that was a protocol deviation in terms of age group.
- Only a quarter of the participants were living as a couple, two thirds of the participants (61%) were single. Over a third stated that they were or had been living with a spouse.
- The average number of children per participants was 0,5. The large majority did not have children (74%). For those that did have some, 20% had from one to two children; only 6% had three or more.
- Half of the participants reported that their main source of income was reported in the "other source of income". It mainly consisted of disability pension (public/private) and pension plan (public/private); results will indicate in the economic status (Table 22) that 23% of the enrolled participants were retired from the workforce. Also, 29% received social aid and another 25% had employment as a source of income.

Table 7: Number of people living with the participant

NUMBER OF PEOPLE LIVING WITH THE PARTICIPANT	(n=31)
Living alone	48%
1 to 2	42%
3 to 5	6%
More than 5	0%
Living in a specialized center for people with reduced autonomy	3%

Table 7 represents the number of people living with the participant. The results indicate that:

- Half (48%) of the study group lives alone
- However, almost half (42%) of the study group lives with one to two person.
- Less than 10% lives with three or more people.

Table 8: Level of adaptation of the residence

RESIDENCE LEVEL OF ADAPTATION	(n=31)
Not adapted	0%
Partially adapted	74%
Adapted	23%
Living in a specialized center for people with reduced autonomy (adapted for wheelchairs)	3%

Table 8 represents the residence level of adaptation of the participants. The results indicate that:

- All participants had a form of adaptation to their home to adjust for their level of reduced autonomy. For a quarter of the participants, homes are well adapted. However, the results indicate that a large proportion (74%) would require more adaptation to their homes as they indicated that their homes were only partially adapted.
- A very small proportion of participants lived in a specialized center (3%).

Table 9: Residence adaptation facilities

RESIDENCE ADAPTATION FACILITIES (n=31)	Yes	Mostly	No
Liberty to go out autonomously	74%	23%	3%
Ease of moving around inside the house	87%	13%	0%
Accomplish daily tasks (*e.g., Kitchen, bathroom, laundry room, etc.*)	42%	52%	6%

Table 9 represents the residence level of adaptation of the participants. The results indicate that:

- Most participants (87%) can easily move around inside the house. No participants indicated a lack of mobility inside their homes.
- The large majority of participants (74%) have the liberty to go out autonomously; only 3% require a caregiver to leave their home.
- However, even though almost all participants (94%) have a certain ability to accomplish daily tasks, only 42% indicate that they are autonomous; 52% can perform them partially. Rare (6%) are those that are completely dependent of caregivers to accomplishing activities of daily living.

PHYSICAL PROFILE

The "physical profile" results were acquired during completion of form CRF-1A. This section presents the main physical abilities of the cohort and contains the following tables:

- ☑ Source of physical handicap
- ☑ Number of reported diagnoses
- ☑ Reported diagnoses
- ☑ Physical ability to perform upper body movements - dominant side
- ☑ Physical ability to perform lower body tasks
- ☑ Physical profile
- ☑ Edinburgh test tasks
- ☑ Manual muscle testing for the participant's upper extremity - right side
- ☑ Manual muscle testing for the participant's upper extremity - left side
- ☑ Years of utilization with technical aids

Table 10: Source of physical handicap

SOURCE OF PHYSICAL HANDICAP	(n=30)
Birth	37%
Illness	23%
Accident	40%

Table 10 represents the participants' source of physical handicap. The results indicate that:

- Accidents (40%) and birth (37%) are slightly more prevalent than illness (23%) as the main source of the physical handicap.

Table 11: Number of reported diagnoses

NUMBER OF DIAGNOSES	(n = 32)
n = 1	97%
n = 2	3%
n > 2	-

A diagnosis refers to a health condition. Table 11 represents the participants' number of reported diagnoses. The results indicate that:

- The majority of the reported diagnoses were single (97%).
- No participant has reported having more than two diagnoses.
- The diagnoses and their respective prevalence are reported in table 15.

The reported health conditions of the participants are reported in Table 12. The results indicate that:

- The most reported diagnoses were tetraplagia (33%) followed by the various forms of muscular dystrophy.
- The different diagnoses may be grouped in the five following main categories: neuromuscular diseases (33%), muscle disorder (3%), spinal cord injuries (45%), multiple sclerosis (15%) and cerebral palsy (3%).

Table 12: Reported diagnoses

DIAGNOSES	(n=32)
Tetraplagia	33%
Duchenne muscular dystrophy	9%
Multiple Sclerosis	9%
Amyotrophic lateral sclerosis	6%
Limb-girdle muscular dystrophy (LGMD)	6%
Quadraplegia	6%
Spinal cord compression/injury	6%
Spinal muscular amyotrophy	6%
Facioscapulohumeral (FSH) muscular dystrophy	3%
Juvenile rheumatoid arthritis	3%
Mitochondrial myopahty	3%
Myotonic muscular dystrophy	3%
Spastic paraparesis	3%
SSH muscular dystrophy	3%

Table 13: Physical ability to perform upper body movements - dominant side

PHYSICAL ABILITY TO PERFORM UPPER BODY MOVEMENTS (n=33-34)	Yes	Yes with TA**	Difficultly w/wo TA*	No
Touch a target on your left	71%	6%	15%	9%
Touch a target on your right	68%	3%	18%	12%
Touch a target in front of you	68%	6%	18%	9%
Touch your shoulder (target)	58%	0%	27%	15%
Touch a target above you	44%	12%	18%	26%
Touch a target on the floor	29%	26%	15%	29%
Turn the opening of the fingers toward the left side	68%	0%	24%	9%
Turn the opening of the fingers toward the right side	47%	0%	32%	21%
Turn the opening of the fingers upwards	55%	0%	21%	24%
Turn the opening of the fingers downwards	65%	0%	21%	15%
Turn the thumb upwards	45%	3%	9%	42%
Turn the thumb downwards	39%	3%	18%	39%
Close the fingers	44%	0%	21%	35%
Open the fingers	47%	0%	21%	32%
Point a target	50%	6%	18%	26%

**w/wo TA: with or without a technical aid*
*** TA = Technical aid*

Table 13 presents the participants' physical ability to perform upper body movements. These fifteen (15) upper body movements represent the same movements that the participants were requested to perform by using the JACO arm (except for pressing the button for reinstating JACO in the initial position). The results with the JACO arm will be described in Table 25. The results indicate that:

- Out of the fifteen (15) movements, ten (10) could not be performed, or performed with difficulty, by more than 40% of the participants. Those movements represented mostly:
  - ☑ Upward movements of the arm (touch your shoulder, touch a target above you),
  - ☑ Reaching for the floor (touch a target on the floor),
  - ☑ Movements of the wrist (turn the opening of the fingers toward the right side, turn the opening of the fingers upwards, turn the thumb upward, turn the thumb downward),
  - ☑ Movements of the fingers (close the fingers, open the fingers, point a target).
- The five (5) movements that had the highest ability to be performed were: touch a target on the left (77%), touch a target in front of them (74%), touch a target on their right (71%), turn the opening of the fingers toward the left side (68%) and turn the opening of the fingers downwards (65%).
- The five (5) movements that had the lowest ability to be performed alone were: turn the thumb downwards (57%), close the fingers (56%), open the fingers (53%), turn the opening of the fingers toward the right side (53%), turn the thumb upwards (51%).

Table 14: Physical ability to perform lower body tasks

PHYSICAL ABILITY TO PERFORM LOWER BODY TASKS	Yes without support	Yes with support	No
Stand up alone from wheelchair (n=33)	9%	21%	71%
Walk a distance of 1 meter (n=34)	6%	9%	85%

Table 14 presents the participants' physical ability to perform lower body movements. The results indicate that:

- The participants that are in powered wheelchair are limited in their ability to use their lower body to perform tasks to help upper body movements.
- Less than 10% of the participants can stand alone from their wheelchair or walk a distance of 1 meter.
- The results are slightly better when the participants can have access to support.

Table 15: Physical profile

PHYSICAL PROFILE	(n=33-34)
Dominant side	
Left-handed & right-handed	3%
Right-handed	59%
Left-handed	38%
Ability to move trunk (from front to back)	
Yes	55%
With difficulty	33%
No	12%

Table 15 represents the participants' physical profile. The results indicate the following results:

- Most participants were right-handed (59%)
- 3% were both right- and left-handed; this was not an option in the data collection form. However, as the evaluators stated that both hands were dominant, the results are described according to the evaluators assessment in the data collection form.
- Almost half of the participants (45%) could not move or move with difficulty the trunk from front to back.

Table 16: Edinburgh test tasks

ABILITY TO PERFORM THE EDINBURGH TEST TASKS (n=34)	Left side			Right side			Dominant side
	No	A little	A lot	No	A little	A lot	A lot
Writing	76%	9%	15%	29%	15%	56%	56%
Drawing	79%	6%	15%	41%	12%	47%	47%
Throwing an object	59%	26%	15%	53%	21%	26%	26%
Using scissors	71%	21%	9%	53%	15%	32%	32%
Using a toothbrush	59%	12%	29%	47%	12%	41%	41%
Using a knife (without fork)	76%	18%	6%	62%	9%	29%	29%
Using a spoon	56%	15%	29%	41%	12%	47%	47%
Using a broom (upper hand)	71%	12%	18%	68%	12%	21%	21%
Using a match	85%	9%	6%	85%	9%	6%	6%
Opening a can (cover)	76%	12%	12%	68%	12%	21%	21%

Table 16 represents the results of the Edinburgh test tasks. The results (with the dominant side) indicate the following results:

- The tasks that the participants could perform (a lot) with the greatest scores were:
  - ☑ writing (56%),
  - ☑ drawing (47%),
  - ☑ using a spoon (47%),
  - ☑ using a toothbrush (41%).

- For all the other tasks, the success rate of the participants ("no" or "a little") was inferior to 40%.
- The worst score were associated with: using a match (6%).

Table 17: Manual muscle testing for the participant's upper extremity - right side

MANUAL MUSCLE TESTING - RIGHT SIDE							
(n=32-34)	0	1	2	3	4	5	NA
Shoulder adduction	19%	13%	16%	3%	22%	28%	0%
Shoulder abduction	18%	12%	15%	3%	18%	33%	0%
Shoulder flexion	18%	15%	18%	9%	24%	15%	0%
Shoulder extension	19%	0%	13%	0%	13%	6%	50%
Elbow flexion	12%	15%	15%	6%	21%	30%	0%
Elbow extension	13%	3%	9%	9%	3%	9%	53%
Wrist flexion	30%	6%	12%	12%	24%	15%	0%
Wrist extension	27%	0%	21%	12%	27%	9%	3%

Legend

0 = No contraction *1 = Perceptible contraction without movement* *2 = Partial movement against gravity*

3 = Total movement against gravity *4 = Total movement against a slight resistance* *5 = Total movement against a strong resistance*

Table 18: Manual muscle testing for the participant's upper extremity – left side

MANUAL MUSCLE TESTING - LEFT SIDE							
(n=32-34)	0	1	2	3	4	5	NA
Shoulder adduction	9%	21%	9%	9%	26%	26%	0%
Shoulder abduction	15%	15%	12%	9%	24%	26%	0%
Shoulder flexion	24%	15%	12%	12%	21%	18%	0%
Shoulder extension	18%	0%	9%	3%	15%	6%	48%
Elbow flexion	18%	9%	12%	9%	26%	26%	0%
Elbow extension	19%	3%	6%	6%	9%	3%	53%
Wrist flexion	24%	9%	18%	15%	21%	15%	0%
Wrist extension	18%	6%	15%	18%	35%	6%	3%

Legend

0 = No contraction *1 = Perceptible contraction without movement* *2 = Partial movement against gravity*

3 = Total movement against gravity *4 = Total movement against a slight resistance* *5 = Total movement against a strong resistance*

Table 17 and Table 18 represent the results of the Manual Muscle Testing respectively for the right and the left side. For both tables, the results indicate the following results:

- Exception made of shoulder and elbow extension, approximately half of the participants can manage to obtain total movement against gravity up to a total movement against a strong resistance (score 3 to 5) for most of the specific muscle testing. The other half of the participants range from no contraction to a partial movement against gravity.

- For the shoulder and elbow extension, half of the participants did not perform the test. These two segments of the muscle testing exercise generate the lowest scores. Graphic 1 shows the combined results for the manual muscle testing of the participants' dominant side.

Graphic 1: Manual muscle testing results for the dominant side

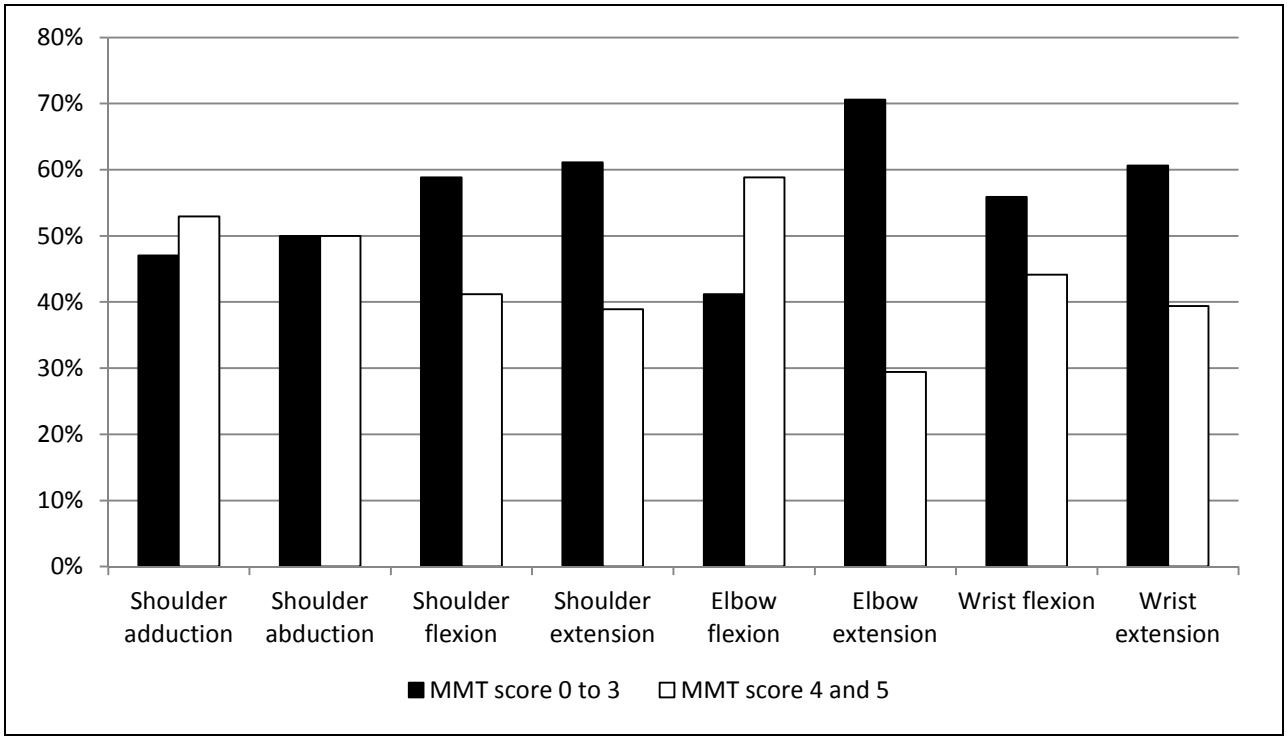


Table 19: Years of utilization with technical aids

UTILIZATION OF TECHNICAL AIDS (n=27-30)	Year (mean ± std.dev)
Technical aids	18,62 ± 13,56
Wheelchair	17,32 ± 13,23
Powered wheelchair	17,06 ± 11,94

Table 19 represents the participants' experience with different technical aids. The results indicate that:

- Participants have been using technical aids for a long time, almost twenty years; some have been using them for over than 50 years.
- Most participants were shortly in a manual wheelchair (0,3 years) before being transferred to a powered wheelchair.

STUDIES

The participants' academic profile was acquired during completion of form CRF-1B. This section presents the cohort's study level and impact of handicap on studies.

Table 20: Highest level of studies completed

HIGHEST LEVEL OF STUDIES COMPLETED	(n=31)
Elementary	3%
Secondary	35%
CEGEP/technical/trade	23%
University	32%
Post-graduate	6%

Table 20 represents the highest level of studies completed by the participants. The results indicate that:

- The majority of the participants have completed more than a high school diploma.
- More than a third (38%) has a graduate and post-graduate degree.
- Only 3% did not complete their secondary level

Table 21: Impact of the physical handicap on studies

IMPACT OF THE PHYSICAL HANDICAP ON STUDIES	Yes	Mostly	No	N/A	n
Discontinuation of studies because of the physical handicap	29%	10%	42%	19%	31
	*36%**	*12%*	*52%*		
Factors that caused discontinuation of studies					
Transportation	19%	7%	15%	59%	27
	45%	*18%*	*36%*		
Non-adapted classes	23%	0%	15%	62%	26
	60%	*0%*	*40%*		
Limitation/physical incapacity of the participants arm	23%	8%	8%	62%	26
	60%	*20%*	*20%*		
Other	24%	4%	4%	68%	25
	75%	*13%*	*13%*		
Belief that JACO could of made a difference for the achievement of the expected level of studies	10%	10%	71%	10%	31
	11%	*11%*	*79%*		

* The smaller italic row refers to proportions when those that have checked the NA checkbox have been excluded from the statistics

Table 21 represents the physical handicap's impact on the studies of participants. The results indicate that:

- Physical handicap had an impact on studies for almost of the participants.
- Transportation and non-adapted classes was a significant problem for more than 50% of the participants (ones who reported an impact). They also reported in the comments that

the understanding of their condition and the respect of the surroundings was somewhat an issue. However, some stated that there has been an evolution of the society towards people in wheelchairs.

- 80% of participants (ones who reported an impact) associated their decision with the limited physical capacities of their arms. However, regardless of this interesting result, only 22% (ones who reported an impact) believed that JACO could have made a difference for the achievement of the expected level of studies.

WORKFORCE

The "workforce" results were acquired during completion of form CRF-1B. This section presents the cohort's general past and present working status and contains the following tables:

- ☑ Economic status
- ☑ Work status impact
- ☑ Perceived highest salary

Table 22: Economic status

ECONOMIC STATUS (n=31)	Presently	In the Past
Full time work	10%	10%
Part time work	6%	0%
Volunteer work	13%	68%
At-home parent	0%	6%
Retired	23%	6%
Do not work	48%	10%

Table 22 represents the physical handicap's impact of the participants' workforce. The results indicate that:

- Only a few participants have worked (presently or in the past). It is interesting to note that there has been no change for the full time workers (10%). However, there are 6% more participants that are working part-time today versus the past.
- There has been a significant drop in the volunteer work. In the past, 68% has stated that they had been involved with some type of volunteer activity, as for presently, only 13% has stated that they were implicated.
- The large majority of the participants (71%) are either retired or do not work.
- A small proportion (6%) of the participants has been an at-home parent. However, the case report form does not inform us if this person was relatively disabled or not at the moment of being an at-home parent.

Table 23: Work status impact

IMPACT OF THE PHYSICAL HANDICAP ON WORK	Yes	Mostly	No	NA	n
Work status change	79%	4%	18%		28
	*79%**	*4%*	*18%*		
Impact on employment					
Loss of employment	47%	9%	24%	21%	34
	59%	*11%*	*30%*		
Change of employment	26%	0%	56%	18%	34
	32%	*0%*	*68%*		
Reduction of hours	32%	0%	50%	18%	34
	39%	*0%*	*61%*		
Status change (full time to part time)	24%	3%	56%	18%	34
	29%	*4%*	*68%*		
Salary change	44%	0%	38%	18%	34
	54%	*0%*	*46%*		
Responsibility change	35%	3%	44%	18%	34
	43%	*4%*	*54%*		
Principal causes of the impact on employment					
Transportation	24%	6%	50%	21%	34
	30%	*7%*	*63%*		
Non-adapted offices	9%	9%	62%	21%	34
	11%	*11%*	*78%*		
Physical limitation of the arms (to allow to perform tasks inherent to the job)	38%	9%	32%	21%	34
	48%	*11%*	*41%*		
Other	24%	9%	30%	36%	33
	38%	*14%*	*48%*		
Beliefs that JACO could of made a difference on employment status					
	26%	13%	61%	0%	31
	26%	*13%*	*61%*		

* The smaller italic row refers to proportions when those that have checked the NA checkbox have been excluded from the statistics

Table 23 represents the physical handicap's impact on the work of participants. The results indicate that:

- Around 80% of participants believed that their physical handicap has generated a significant impact on their work status.
- For those who reported an impact on employment, the most significant appears to be the loss of employment (70%), followed by salary change (54%) and responsibility change (47%). Approximately one-third attributed an impact on reduction of hours (39%), status change (33%) and change on employment (32%).
- The principal cause of the impact appears to be the physical limitation of the arms (59%). It is interesting to note that more than one-third of the participants (39%) believed that JACO would have made a difference on their employment status.

Table 24: Perceived highest salary

PERCEIVED HIGHEST SALARY LEVEL	Presently (n=31)	In the Past (n=28)
High	13%	25%
Medium	29%	54%
Low	35%	21%
None (*Volunteer/At-home parent*)	23%	0%

Table 24 represents the participants' perceived highest salary level. The results indicate that:

- In the past, almost 80% of the participants perceived that they were making a high, if not medium, salary level. As for today, almost half of the participants (versus 80%) believe that their perceived salary is medium to high
- It is interesting to note that, in the past, no respondents mentioned that they had no income and that only 21% thought that their income level was perceived low; whereas 23% now report a non-existent salary presently.

THE JACO EXPERIENCE

"The JACO experience" section presents the main trial results. Hereunder is a list of the tables found in this section and the respective part from which the results were collected:

- ☑ Efficacy of performing JACO's movements (Part 1A: assessment of 16 movements with JACO)
- ☑ Efficacy of performing tasks with JACO (Part 1A: assessment of 16 movements with JACO)
- ☑ Easiness and interest of being able to perform the tasks with JACO
- ☑ Perspective of manipulating JACO – Before the trial (CRF Part 1A)
- ☑ Perception of JACO's ability to facilitate performing essential ADL – Before the trial (CRF Part 1A)
- ☑ Perception of life with JACO – After the trial (CRF Part 1B)
- ☑ General satisfaction with the JACO arm (CRF Part 1B)

Table 25: Efficacy of performing JACO's movements

EFFICACY OF PERFORMING JACO'S MOVEMENTS	*Average for attempt…*		Failure to achieve	Ease of accomplishing the exercise			
(n = 28-32)	No1	No2		Absol	Very	A little	Not at all
Touch a target on your left	1,36	1,36	-	90%	10%	0%	0%
Touch a target on your right	1,36	1,36	-	90%	10%	0%	0%
Touch a target in front of you	1,33	1,36	-	87%	6%	3%	3%
Touch your shoulder (target)	1,39	1,39	-	87%	13%	0%	0%
Touch a target above you	1,36	1,36	-	87%	13%	0%	0%
Touch a target on the floor	1,33	1,36	-	84%	16%	0%	0%
Turn the opening of the fingers toward the left side	1,38	1,38	-	90%	7%	3%	0%
Turn the opening of the fingers toward the right side	1,38	1,38	-	90%	10%	0%	0%
Turn the opening of the fingers upwards	1,31	1,31	-	90%	10%	0%	0%
Turn the opening of the fingers downwards	1,34	1,34	-	93%	3%	3%	0%
Turn the thumb upwards	1,34	1,34	-	87%	10%	3%	0%
Turn the thumb downwards	1,34	1,38	-	90%	7%	3%	0%
Close the fingers	1,34	1,34	-	93%	3%	3%	0%
Open the fingers	1,34	1,34	-	93%	3%	3%	0%
Point a target	1,38	1,38	-	93%	3%	3%	0%
Initial position	1,38	1,48	-	89%	4%	0%	7%
Average (all movements combined)	**1,36**	**1,37**		**90%**	**8%**	**2%**	**1%**

Table 25 represents the participants' ability to perform JACO's movements. These sixteen (16) movements represent the same movements that the participants were requested to perform by using their dominant arm; in addition to the command to re-initialize JACO's position. The results indicate that:

- Participants could succeed to perform JACO's movements almost the first time; the average success time being 1,36. Results are highly similar at the second attempt. The highest attempt for performing the movements was four times.
- Considering the low attempts to performing the movements, it was not surprising that almost all the participants stated that it was very to absolutely easy to perform the movements.
- The most surprising result was associated with 7% of the participants that stated that it was not easy at all to reset in the initial position JACO.

Table 26: Efficacy of performing tasks with JACO – Average attempts

EFFICACY OF PERFORMING TASKS WITH JACO (n=28-32)	Attempt 1 Average attempts	Attempt 2 Average attempts	Failure to achieve
Take a bottle from your left off a table	1,22	1,22	-
Take a bottle from your right off a surface near the ground and place it on the table	1,19	1,19	-
Push the buttons of a calculator	1,34	1,34	-
Take a facial tissue from the box on the table	1,28	1,28	-
Take a straw from a glass on the table	1,24	1,24	-
Pour water into a glass using a bottle	1,24	1,24	-
Average attempts (all tasks combined)	**1,25**	**1,25**	

Table 26 represents the participants' physical ability to perform ADL-related-tasks with JACO. A task refers to a pre-defined sequence of movements that enables to perform a given task of essential activities of daily living. The results indicate that:

- Participants could succeed to perform JACO's movements almost the first time as less than 10% of the participants had to attempt at least twice to succeed the tasks with the JACO arm.
- It took an average of 1,25 attempts to succeed the various tasks with JACO.
- The highest attempt for performing the tasks was four times.
- The database indicates that the large majority attempted to perform the tasks only once. Results are highly similar for the second attempt.

Table 27: Easiness and interest of being able to perform the tasks with JACO

TASKS TO BE PERFORMED WITH JACO	Ease of performing the tasks for the participant				Interest in being able to perform the tasks for the participant			
(n=30-32)	Absolutely	Very	A little	Not at all	Absolutely	Very	A little	Not at all
Take a bottle from your left off a table	75%	22%	0%	3%	66%	22%	13%	0%
Take a bottle from your right off a surface near the ground and place it on the table	68%	16%	16%	0%	77%	6%	16%	0%
Push the buttons of a calculator	57%	37%	7%	0%	60%	17%	13%	10%
Take a facial tissue from the box on the table	77%	23%	0%	0%	70%	7%	20%	3%
Take a straw from a glass on the table	80%	17%	0%	3%	60%	20%	20%	0%
Pour water into a glass using a bottle	63%	30%	7%	0%	77%	13%	10%	0%
Average	**70%**	**24%**	**5%**	**1%**	**68%**	**14%**	**15%**	**2%**

Table 27 represents the participants' easiness and interest of being able to perform the tasks with the JACO arm. The results indicate that:

- Participants believed that it was very easy to perform the pre-defined tasks. On average, 94% believed that the tasks were, at least, very easy to perform. The task that was judged to be the most complex to be performed was "take a bottle from your right off a surface near the ground and place it on the table"; although 85% believed that it was, at least, very easy to perform.
- Participants indicated a high interest in being able to perform the pre-defined tasks. On average, 82% believed that the tasks were, at least, very interesting to perform. The tasks that participants mostly wished to be able to perform were:
  - ☑ Pour water into a glass using a bottle (90%),
  - ☑ Take a bottle off a table (88%)
  - ☑ Take a straw from the glass on the table (80%).

Table 28: Perspective of manipulating JACO – Before the trial

PERSPECTIVE OF MANIPULATING JACO - BEFORE THE TRIAL (n=34)	Yes	No
Excited	38%	62%
Curious	85%	15%
Skeptical	9%	91%
Worried	12%	88%
Indifferent	0%	100%
Other	6%	94%

Table 28 represents the participants' perspective of manipulating JACO before the trial. The results indicate that:

- Most participants (85%) were curious about the experience
- 38% were excited.
- Approximately 10% were either skeptical or worried with the experience.
- One participant was surprised by JACO's large size.

Table 29: Perception of JACO's ability to facilitate performing essential ADL – Before the trial

PERCEPTION OF JACO'S ABILITY TO FACILITATE PERFORMING ESSENTIAL ADL - BEFORE TRIAL (n=34)	
Absolutely	44%
Probably	35%
I do not know	18%
I do not think so	3%
No	0%

Table 29 represents the participants' ability to performing essential activities of daily living (before the trial). The results indicate that:

- Most participants (79%) thought that JACO could facilitate performing essential activities of daily living.
- Only 3% did not believe that JACO could facilitate performing essential activities of daily living.
- There were 18% that were not sure of the relevance of JACO.

Table 30: Perception of life with JACO – After the trial

PERCEPTION OF LIFE WITH JACO - AFTER THE TRIAL (n=29-30)	Absolutely	Very	A little	Not at all
Reduction of stress /anxiety level when left alone for several consecutive hours	40%	17%	33%	10%
Allowing to have more quality time with…				
Attendant	17%	17%	17%	48%
Friends / family / volunteers	20%	33%	23%	23%
Others	23%	30%	27%	20%
Inspiration for…	23%	7%	27%	43%
Returning on the workplace or facilitating current work	13%	13%	20%	53%
Returning to studies or allowing to take more courses	27%	17%	20%	37%
Taking up projects that had been abandoned	70%	27%	3%	0%
Significant technical aid for powered wheelchair users with upper extremity disabilities	70%	27%	3%	0%

Table 30 represents the participants' perception of life with JACO after performing the trial. The results indicate their following perceptions:

- Almost all participants (97%) believed that JACO represents a significant technical aid for powered wheelchair users with upper extremity disabilities. Only 3% are not totally convinced.
- Almost (97%) all participants believed that JACO would represent a significant tool for inspiring them for taking up projects that had been abandoned
- It is interesting to note that nearly half of the participants (44%) would be inspired into returning to studies or allowing to take more courses if they had JACO
- Also, 26% would be inspired into returning on the workplace or thought that JACO would facilitate their current work.
- Many participants believed that JACO could enable them to have more quality time with attendants (34%) or friends and others (53%).
- Finally, almost 60% believe that JACO could enable them to reduce the stress level when left alone for several hours.

Table 31Table 31 presents the participants' satisfaction with the JACO arm after performing the trial of the movements and the tasks. The results indicate that:

- All participants (100%) were very satisfied with the ease of use of the joystick and the possibilities of use for general tasks.
- Almost all participants were very satisfied with JACO's safety for users (96%) and the easiness of adaptation (97%).
- A very large proportion of participants (90-94%) were very satisfied with JACO's easiness for the overall training, the safety for people nearby, JACO's appearance and the user instruction.
- After this first experience with the JACO arm, 87% were very satisfied with the possibilities of use for fine motor control (precision capabilities)

- Most participants (80%) perceived that JACO was very safe for the power wheelchair; however, 20% were not convinced
- Most participants (77%) were very satisfied with the controls (buttons)

Table 31: General satisfaction with the JACO arm

GENERAL SATISFACTION WITH THE JACO ARM	Absolutely	Very	A little	Not at all	n/a	n
Ease of use						
Joystick	70%	30%	0%	0%	0%	31
Controls (buttons)	40%	37%	7%	10%	7%	31
User instructions for the JACO arm	67%	23%	3%	7%	0%	31
Summary sheets for the command modes	54%	19%	15%	8%	4%	26
Overall training	77%	17%	3%	3%	0%	30
Ease of adaptation	76%	21%	0%	3%	0%	29
Safety						
Users	83%	13%	3%	0%	0%	30
People nearby	63%	30%	7%	0%	0%	30
Safety perception for the powered wheelchair	57%	23%	20%	0%	0%	30
Possibilities of use						
Fine motor control (precision capabilities)	60%	27%	13%	0%	0%	30
General tasks	73%	27%	0%	0%	0%	30
Physical appearance of JACO	60%	33%	3%	3%	0%	30

QUEST FOR AUTONOMY

The “quest for autonomy” results were acquired during completion of form CRF Part 1B. This section presents the results concerning technical aids and time devoted by attendants and natural caregiver. It includes the following tables:

- ☑ Level of autonomy
- ☑ Quest for solutions to increase level of autonomy
- ☑ Technical aids purchases: value and reimbursement
- ☑ Average total hours supplied by type of caregiver to the participants
- ☑ Average total cost by type of caregiver
- ☑ 3 preferred activities that participants would rather spend more time with attendant and natural caregiver
- ☑ Perceived importance of a caregiver if JACO was available (all participants)
- ☑ Perceived importance of a caregiver if JACO was available (when excluding participants that checked the box “not applicable”)

Table 32: Level of autonomy

LEVEL OF AUTONOMY	ABILITY					WILLINGNESS TO LEARN NEW METHODS					IMPORTANCE					FRUSTRATION					
	Yes	Yes TA	Diff	No	NA	Absol	Very	A little	No	NA	Absol	Very	A little	No	NA	Absol	Very	A little	No	NA	n
Drinking	**55%**	**27%**	**12%**	**6%**	**0%**	**61%**	**9%**	**9%**	**21%**	**0%**	**88%**	**9%**	**3%**	**0%**	**0%**	**39%**	**24%**	**15%**	**21%**	**0%**	**33**
Serving a drink with a pitcher	24%	3%	18%	56%	0%	68%	12%	6%	15%	0%											34
Using an automatic fountain	35%	0%	18%	47%	0%	59%	6%	15%	21%	0%											34
Drinking with a straw	91%	6%	3%	0%	0%	53%	3%	9%	35%	0%											34
Preparing a drink	**36%**	**6%**	**9%**	**48%**	**0%**	**58%**	**21%**	**9%**	**12%**	**0%**	**73%**	**6%**	**15%**	**6%**	**0%**	**36%**	**18%**	**24%**	**21%**	**0%**	**33**
Boiling water	44%	0%	11%	44%	0%	52%	19%	11%	19%	0%											27
Process of preparing a powder-based liquid	52%	0%	4%	44%	0%	56%	15%	15%	15%	0%											27
Eating	**55%**	**30%**	**12%**	**3%**	**0%**	**70%**	**6%**	**6%**	**18%**	**0%**	**73%**	**24%**	**3%**	**0%**	**0%**	**45%**	**21%**	**15%**	**18%**	**0%**	**33**
Dry food (granola bar)	76%	9%	6%	9%	0%	61%	6%	12%	21%	0%											33
Soft food (grape)	76%	6%	9%	9%	0%	64%	6%	9%	21%	0%											33
Preparing a meal	**15%**	**0%**	**36%**	**48%**	**0%**	**67%**	**15%**	**3%**	**15%**	**0%**	**52%**	**27%**	**18%**	**3%**	**0%**	**39%**	**24%**	**24%**	**12%**	**0%**	**33**
Opening/closing the refrigerator door	70%	4%	7%	19%	0%	48%	7%	7%	37%	0%											
Putting a container into the microwave	54%	4%	15%	27%	0%	50%	12%	15%	23%	0%											27
Activating the microwave	69%	8%	8%	15%	0%	54%	4%	8%	35%	0%											26
Emptying food into a pot	26%	0%	30%	44%	0%	67%	7%	7%	19%	0%											26
Starting a manual timer	70%	4%	15%	11%	0%	44%	11%	19%	26%	0%											27
Removing a dish from the oven	15%	11%	15%	59%	0%	63%	7%	7%	22%	0%											27
Taking & moving a container (bottle of water)	56%	11%	22%	11%	0%	48%	7%	15%	30%	0%											27
Picking up a dropped dish	15%	4%	22%	59%	0%	70%	15%	4%	11%	0%											27

Legend:
Yes = Yes *Yes TA = Yes with technical aid* *Diff = With Difficulty* *No = No* *NA = Not applicable* *Absol. = Absolutely*

Table 32: Level of autonomy (cont'd)

LEVEL OF AUTONOMY	ABILITY					WILLINGNESS TO LEARN NEW METHODS					IMPORTANCE					FRUSTRATION					
	Yes	Yes TA	Diff	No	NA	Absol	Very	A little	No	NA	Absol	Very	A little	No	NA	Absol	Very	A little	No	NA	n
Personal care / ADL	**42%**	**6%**	**24%**	**27%**	**0%**	**64%**	**15%**	**9%**	**12%**	**0%**	**79%**	**18%**	**0%**	**3%**	**0%**	**48%**	**21%**	**18%**	**12%**	**0%**	**33**
Washing face with a damp washcloth	65%	3%	16%	16%	0%	65%	3%	10%	23%	0%											31
Brushing teeth	61%	16%	13%	10%	0%	58%	10%	10%	23%	0%											31
Using an electric razor/applying lipstick	65%	0%	6%	26%	3%	61%	3%	13%	19%	3%											31
Applying deodorant	68%	6%	13%	13%	0%	52%	0%	16%	29%	3%											31
Taking medication	32%	0%	6%	58%	3%	61%	0%	19%	16%	3%											31
Putting on a hat	45%	0%	23%	29%	3%	61%	6%	19%	10%	3%											31
Putting on glasses	71%	3%	13%	13%	0%	55%	3%	6%	35%	0%											31
Scratching face	74%	3%	19%	3%	0%	52%	6%	3%	39%	0%											31
Picking up objects	**52%**	**18%**	**21%**	**9%**	**0%**	**76%**	**3%**	**9%**	**12%**	**0%**	**76%**	**24%**	**0%**	**0%**	**0%**	**42%**	**30%**	**18%**	**9%**	**0%**	**33**
A book/magazine	56%	9%	21%	15%	0%	68%	12%	3%	18%	0%											34
A piece of paper	71%	9%	12%	9%	0%	65%	6%	6%	24%	0%											34
Turning the pages of a book/magazine	65%	15%	12%	9%	0%	65%	6%	6%	24%	0%											34
Writing on an envelope & sticking a stamp	47%	6%	24%	24%	0%	68%	3%	6%	24%	0%											34
Picking up change	44%	0%	35%	21%	0%	65%	9%	6%	21%	0%											34
Moving small objects	53%	6%	24%	18%	0%	62%	9%	9%	21%	0%											34
Opening & closing door/drawer	**42%**	**9%**	**24%**	**24%**	**0%**	**70%**	**12%**	**3%**	**15%**	**0%**	**64%**	**30%**	**6%**	**0%**	**0%**	**45%**	**24%**	**15%**	**15%**	**0%**	**33**
A door with a lever handle *(standard for handicapped use)*	59%	3%	16%	22%	0%	63%	9%	3%	25%	0%											32
A door with a round handle	16%	6%	22%	56%	0%	72%	16%	6%	6%	0%											32
A drawer with a handle	72%	3%	16%	9%	0%	59%	9%	6%	25%	0%											32

Legend:
Yes = Yes *Yes TA = Yes with technical aid* *Diff = With Difficulty* *No = No* *NA = Not applicable* *Absol. = Absolutely*

Table 32: Level of autonomy (cont'd)

LEVEL OF AUTONOMY	ABILITY					WILLINGNESS TO LEARN NEW METHODS					IMPORTANCE					FRUSTRATION					
	Yes	Yes TA	Diff	No	NA	Absol	Very	A little	No	NA	Absol	Very	A little	No	NA	Absol	Very	A little	No	NA	n
Playing games	**48%**	**15%**	**24%**	**12%**	**0%**	**67%**	**3%**	**18%**	**12%**	**0%**	**48%**	**21%**	**24%**	**6%**	**0%**	**24%**	**15%**	**30%**	**30%**	**0%**	**33**
Playing chess/checkers/Monopoly	56%	9%	19%	16%	0%	53%	3%	22%	22%	0%											32
Shuffling and passing cards	16%	9%	25%	50%	0%	53%	9%	19%	19%	0%											32
Using an audio/video system/computer/switch	**64%**	**21%**	**12%**	**3%**	**0%**	**67%**	**0%**	**18%**	**15%**	**0%**	**79%**	**21%**	**0%**	**0%**	**0%**	**39%**	**24%**	**18%**	**18%**	**0%**	**33**
Choosing a radio station /adjusting the volume	61%	18%	12%	9%	0%	61%	3%	9%	27%	0%											33
Inserting a compact disc	55%	9%	15%	21%	0%	61%	0%	12%	27%	0%											33
Using the keyboards of a computer / telephone	52%	30%	18%	0%	0%	64%	9%	12%	15%	0%											33
Using a mouse	55%	24%	15%	6%	0%	61%	9%	12%	18%	0%											33
Turning on and off a switch (*the one that lifts and lowers*)	58%	24%	6%	12%	0%	64%	3%	15%	18%	0%											33
Other	**82%**	**9%**	**0%**	**9%**	**0%**	**100%**	**0%**	**0%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**	**0%**	**17%**	**50%**	**17%**	**17%**	**0%**	**6-10**
Other	24%	18%	41%	18%	0%	82%	6%	6%	6%	0%											17
Other	0%	17%	17%	50%	17%	83%	0%	0%	0%	17%											8

Legend:
Yes = Yes *Yes TA = Yes with technical aid* *Diff = With Difficulty* *No = No* *NA = Not applicable* *Absol. = Absolutely*

Table 32 presents the level of autonomy of the participants to perform activities of daily living. It also indicates their willingness to learn new methods to increase their level of autonomy, the importance and frustration of not being able to perform activities of daily living. The results indicate the following:

☑ **Ability**

- On average, 15% to 82% are able to perform the essential activities of daily living without TA or without any difficulties.
- On average, only 45% of the participants could perform the 9 general tasks involved in activities of daily living.

☑ **Importance**

- Out of the nine specific ADL-related tasks, six (6) are considered as very important by a large majority (94-100%) of the participants. Those tasks are using an audio/video system (100%), picking up objects (100%), drinking and eating alone (97%), personal care/ADL (97%), drinking (97%), eating (97%) and opening/closing doors and drawers (94%).
- The only component that was considered important by less than 70% of the participants was the "playing game" tasks.
- Picking up objects and being able to use an audio/video system is unquestionable two components of the activities of daily living that participant all agree that it is very important to be autonomous to do so; as all of them (100%) stated that it was very important for them.
- The only important component that was "absolutely" important for almost of all of the participants was drinking alone (88%). This was followed by personal ADL (79%), using an audio/video system (79%), picking up objects (76%), eating (73%) and preparing a drink (73%).

☑ **Frustration**

- On average, 62% are very frustrated of their level of autonomy to perform the activities of daily living.
- Being able to be autonomous to perform personal care/ADL is stated as the second most frustrating aspect; slightly after picking up objects (72%) and is *ex-æquo* to opening and closing a door/drawer.
- It is interesting to note that more than 80% are able to eat on their own. Regardless of their ability, near to 70% are very frustrated about it. It is not surprising to note that 70% are eager to learn new methods to ease eating and drinking on their own.
- More than 80% of the participants are able to drink and eat on their own, and use an audio/video system. However, regardless of this large proportion, almost 70% remain frustrated with their ability to do so and thus are willing to learn new methods.

☑ **Willingness to learn new methods**

- The other components of activities of daily living that 80% of the participants were more willing to learn new methods to increase their level of autonomy were: preparing a meal and a drink, opening and closing a drawer or door, picking up objects, personal

care/ADL. Once again, playing games represents the important component to find new methods, even though more than 50% are willing to learn to methods.

- Regardless of their ability to perform the various activities of daily living, participants are willing to learn new methods with a mean of 78% for all ADL-related-tasks.

A more thorough analysis of each component of activities of daily living is described hereunder:

☑ **Drinking alone:**

- Almost all participants (97%) believed that drinking alone is very important.
- It is interesting to note that 82% of the participants can drink on their own. If there is a straw in the drink, almost all the participants (97%) can achieve to drink.
- However, the drink must be ready to drink since only 27% can serve their drink with a pitcher.
- It should also be stressed that 20% of the participants cannot drink or drink with difficulty on their own. This would probably express the high rate of willingness to learn new methods (up to 70%) and the moderate level of frustration around the ability to do so (63%).

☑ **Preparing a drink**

- Less than half of the participants (36%) can prepare a drink alone without any TA.
- However, almost 80% think that it is very important for them and thus they would like to learn new methods to enable them to be more autonomous to do so. However, regardless the large proportion that thinks it is important, a little more than half (54%) are very frustrated about it.

☑ **Eating**

- Almost all participants (97%) believe that being able to eat on their own is very important.
- However, it is interesting to note that almost 15% of them cannot or have difficulties to feed themselves (without a technical aid).
- It is interesting to note that most of the participants can eat soft (82%) and dry (85%) food with the same ability rate. Hence, eating soft food does not represent a significant problem for them.
- Regardless of the significant ability to eat dry and soft food, eating on their own remains a significant component that participants (66%) are very frustrated about and thus 76% are willing to learn new methods.

☑ **Preparing a meal**

- Preparing a meal appears to be the most complex task for people with upper-extremity disabilities as only 15% states that they were able to prepare a meal.
- Considering that 79% stated they thought it was very important, it is not surprising to note that 82% would be willing to learn new methods to increase their autonomy to do so and that it frustrates 63% not to be able to prepare a meal, with or without a technical aid.

☑ **Personal care / ADL**

- Less than half of the participants (48%) stated that they are not able to perform personal care/ADL. However, 97% believed that it is very important for them to be able to accomplish them on their own.
- It is not surprising that 69% stated that it frustrated them and thus they were willing to learn new methods.
- The personal care/ADL that the participants had the highest ability to perform are: scratching face (77%), brushing teeth (77%), putting on eye glasses (74%) and applying deodorant (74%).
- The component that participants seem to have the greatest difficulty is taking medication. Only 32% are able to do so.

☑ **Picking up objects**

- Picking up object was considered an important task by all (100%) of the participants.
- It is interesting to note that 72% are frustrated about their ability to pick up objects although significant proportion (70%) stated that they were able to do it.
- Hence, it is not surprising to state that 79% were willing to learn new methods.
- It is interesting to note that picking up a book or magazine is harder for them to do than grabbing a piece of paper; respectively, where 65% are able vs. 80%.
- Up to 80% are able to turn the pages of a book or magazine.
- However, picking up change is the most challenging for them, followed by writing on an envelope and sticking a stamp; respectively, where 44% are able vs. 53%.

☑ **Opening and closing drawers/doors**

- Only half of the participants (51%) stated that they can open/close a door and drawer.
- The most difficult type of handle is a round one where only 22% stated that they can open.
- However, most participants (75%) can open drawers with a handle.
- Almost all participants (94%) thought that it was very important to be able to open and close drawers/doors.
- 69% stated that their inability was a source of frustration. Hence it is not surprising that 82% stated that they were willing to learn new methods

☑ **Playing games**

- Playing games, regardless that 69% of the participants stated it is a very important aspect of their ADL, clearly represents their least priority.
- Few (39%) are frustrated about this limitation compared to the other life components.

☑ **Using an audio/video system**

- As stated previously, all participants (100%) agree that it is very important to being able to use an audio/video system.

- Regardless that 85% stated that they could use the system, 63% are frustrated with their limited ability and thus 67% are willing to learn new methods to improve their ability.
- The most complicated task for them is inserting a compact disc. Still, a significant proportion (64%) considers that they are able to perform the task.

The tasks that most of participants (82%) stated having the greatest ability is using the keyboard

Table 33 indicates the participants' quest to increase level of autonomy. The results indicate that:

☑ **Discussion**

- Very few participants have discussed with caregivers alternatives enabling them to increase their level of autonomy. The most frequent discussion was about finding better ways to use an audio/video system (37%) followed by preparing a meal (31%). Up to 37% had a discussion a long time ago for finding solutions for picking up objects.
- For most of the ADL categories, more than half of the participants did not discuss with their caregivers about finding means enabling them to increase their level of autonomy.
- The ADL categories least likely to be discussed are playing games (87%), preparing a drink (73%) and drinking (67%).

☑ **Exercises**

- Very few participants have requested to perform specific exercises to increase their ability to perform activities of daily living.
- More than 75% of the participants stated that they did not make any specific exercise requests, except for eating where 36% of the participants already did exercises for this task.
- The activities that were least likely to request an exercise program were: playing games (90%) and preparing a drink (87%)

☑ **Available technical aids**

- A mean of 21% of the participants recently inquired about the availability of technical aids for accomplishing the nine (9) principal ADL.
- The most frequent categories for which participants already searched for (yes and yes/ LTA) are: using a audio/video system (70%), preparing a meal (56%), eating (53%) and picking up objects (52%).
- The components that were least likely to be searched for available technical aids were: playing games (77%) and preparing a drink (73%).

Table 33: Quest for solutions to increase level of autonomy

LEVEL OF AUTONOMY QUEST FOR SOLUTIONS	Discussion			Exercises			Available TA			TA Purchase			TA Satisfaction		
(n=29-32)	Yes	Yes-LTA	No	Yes	Yes-LTA	No	Yes	Yes-LTA	No	Yes	Yes-LTA	No	Yes	Yes-LTA	No
Drinking	17%	17%	67%	3%	13%	83%	17%	23%	60%	30%	30%	40%	58%	13%	29%
Preparing a drink	17%	10%	73%	3%	10%	87%	13%	13%	73%	0%	0%	100%	0%	0%	100%
Eating	23%	27%	50%	13%	23%	63%	23%	30%	47%	37%	17%	47%	46%	15%	38%
Preparing a meal	31%	19%	50%	6%	16%	78%	31%	25%	44%	22%	22%	56%	29%	25%	46%
Personal care / ADL	22%	22%	56%	6%	19%	75%	25%	16%	59%	28%	16%	56%	50%	4%	46%
Picking up objects	17%	37%	47%	3%	21%	76%	21%	31%	48%	24%	14%	62%	33%	17%	50%
Opening & closing door/drawer	13%	29%	58%	6%	16%	77%	13%	26%	61%	16%	10%	74%	35%	0%	65%
Playing games	6%	6%	87%	3%	6%	90%	10%	13%	77%	10%	6%	84%	18%	9%	73%
Using an audio/video system/computer/switch	37%	23%	40%	3%	13%	83%	40%	30%	30%	33%	23%	43%	67%	13%	21%
Other* (n=15-18)	17%	11%	72%	11%	11%	78%	22%	11%	67%	17%	11%	72%	20%	7%	73%

* Different sample size than stated in title

Table 34: Technical aids purchases: value and reimbursement

TECHNICAL AIDS PURCHASES: VALUE AND REIMBURSEMENT	Approx. Value of TA		Reimbursed by a third party		
			Yes	Partial	No
Drinking (n=18)	27,15 $		6%	6%	89%
(Minimum / Maximum value)	0,05 $	300,00 $			
Preparing a drink (n=0)	$				
(Minimum / Maximum value)	- $	- $			
Eating (n=17)	101,15 $		59%	0%	41%
(Minimum / Maximum value)	0,50 $	200,00 $			
Preparing a meal (n=14-15)	37,57 $		40%	7%	53%
(Minimum / Maximum value)	1,00 $	114,00 $			
Personal care / ADL (n=15-16)	408,73 $		38%	6%	56%
(Minimum / Maximum value)	0 $	5 000,00 $			
Picking up objects (n=16)	117,31 $		50%	19%	31%
(Minimum / Maximum value)	1,00 $	400,00 $			
Opening & closing door/drawer (n=10-11)	1 926,00 $		82%	9%	9%
(Minimum / Maximum value)	0 $	10 000,00 $			
Playing games (n=6)	19,83 $		50%	0%	50%
(Minimum / Maximum value)	1,00 $	45,00 $			
Using an audio/video system/computer/switch (n=20)	1 557,75 $		55%	20%	25%
(Minimum / Maximum value)	10,00 $	9 000,00 $			
Other (n=5)	647,50 $		80%	0%	20%
(Minimum / Maximum value)	17,50 $	2 300,00 $			
TOTAL (average)	**4 842,99 $**				
(Minimum / Maximum value)	**31,05 $**	**27 359,00 $**			

Table 34 indicates the purchases and the reimbursement status of any technical aid bought by the participants to help them increase their level of autonomy. The results indicate that:

- On average, participants have spent around 5000 $ in technical aid. If participants limited themselves to the minimal values that were mentioned by the participants, the least costly participant would have purchased the value of only 30 $ for technical aids. If all the maximum values were added, up to 30 000 $ worth of technical aid would have been reported.
- On average, only half was reimbursed completely, about 7% was reimbursed partially and 42% were not reimbursed.
- The **mean most expensive technical aids** are purchased for opening & closing doors/drawers (1926 $), using an audio-video/computer/switch (1558 $) and others (648 $).

- The **highest technical aid purchase values** were for opening & closing doors/drawers, using an audio-video/computer/switch and personal care; ranging between 5000 $ and 10 000 $.

Table 35: Average total hours supplied by type of caregiver to the participants

AVERAGE TOTAL HOURS BY TYPE OF CAREGIVER	Attendant		Natural Caregiver		Total Caregiver Time	
(n=32)	Daily	Yearly	Daily	Yearly	Daily	Yearly
Average total hours by type of caregiver	**3,19**	**1 161,16**	**1,37**	**498,68**	**4,56**	**1 659,84**
Feeding / Helping	0,28	101,92	0,08	29,12	0,36	131,04
Preparing meals / beverages	0,69	251,16	0,39	141.96	1,07	389,48
Running errands / housekeeping	0,49	178,36	0,25	91,00	0,74	269,36
Helping you dress / wash	1,07	389,48	0,17	61,88	1,24	451,36
Leisure/discussion - at home	0,06	21,84	0,38	138,32	0,45	163,80
Leisure /discussion - away from home	0,19	69,16	0,18	65,52	0,37	134,68
Exercises*	0,07	25,48	0,01	3,64	0,08	29,12
Other*(n=26-27)	0,30	109,20	0,06	21,84	0,36	131,04

* Different sample size than stated in title

Table 35 indicates the average total hours supplied by type of caregiver for several ADL categories. For economic assumptions related to those results, please refer to appendix 4. The results show that:

- On average, a total of approximately 32 hours of caregiving time (attendant and natural caregiver) are devoted to participants on a weekly basis; where the total weekly hours can range up to more than 100 hours for certain participants.
- The attendant spends an average of 22 hours per week and the natural caregiver 10 hours per week.
- The most time consuming activities by the attendant are for helping dress/wash, preparing meals/beverages and running errands/housekeeping.
- The most time consuming activities by the natural caregiver are for preparing meals/beverages and leisure/discussion at home.
- Very little time is devoted by attendants for helping them eat or drink (less than 2 hours a week)

Table 36: Average total cost by type of caregiver

AVERAGE TOTAL COST BY TYPE OF CAREGIVER	Attendant		Natural Caregiver		Total Caregiver Time	
	Daily	Yearly	Daily	Yearly	Daily	Yearly
Average total hours by type of caregiver	**79,76 $**	**29 031,84 $**	**13,72 $**	**4 992,49 $**	**93,47 $**	**34 024,33 $**
Feeding / Helping	7,03 $	2 559,38 $	0,81 $	295,75 $	7,84 $	2 855,13 $
Preparing meals / beverages	17,13 $	6 233,50 $	3,86 $	1 404,81 $	20,98 $	7 638,31 $
Running errands / housekeeping	12,19 $	4 436,25 $	2,54 $	925,93 $	14,73 $	5 362,18 $
Helping you dress / wash	26,73 $	9 728,47 $	1,72 $	625,63 $	28,45 $	10 354,10 $
Leisure/discussion - at home	1,56 $	568,75 $	3,83 $	1 393,44 $	5,39 $	1 962,19 $
Leisure /discussion - away from home	4,74 $	1 726,16 $	1,80 $	654,06 $	6,54 $	2 380,22 $
Exercises	1,84 $	668,28 $	0,08 $	28,44 $	1,91 $	696,72 $
Other	7,49 $	2 726,24 $	0,58 $	212,85 $	8,07 $	2 939,09 $

Table 36 indicates the average total cost by type of caregiver. Assuming that an attendant costs the system 25 $ an hour and that the opportunity cost of a natural caregiver represents 10 $ an hour (regarding the underlying assumptions of these fees, please refer to the economic model assumptions – chapter 7), the results show that:

- The time devoted by a natural caregiver to a participant costs to society (opportunity cost) a value of 14 $ a day, which represents a value of 5000 $ on a yearly period, for having a natural caregiver tending to the needs of the participants
- A participant, on average, costs the healthcare system 80 $ a day, which represents 30 000 $ on a yearly period, for having an attendant tending to their needs; this excludes traveling time that can be required more than once per day depending on the level of autonomy.

Table 37: 3 preferred activities that participants would rather spend more time with attendant and natural caregiver

3 PREFERRED ACTIVITIES	Activity preference with the attendant					Activity preference with the natural caregiver				
	1st	2nd	3rd	NA	4+	1st	2nd	3rd	NA	4+
Being fed /being helped to drink	7%	3%	7%	3%	80%	7%	7%	3%	0%	83%
Preparing meals / beverages	7%	10%	10%	3%	70%	17%	7%	3%	0%	73%
Running errands	10%	13%	3%	3%	70%	10%	10%	27%	0%	53%
Housekeeping	13%	10%	10%	3%	63%	0%	3%	10%	0%	87%
Helping to get dressed	3%	17%	0%	3%	77%	0%	0%	7%	0%	93%
Helping to groom	7%	3%	20%	3%	67%	0%	0%	3%	0%	97%
Sharing pastimes	13%	10%	13%	3%	60%	23%	33%	0%	0%	43%
Getting quality time for exercises / activities / discussions	13%	13%	10%	3%	60%	27%	17%	17%	0%	40%
Other	7%	0%	3%	3%	87%	0%	0%	0%	3%	97%

Table 37 indicates the 3 preferred activities for which spending more time with the attendant and natural caregiver would be appreciated by the participants.

☑ **The results show that with the attendant:**

- One third of participants would prefer having more help for getting quality time for exercises/activities/discussions, sharing leisure time and housekeeping chores.
- The activities that registered the lesser score for more help were: being fed/being helped to drink (17%) and getting help to get dressed (20%).

☑ **The results show that with the natural caregivers:**

- Half (47-60%) would prefer having more help for running errands, getting quality time for exercises/activities/discussions and sharing leisure time.
- The activities that registered the lesser score (more than 90% did not vote for these categories as top 3) for obtaining more help: helping to get dressed and to groom.

Table 38: Perceived importance of a caregiver if JACO was available (All participants)

PERCEIVED IMPORTANCE OF A CAREGIVER IF JACO WAS AVAILABLE	Absolutely	Very	A little	Not at all	n/a
Drinking	**3%**	**3%**	**19%**	**29%**	**45%**
Serving a drink with a pitcher	6%	3%	16%	50%	25%
Using an automatic fountain	6%	6%	16%	28%	44%
Drinking with a straw	3%	6%	3%	38%	50%
Preparing a drink	**6%**	**6%**	**23%**	**42%**	**23%**
Boiling water	9%	6%	13%	47%	25%
Process of preparing a powder-based liquid	6%	9%	13%	41%	31%
Eating	**7%**	**7%**	**17%**	**23%**	**47%**
Dry food (granola bar)	6%	0%	3%	35%	55%
Soft food (grape)	6%	6%	3%	26%	58%
Preparing a meal	**20%**	**10%**	**27%**	**23%**	**20%**
Opening/closing the refrigerator door	3%	0%	10%	52%	35%
Putting a container into the microwave	6%	6%	13%	42%	32%
Activating the microwave	3%	0%	13%	42%	42%
Emptying food into a pot	10%	19%	16%	39%	16%
Starting a manual timer	0%	0%	16%	48%	35%
Removing a dish from the oven	16%	13%	26%	29%	16%
Taking & moving a container (bottle of water)	6%	3%	3%	58%	29%
Picking up a dropped dish	16%	6%	19%	42%	16%
Personal care / ADL	**14%**	**25%**	**18%**	**21%**	**21%**
Washing face with a damp washcloth	10%	13%	23%	23%	32%
Brushing teeth	16%	6%	6%	29%	42%
Using an electric razor/applying lipstick	10%	10%	13%	26%	42%
Applying deodorant	13%	10%	6%	26%	45%
Applying deodorant	17%	13%	13%	27%	30%
Putting on a hat	6%	13%	16%	42%	23%
Putting on glasses	10%	10%	16%	23%	42%
Scratching face	0%	10%	10%	39%	42%
Picking up objects	**0%**	**3%**	**27%**	**57%**	**13%**
Opening & closing door/drawer	**3%**	**0%**	**23%**	**57%**	**17%**
Playing games	**3%**	**7%**	**17%**	**37%**	**37%**
Using an audio/video system / computer / switch	**10%**	**3%**	**17%**	**40%**	**30%**
Other	**0%**	**0%**	**9%**	**30%**	**62%**

Table 38 indicates the level of importance of a caregiver if JACO was available to them. As on average 34% of the participants have checked the box “Not applicable”, ranging from 13-62%, results were re-analyzed (refer to Table 39) by excluding the “not applicable” results.

Table 39: Perceived importance of a caregiver if JACO was available (when excluding participants that checked the box "Not applicable")

IMPORTANCE OF A CAREGIVER IF JACO WAS AVAILABLE	n	Absolutely	Very	A little	Not at all
Drinking	**17**	**6%**	**6%**	**35%**	**53%**
Serving a drink with a pitcher	24	8%	4%	21%	67%
Using an automatic fountain	18	11%	11%	28%	50%
Drinking with a straw	16	6%	13%	6%	75%
Preparing a drink	**24**	**8%**	**8%**	**29%**	**54%**
Boiling water	24	13%	8%	17%	63%
Process of preparing a powder-based liquid	22	9%	14%	18%	59%
Eating	**16**	**13%**	**13%**	**31%**	**44%**
Dry food (granola bar)	14	14%	0%	7%	79%
Soft food (grape)	13	15%	15%	8%	62%
Preparing a meal	**24**	**25%**	**13%**	**33%**	**29%**
Opening/closing the refrigerator door	20	5%	0%	15%	80%
Putting a container into the microwave	21	10%	10%	19%	62%
Activating the microwave	18	6%	0%	22%	72%
Emptying food into a pot	26	12%	23%	19%	46%
Starting a manual timer	20	0%	0%	25%	75%
Removing a dish from the oven	26	19%	15%	31%	35%
Taking & moving a container (bottle of water)	22	9%	5%	5%	82%
Picking up a dropped dish	26	19%	8%	23%	50%
Personal care / ADL	**22**	**18%**	**32%**	**23%**	**27%**
Washing face with a damp washcloth	21	14%	19%	33%	33%
Brushing teeth	18	28%	11%	11%	50%
Using an electric razor/applying lipstick	18	17%	17%	22%	44%
Taking medication	17	24%	18%	12%	47%
Applying deodorant	21	24%	19%	19%	38%
Putting on a hat	24	8%	17%	21%	54%
Putting on glasses	18	17%	17%	28%	39%
Scratching face	18	0%	17%	17%	67%
Picking up objects	**26**	**0%**	**4%**	**31%**	**65%**
Opening & closing door/drawer	**25**	**4%**	**0%**	**28%**	**68%**
Playing games	**19**	**5%**	**11%**	**26%**	**58%**
Using an audio/video system/computer/switch	**21**	**14%**	**5%**	**24%**	**57%**
Other		**0%**	**0%**	**20%**	**80%**

Table 39 indicates the level of importance of a caregiver if JACO was available to them. The results indicate that:

- The tasks they perceived to require the least help is picking up objects (4%) and opening/closing door/drawer (4%)
- The tasks they perceived to require the most help is personal care/ADL (50%) and preparing a meal (38%)

☑ **Drink and preparing a drink**

- Respectively only 12% and 17% of the participants perceived that a caregiver would be very important for them to be able to drink or to prepare a drink.
- Only 13% perceived that a caregiver would be very important for serving a drink with a pitcher
- 21% perceived that a caregiver would be very important for boiling water or preparing a powder-based liquid

☑ **Eat and prepare a meal**

- Respectively only 14% and 30% of the participants perceived that caregivers would be very important for them to be able to eat or to prepare a meal.
- Respectively, 14%, 31% and 35% perceived that a caregiver would be very important for eating a dry food (such as a granola), soft food (grape) and to emptying food into a pot or removing a dish from the over.
- Only 5% perceived that a caregiver would be very important for opening and closing the refrigerator door or activating the microwave
- Respectively, 14%, 19% and 27% perceived that a caregiver would be very important taking and moving a container (bottle of water), for putting a container in the microwave and picking up a dropped dish
- No participants perceived that a caregiver would be very important for starting a manual timer.

☑ **Personal care/ADL**

- Half of the participants perceived that caregivers would not be very important for them to be able to attend for their personal care/ADL.
- The tasks they perceived to require the least help for personal care/ADL if they had JACO are: Scratching face (17%) and putting on a hat (25%)
- The tasks they perceived to require the most help for personal care/ADL if they had JACO are: applying deodorant (43%), taking medication (41%) and brushing teeth (39%).

EVALUATOR'S SATISFACTION

Table 40: Evaluators general satisfaction with the JACO arm

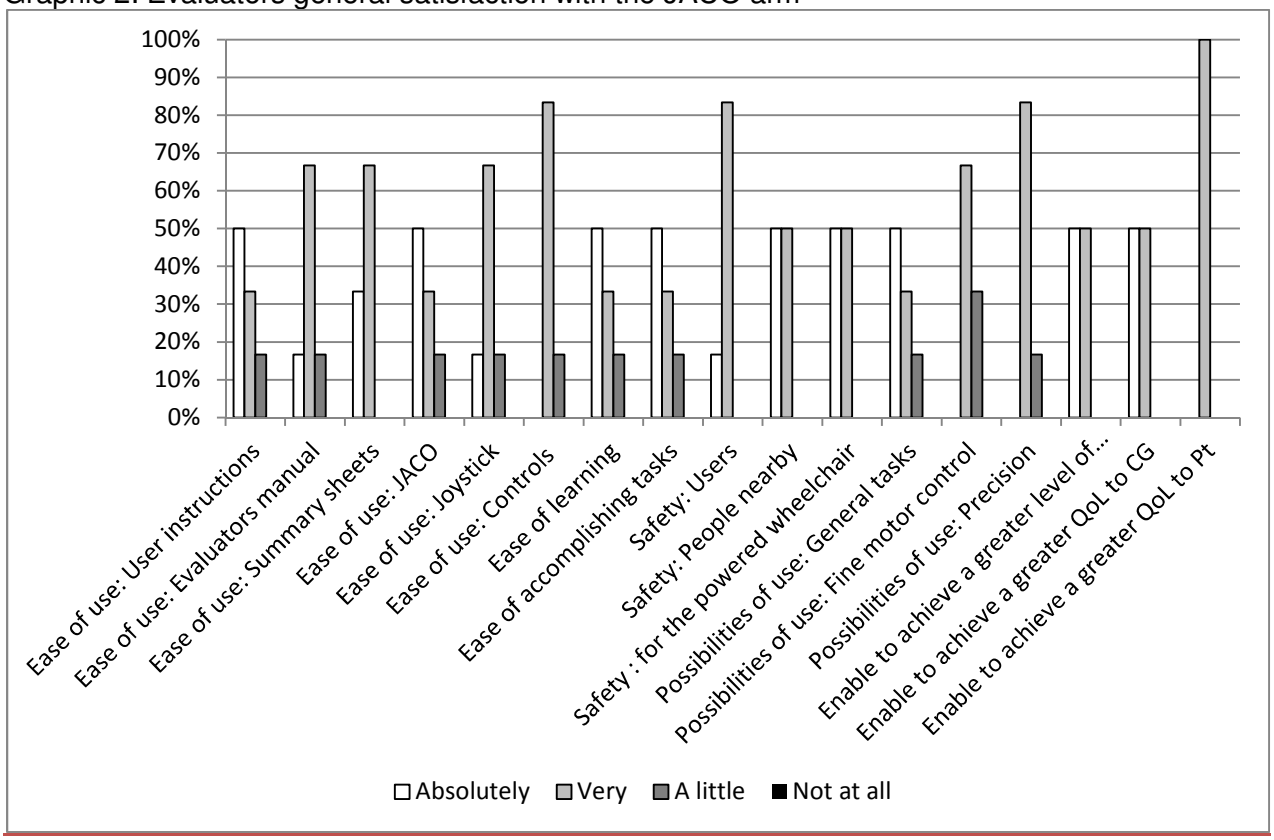
EVALUATORS GENERAL SATISFACTION WITH JACO (n=6)	Absolutely	Very	A little	Not at all
Ease of use				
User instructions for the JACO arm	50%	33%	17%	0%
Evaluators manual	17%	67%	17%	0%
Summary sheets for the command modes	33%	67%	0%	0%
JACO	50%	33%	17%	0%
Joystick	17%	67%	17%	0%
Controls (buttons)	0%	83%	17%	0%
Ease of learning	50%	33%	17%	0%
Ease of accomplishing tasks	50%	33%	17%	0%
Safety				
Users	17%	83%	0%	0%
People nearby	50%	50%	0%	0%
Safety perception for the powered wheelchair	50%	50%	0%	0%
Possibilities of use				
General tasks	50%	33%	17%	0%
Fine motor control	0%	67%	33%	0%
Precision	0%	83%	17%	0%
Enable to achieve a greater level of autonomy to my participants	50%	50%	0%	0%
Enable to achieve a greater quality of life to caregivers of my participants	50%	50%	0%	0%
Enable to achieve a greater quality of life to my participants	0%	100%	0%	0%

Table 40 indicates the evaluators' general satisfaction following the experience with the JACO arm; please also refer to the graphic hereunder to depict the study results. The results indicate that:

- The evaluators were generally very satisfied from their experience with the JACO arm
- 100% of the evaluators (n=6) were very satisfied with seven (7) of the following features of JACO that were assessed during the study: safety (users, people nearby, powered wheelchair), technical aid that could enable to achieve a greater level of autonomy to their participants, technical aid that could enable to achieve a greater quality of life (participants and caregivers) and the summary sheets for the command modes.

- The majority (83%) of the evaluators were very satisfied with the following features: JACO's ease of use features, ease of learning, and JACO's possibilities of use (except for fine motor control).
- The only aspect that evaluators were not as overwhelmed with was regarding JACO's possibility of use for fine motor control; although 67% were very satisfied with this aspect even after a short single experience with the JACO arm.

Graphic 2: Evaluators general satisfaction with the JACO arm



6) ECONOMIC MODEL: TIME SAVINGS ASSUMPTIONS

One of the main issues at stake for this study was to document and understand the added value of the JACO arm for powered wheelchair users, in terms of increased autonomy in their activities of daily living; especially in the current context where attendants and natural caregivers suffer shortage of resources while demand for their service is increasing. As mentioned previously, over the past 5-year period, the demand has increased by 30% (Lemay 2010) in Québec. Hence, finding means to increase the level of autonomy of powered wheelchair users is becoming critical; thus enabling to reduce the required daily hours that attendants must supply for them to meet their basic ADL needs.

The study results inferred that, on average, the JACO arm could save a powered wheelchair user 1,33 hours per day; where the study time savings results have been inferred to range between 1,05 – 1,6 hours, depending of the underlying assumptions. Those assumptions rely on the cohort's perceived ability to perform ADL-related-tasks with the JACO.

ABILITY OF THE COHORT TO PERFORM ADL-RELATED TASKS

Table 41 indicates the average ability to perform the listed ADL-tasks that the participants reported being able to perform following their experience with JACO. The first column represents each ADL tasks. The next two columns refer to the proportion of participants that perceived, respectively, being "fully able" and "very able" to perform the given ADL-tasks. The information corresponds to results of the participant's perceived importance of an attendant if JACO was available to them. The "fully able" column represents the perceived importance as "not at all" while the "very able" column represents the addition of the "not at all" and "a little" perceived importance.

A mean proportion of the "fully able" and "very able" was produced as to give an insight of an in-between result as the range between both results was significant. Finally the delta value for each parameter was generated as to assess the cohort impact between "Fully able" and "Very able".

For those that reported being "fully able" to perform of the reported ADL-tasks, the result varied between 27% and 68%. For those that reported being "very able", the proportion grows significantly, ranging from 50% to 96%; which generates an increased proportion (delta), being able to perform the various daily tasks, ranging between 20% up to 35%.

The "fully able" proportion gives an insight of the quick outcomes that could be generated once JACO has been handed to wheelchair users. However, considering the upcoming shortage of attendants, powered wheelchair users eventual experience with the JACO arm and also their ability to adjust to adapted and relevant tasks in their environment, it is important to highlight the proportion of users that believe that they would be "very able" to perform the ADL-tasks.

Table 41: Average ability of the cohort to perform ADL-tasks

ADL	% Fully able	% Very able	Mean (%)	Delta
Drinking	53%	88%	71%	35%
Preparing a drink	54%	83%	69%	29%
Eating	44%	75%	59%	31%
Preparing a meal	29%	63%	46%	33%
Personal care / ADL	27%	50%	39%	23%
Picking up objects	65%	96%	81%	31%
Opening and closing doors /drawers	68%	96%	82%	28%
Playing games	58%	84%	71%	26%
Using an audio/video system/computer/switch	57%	81%	69%	24%
Other*	-	-	30%	-

The results presented for the "other" ADL differs from the rest of the table as only the participants concerned by this ADL did give an answer. The result was directly transferred from Table 39 (answers to "not at all") as it represented a more conservative estimate of the global population's ability to achieve ADL-tasks that would fall into this category. Please note that a sensitivity analysis was performed around this value. When the underlying assumptions were adjusted, it was inferred that this value could climb up to 70% (see APPENDIX 8)Special scenario: Review of time saving assumptions). However, we believe that reality probably figures mid-range between these estimates (30%-70%).

In order to coordinate the answers acquired in CRF Part 1B concerning the devoted time of attendants and caregiver, the ADL presented in Table 41 were joined in four (4) categories:

ADL categories	Includes following ADL
☑ Feeding / Helping drink	Drinking Eating
☑ Preparing meals / beverages	Preparing a drink Preparing a meal
☑ Helping you dress / wash	Personal care / ADL
☑ Other	Other

WEIGHTED TIME SAVINGS ASSUMPTION - ATTENDANTS

Table 42 indicates the average time the caregivers devote to participants for each ADL-tasks. When participants were asked how much time the caregiver spent for each ADL-tasks, some items were grouped. Hence, the mean devoted time was taken when items were grouped together.

The time value for the "other" was inferred as no specific question about time devoted for this ADL category was directly asked to participants. Results indicated that caregivers devoted on average 3,19 hours per day. As the feeding, drinking and ADL tasks generated a time period of 2,04 hours, the delta value was applied for the "other" category.

Table 42: Average time the caregivers devote to participants for each ADL-tasks

Average total hours by type of caregiver	Devoted time by CG wo/"other" (hrs)	Devoted time by CG w/"other" (hrs)
Feeding / Helping drink	0,28	0,28
Preparing meals / beverages	0,69	0,69
Helping you dress / wash	1,07	1,07
Other	-	1,16
Total hours (daily) - without "other"	**2,04**	**2,04**
Total hours (daily) - with "other"	-	**3,19**

Table 43, Table 44 and Table 45 indicate the weighted time savings with the JACO arm for the cohort that stipulated that they would be, respectively, “fully able”, “very able” and average results of both cohorts to perform the ADL-tasks. The weighted time savings results combine the data presented in Table 41 (participant’s average ability to perform ADL-tasks) and Table 42 (average time devoted by caregivers for ADL-tasks).

Table 43: Weighted time savings with the JACO arm: fully able cohort

Average total hours by type of caregiver	Devoted time by CG (hrs)	"Fully able" cohort	Weighted time savings (hrs)
Feeding / Helping drink	0,28	48%	0,14
Preparing meals / beverages	0,69	42%	0,29
Helping you dress / wash	1,07	27%	0,29
Other	1,16	30%	0,34
Total hours (daily)			**1,05**

The results indicate that, on average, the participants could save the equivalent of 1,05 hours attendant time per day if considering only the “fully able” cohort. When considering the “very able” cohort, the results indicate that, on average, the participants could save the equivalent of 1,60 hours attendant time per day; representing 0,6 hour more time savings versus the “fully able” scenario.

Table 44: Weighted time savings with the JACO arm: very able cohort

Average total hours by type of caregiver	Devoted time by CG (hrs)	"Very able" cohort	Weighted time savings (hrs)
Feeding / Helping drink	0,28	82%	0,23
Preparing meals / beverages	0,69	73%	0,50
Helping you dress / wash	1,07	50%	0,53
Other	1,16	30%	0,34
Total hours (daily)			**1,60**

Table 45: Average weighted time savings with the JACO arm

Average total hours by type of caregiver	Devoted time by CG (hrs)	Average: "Fully & Very able"	Weighted time savings (hrs)
Feeding / Helping drink	0,28	65%	0,18
Preparing meals / beverages	0,69	57%	0,39
Helping you dress / wash	1,07	39%	0,41
Other	1,16	30%	0,34
Total hours (daily)			**1,33**

The results of Table 44 indicate that, on average, the participants could save the equivalent of 1,33 hours attendant time per day. This result will be used as the mean time savings throughout the analysis (base-case result). Minimal and maximal time savings results published by Romer at al. (2005) of, respectively, 0.7 and 1.8 hours were used as sensitivity analysis values.

It is interesting to note that the mean time savings value generated from the study results is highly similar to the one published by Römer (2005). Römer's average time savings resulted of 1,25 hours per day versus our inferred study result of 1,33 hours.

WEIGHTED TIME SAVINGS ASSUMPTION – NATURAL CAREGIVERS

The weighted time savings, for natural caregivers, are based on the study results of the attendants. The study results indicate that:

- ☑ Caregivers, on average, supply the equivalent of 1,37 hours per day to participants;
- ☑ There is a potential time reduction of 42% over the care time needed from the attendant if JACO is available to the participant;
- ☑ The minimal and maximal values of attendants' time reduction vary of approximately 20% from the calculated mean.

Hence, it is expected that JACO could reduce their care time of 0,57 hours for natural caregivers. An approximate variation of 25% was applied to this value to produce minimal and maximal values of the caregiver time savings. Hence the time saving values for natural caregivers is considered to be between 0,43 and 0,71 hours.

Table 46 resumes the assumptions leading to the natural caregivers weighted time savings with the JACO arm.

Table 46: Caregivers weighted time savings with the JACO arm

	Mean	Min	Max
Caregiver's daily time (study results)	1,37		
Time savings assumption with the JACO arm (based on the attendants time savings)	42%		
Time adjustment variation to the mean		25%	25%
Caregivers time savings	0,57	0,43	0,71

7) ECONOMIC MODEL: COST SAVINGS ASSUMPTIONS

A cost saving model was produced to inform decision-makers about the financial and economic impact of enabling powered wheelchair users to own a JACO arm. The assumptions underlying the financial and economic model are described hereunder and include the cost of labour (attendants and natural caregiver), the possible transfer to a specialized center, the cost of the JACO arm and the potential cost saving of other assistive devices. For each of those elements, the underlying assumptions used to generate the model are explained. Daily and annual costs saving expectations per users are presented in addition to yearly cost saving evaluation of a 100, 300, and 500 users' cohort. An overview of mean cost saving assumptions and associated sensitivity analysis values is presented in Table 47.

Table 47: Economic Parameters – Type, Source, Unit price

PARAMETERS	Unit price			Unit
	Min	Mean	Max	
Specialized center *(RAMQ 2008)* *For wheelchair users with upper-extremity disabilities, excluding basic ADL-care*	989 $	1 290 $	1 591 $	Monthly
JACO *(Kinova Canada, internal document)* *Contract price*	-	30 000 $	-	Lump sum
Technical aids *(Study data collection)*	-	4 843 $	-	Lump sum
Attendant hourly total cost *(Québec 2010)* *Including hourly wage, overhead, transportation fees*	20 $	25 $	-	Hourly
Natural caregiver *(Québec 2010)*	-	10 $	15 $	Hourly

For the explanation of all time saving assumption, please refer to the previous section.

The economic model always used the mean/main value for each parameter; unless specified otherwise. However, it should be noted that for the minimum cost savings scenario's, all the minimum values were input into the model to generate the most conservative scenario. A parallel strategy was used to capture the maximal cost savings (e.g., using the maximum values of the parameters).

These time savings scenarios were also used to generate:

- ☑ The potential cost savings that could be encountered over various time horizons (e.g, 3, 5, 7-year period horizons)
- ☑ The various time to generate the break even time (years) for the return on investment

ATTENDANTS (PAID)

Here are presented some general assumptions used for the economic model:

- ☑ Attendants supply their services 7 days/week; 52 weeks a year
- ☑ The daily mean expected time savings is assumed to be 1,33 hours. This time savings forecast was based on the average time saving that the participants expected to encounter if they had the JACO arm. A sensitivity analysis was performed around this key value according to the following scenarios:
  - 0,7 hours; minimal time saving value published by Römer et al (2005)
  - 1,05 hour; minimal time saving value inferred from the study
  - 1,25 hours; average time saving value published by Romer et al (2005)
  - 1,33 hours; main time saving value inferred from the study results
  - 1,6 hours; maximal time saving value inferred from the study results
  - 1,8 hours; maximal time saving value published from Romer et al (2005)
- ☑ The total hourly fee of an attendant (homecare) has been assigned at 25 $/hour (please refer to Appendix 4 for the assumptions leading to this value)
  - A more conservative estimate of 20 $/hour was assigned to this value to perform the sensitivity analysis.
  - Romer et al. (2005) assigned a value of 28€ per hour (38 $[4]). This value was not assigned in the economic model as European fees are significantly higher than Canadian ones for homecare attendants.

Based on the daily time savings assumptions that have been described here above, Table 48 and Table 49 indicate the attendants cost savings (respectively daily and annually) that could be encountered to third party payers if participants were allocated a JACO arm. Those results are presented for one participant and are directly inferred from study results.

Table 48: Daily cost savings of attendants with JACO per participant

	Hourly fee	Number of hours/day			Daily Total Savings		
		Mean	Min	Max	Mean	Min	Max
Attendant (main)	25 $	1,33	0,7	1,8	33,23 $	17,50 $	45,00 $
Attendant (min)	20 $	1,33	0,7	1,8	26,58 $	14,00 $	36,00 $

[4] With the assumption of the exchange rate of 1,38 (actual exchange rate on November 18th 2010)

Results presented in Table 48 indicate that, on average, the JACO arm could enable to save 33 $ per day per user; based on the above mentioned assumptions. The sensitivity analysis indicates that daily savings could range between 14 $ up to 45 $; depending on the time savings value and the hourly fee of an attendant.

Based on an annual scale, results indicate that, on average, the JACO arm could enable to save, per user, 12 000 $ per year; based on the above mentioned assumptions. The sensitivity analysis indicates that annual savings could range between 5000 $ up to 16 000 $; depending on the time savings value and the hourly fee of an attendant.

Table 49: Annual cost savings of attendants with JACO per participant

	Hourly fee	Number of hours/year			Annual Total Savings (n=1)		
		Mean	Min	Max	Mean	Min	Max
Attendant (main)	25 $	483,8	254,8	655,2	12 095 $	6 370 $	16 380 $
Attendant (min)	20 $	483,8	254,8	655,2	9 676 $	5 096 $	13 104 $

Table 48 and Table 49 have generated potential savings that could be encountered for a single given powered wheelchair user; generating the breakdown of the annual cost savings of an attendant was generated (giving the progressive impact over daily and annual time periods).

Table 50, Table 51 and Table 52 represent the annual cost savings that could be encountered over a range of, respectively, 100, 300 and 500 potential powered wheelchair users. These scenarios are based on a meeting with the Ministère de la Santé et des Services Sociaux (MSSS, Québec); where the latter expressed the potential interest, if results were relevant clinically and economically, of potentially purchasing up to 500 JACO arm.[5]

Table 50: Annual cost savings of attendants with JACO for a cohort of 100 powered wheelchair users

	Hourly fee	Number of hours/year			Annual Total Savings		
		Mean	Min	Max	Mean	Min	Max
Attendant (main)	25 $	48 379	25 480	65 520	1 209 475 $	637 000 $	1 638 000 $
Attendant (min)	20 $	48 379	25 480	65 520	967 580 $	509 600 $	1 310 400 $

The results presented in Table 50 indicate that, on average, for a cohort of 100 potential JACO users, the device could generate more than one million in savings per year when considering attendant time only; where savings could range between more than half a million (500 000 $) and 1 600 000 $ a year; depending of the underlying assumptions of the model.

Table 51: Annual cost savings of attendants with JACO for a cohort of 300 powered wheelchair users

	Hourly fee	Number of hours/year			Annual Total Savings		
		Mean	Min	Max	Mean	Min	Max
Attendant (main)	25 $	145 137	76 440	196 560	3 628 426 $	1 911 000 $	4 914 000 $
Attendant (min)	20 $	145 137	76 440	196 560	2 902 741 $	1 528 800 $	3 931 200 $

[5] Internal documents; meeting summary with the MSSS

The results presented in Table 51 indicate that, on average, for a cohort of 300 potential JACO users, the device could generate more than three and half million (3 600 000 $) in savings per year for attendant time only; where savings could range between more than one and half million and near five million (1 500 000 $ - 4 000 000 $) a year, depending of the underlying assumptions of the model.

Table 52: Annual cost savings of attendants with JACO for a cohort of 500 powered wheelchair users

	Hourly fee	Number of Hours			Annual Total Savings		
		Mean	Min	Max	Mean	Min	Max
Attendant (main)	25 $	241 895	127 400	327 600	6 047 377 $	3 185 000 $	8 190 000 $
Attendant (min)	20 $	241 895	127 400	327 600	4 837 902 $	2 548 000 $	6 552 000 $

The results presented in Table 52 indicate that, on average, for a cohort of 500 potential JACO users, the device could generate more than six million (6 000 000 $) in savings per year for attendant time only; where savings could range between more than two and half million and eight million (2 500 000 $ - 8 000 000 $) a year, depending of the underlying assumptions of the model.

NATURAL CAREGIVERS

Here are presented some general assumptions used for the economic model:

- ☑ Natural caregivers supply their services 7 days/week; 52 weeks a year
- ☑ The daily mean expected time savings is assumed to be 0,57 hours. This time savings forecast was based on the average time saving that the participants expected to encounter if they had the JACO arm. A sensitivity analysis was performed around this value according to the following scenarios:
  - 0,43 hours; minimal time savings inferred from the study
  - 0,71 hours; maximal time savings inferred from the study
- ☑ The societal cost of a natural caregiver has been assigned at 10 $/hour
  - The minimum wage in Québec (Canada) is 9,50 $/hour; hence this value was rounded at 10 $.
  - A sensitivity analysis scenario was performed around this value; where a value of 15 $/hr was assigned; as to generate a more realistic estimate of the opportunity cost of unpaid caregivers.

Based on the daily time savings assumptions that have been described here above, Table 53 and Table 54 indicate the natural caregivers' opportunity cost (respectively daily and annually) if wheelchair user could beneficiate of a JACO arm. Those results are presents for one participant and are directly inferred from the study results.

Table 53: Daily opportunity cost of a natural caregiver with JACO per participant

	Hourly fee	Number of Hours/day			Daily Total Savings		
Daily cost		**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Natural Caregiver (Max)	15 $	0,57	0,43	0,71	8,56 $	6,42 $	10,70 $
Natural Caregiver (main)	10 $	0,57	0,43	0,71	5,71 $	4,28 $	7,14 $

Results presented in Table 53 indicate that, on average for each user, the JACO arm could enable to save 8 $ per day of natural caregiving time; based on the above mentioned assumptions. The sensitivity analysis indicates that daily savings could range between 4 $ up to 11 $; depending on the time savings value and the hourly fee of a caregiver.

Results presented in Table 54 indicates that, on average for each user, the JACO arm could enable to save society 3 000 $ per year in terms of natural caregiving time; based on the above mentioned assumptions. The sensitivity analysis indicates that annual savings could range between 1500 $ and up to near 4 000 $; depending on the time savings value and the hourly fee of a caregiver.

Table 54: Annual cost savings of a natural caregiver with JACO per participant

	Hourly fee	Number of Hours/year			Annual Total Savings		
		Mean	**Min**	**Max**	**Mean**	**Min**	**Max**
Natural Caregiver (Max)	15 $	207,8	155,8	259,7	3 117 $	2 337 $	3 896 $
Natural Caregiver (main)	10 $	207,8	155,8	259,7	2 078 $	1 558 $	2 597 $

Table 53 and Table 54 have generated potential savings that could be encountered for a single given powered wheelchair user; generating the breakdown how the annual cost savings of a caregiver was generated (giving the progressive impact over daily and annual time periods).

Table 55, Table 56 and Table 57 indicate the annual opportunity cost of a caregiver that could be saved over a range of, respectively, 100, 300 and 500 potential powered wheelchair users. These scenarios have been based on a meeting with the Ministère de la Santé et des Services Sociaux (MSSS, Québec); where the latter expressed the potential interest, if results were relevant clinically and economically, of potentially purchasing up to 500 JACO arm.[6]

Table 55: Annual opportunity cost of a caregiver with JACO for a cohort of 100 powered wheelchair users

	Hourly fee	Number of Hours			Annual Total Savings		
		Mean	**Min**	**Max**	**Mean**	**Min**	**Max**
Natural Caregiver (max)	15 $	20 777	15 583	25 971	311 658 $	233 743 $	389 572 $
Natural Caregiver (main)	10 $	20 777	15 583	25 971	207 772 $	155 829 $	259 715 $

The results presented in Table 55 indicate that, on average, for a cohort of 100 potential JACO users, the device could generate more than 300 000 $ in savings per year for natural caregiver time only; where savings could range between more than 150 000 $ and near 400 000 $ a year; depending of the underlying assumptions of the model.

[6] Internal documents; meeting summary with the MSSS

Table 56: Annual opportunity cost of a caregiver with JACO for a cohort of 300 powered wheelchair users

	Hourly fee	Number of Hours			Annual Total Savings		
		Mean	Min	Max	Mean	Min	Max
Natural Caregiver (Max)	15 $	62 332	46 749	77 914	934 974 $	701 230 $	1 168 717 $
Natural Caregiver (main)	10 $	62 332	46 749	77 914	623 316 $	467 487 $	779 145 $

The results presented in Table 56 indicate that, on average, for a cohort of 300 potential JACO users, the device could generate almost a million in savings per year for natural caregiver time only; where savings could range between around half a million and more than a million a year; depending of the underlying assumptions of the model.

Table 57: Annual opportunity cost of a caregiver with JACO for a cohort of 500 powered wheelchair users

	Hourly fee	Number of Hours			Annual Total Savings		
		Mean	Min	Max	Mean	Min	Max
Natural Caregiver (Max)	15 $	103 886	77 914	129 857	1 558 290 $	1 168 717 $	1 947 862 $
Natural Caregiver (main)	10 $	103 886	77 914	129 857	1 038 860 $	779 145 $	1 298 575 $

The results presented in Table 57 indicate that, on average, for a cohort of 500 potential JACO users, the device could generate more than a million and a half (1 500 000 $) in savings per year for natural caregiver time only; where savings could range between around about 800 000 $ and almost two million a year; depending of the underlying assumptions of the model.

SPECIALIZED CENTERS FOR POWERED WHEELCHAIR USERS WITH UPPER EXTREMITY DISABILITIES

Here are presented some general assumptions used for the economic model:

- ☑ The mean monthly boarding cost of a specialized center, for powered wheelchair users with upper extremity disabilities, excluding basic ADL-care, has been assumed at 1290 $ per month. This value results of the average of the minimal and maximal value reported in (Desjardins 2008):
  - A minimal value scenario was assumed 989 $; the cost representing a room for three (3) occupants
  - A maximal value scenario was assumed 1 591 $; the cost representing a private room
- ☑ The event probability of participant being transferred to a specialized center, due to a lack of homecare attendants to fulfill their basic ADL needs, has been valued as 5%. This event probability was based on the following assumptions:
  - 48% of the study participants live alone. Hence, compared those that live with at least one other person, this parameter increases the risk of being transferred to a specialized center if the number of available attendants is insufficient
  - Homecare need has increased by 30% over the last five years (Lemay 2010) and thus some patients have been put on a waiting list to receive home care

- Since the risk of being transferred to a specialized center is not documented in the literature, this risk (50%) was adjusted significantly in the sensitivity analysis:
  - ✓ Minimal value = 2,5%
  - ✓ Maximal value = 10%

Table 58 presents the specialized care center cost calculation. The weighted total cost of a participant being transferred to a specialized center is 64 $ per month or 774 $ per years; with a yearly cost ranging between 297 $ and 1 909 $; depending of the underlying assumptions of the model.

Table 58: Specialized center cost inference assumptions

Specialized center cost inference assumptions	Mean	Min	Max
Monthly fee	1 290 $	989 $	1 591 $
Annual fee	15 480 $	11 868 $	19 092 $
Event probability of transferring participant to a sp. Ctr	5,0%	2,5%	10%
Weighed annual total cost ($)	774 $	297 $	1 909 $

Source: (RAMQ 2008)

JACO ARM

Here are presented some general assumptions used for the economic model:

- ☑ Accordingly to Kinova, the contract price (multiple group purchasing) of the JACO is 30 000 $, including maintenance service over JACO's lifetime. Considering that the represented study perspective was the Third Party Payer (public or private), the study used the contract price for the main economic analysis. As sensitivity analysis was performed around this key value according to the following scenarios:
  - At the time of the study, JACO's basic model price was approximately 40 000 $.
  - The premium model price was estimated to be around 50 000 $.
- ☑ According to Kinova, the product's lifetime is expected to be 7 years. However, as this product is new, and thus there are no long-term use data, simulations over two other time horizons was performed:
  - 5-year horizon (conservative estimate)
  - 3-year horizon (conservative estimate)
  - To remain conservative, it was decided not to extend the lifetime period of the JACO arm; even though, according to Kinova, JACO's lifetime could be longer.
- ☑ The study results indicate that JACO could replace many of the technical aids that powered wheelchair users with upper-extremity disabilities had to purchase. The mean cost of purchased technical aid was estimated to be 4 842.99 $. Hence, considering that powered wheelchair users could avoid purchasing technical aids, once they have the JACO arm, two types of groups were used to generate the cost savings model:
  - The de novo users (30 000 $); includes the acquisition price of the JACO arm (contract price) with the assumptions that it could avoid the purchase of other technical aid.

- The actual technical aid users (34 842.99 $); includes the acquisition price of the JACO arm (contract price) and the cost of any technical aids already bought.

ECONOMIC MODEL: COST SAVINGS ASSUMPTIONS SUMMARY

Table 59 indicates the value of each parameter that has been input to generate the economic model; including the mean, maximal and minimal value. All of the underlying assumptions leading to these values have been described previously.

Table 59: Economic model parameter summary

Model parameters	Main model assumptions	Annual Total Cost		
		Mean	Min	Max
Attendant	25 $/hour	12 095 $	6 370 $	16 380 $
Specialized center cost	-	774 $	297 $	1 909 $
Natural caregiver	10 $/hour	2 078 $	1 558 $	2 597 $
JACO- De novo users	-	30 000,00 $	30 000,00 $	30 000,00 $
JACO - Actual TA users	-	34 842,99 $	34 842,99 $	34 842,99 $

It should be noted that all above specified value are linked to the study's main assumptions concerning attendants' and natural caregivers' hourly fee. Also, note that when the "Min" cost savings scenarios are used, all the minimal values of the model's parameters are input into the economic model; unless specified otherwise. The same strategy is used for the "Max" cost savings scenarios; that is, all the maximal values of the model's parameters are input into the economic model; unless specified otherwise.

The economic model followed three main study perspectives. Those three study perspectives include the economic benefits considering the cost of attendant only, considering the cost of attendant and the weighed value of avoiding a transfer to specialized center and the societal cost including also the cost of unpaid caregivers.

8) COST SAVINGS CONSIDERING THE MODEL'S MAIN ASSUMPTIONS

This section presents the cost savings results inferred by the economic model for the different scenarios listed previously using the base-case scenario assumptions (e.g.; rate, unit price, quantity); except for the time savings parameter of paid attendants that were varied in the model. The time savings parameter that could be encountered with the JACO arm, presented in each column of every tables of this section, are based on the various time savings scenarios; where the daily time savings ranges between 0.7 and 1.8 hours with the main model assumption being 1.33 hours. Each of the cost savings will present the following underlying assumptions:

- ☑ Actual cost to the system without JACO
  - Calculation based only on the attendants hourly fee (main assumption of 25 $/hour).
- ☑ Net cost savings of JACO – De Novo technical aid users (w/att. cost)
  - Cost savings scenarios based using the De Novo technical aid users.
  - Cost savings scenarios based using only the attendants' time savings parameter.
- ☑ Net cost savings of JACO – De Novo technical aid users (w/att. + sp.ctr cost)
  - Cost savings scenarios based using the De Novo technical aid users.
  - Cost savings scenarios based using the attendants' time savings parameter and reducing the risk of transferring the powered wheel chair user to a specialized center.
- ☑ Net cost savings of JACO – Actual technical aid users (w/att. Cost)
  - Cost savings scenarios based using actual technical aid users.
  - Cost savings scenarios based using only the attendants time savings parameter
- ☑ Net cost savings of JACO – Actual technical aid users (w/att. + sp. Ctr cost)
  - Cost savings scenarios based using actual technical aid users.
  - Cost savings scenarios based using the attendants' time savings parameter and reducing the risk of transferring the powered wheel chair user to a specialized center.
- ☑ Net societal cost savings of JACO – De Novo technical aid users (all parameters)
  - Cost savings scenarios based using the De Novo technical aid users.
  - Cost savings scenarios based using all the study parameters: the attendants' and natural caregivers' time savings parameters and reducing the risk of transferring the powered wheel chair user to a specialized center.
- ☑ Net societal cost savings of JACO – Actual technical aid users (all parameters)
  - Cost savings scenarios based using actual technical aid users.

- Cost savings scenarios based using all the study parameters: the attendants' and natural caregivers' time savings parameters and reducing the risk of transferring the powered wheel chair user to a specialized center.

The various cost savings calculations have been modeled using 3 horizons to denote the potential economic impact of the JACO arm:

- ☑ 7-year period
- ☑ 5-year period
- ☑ 3-year period

It should be reminded that "De Novo" technical aid users represent powered wheelchair users that never purchased technical aids prior to receiving a JACO arm while "Actual" technical aid users represent powered wheelchair users that have purchased technical aids (mean value of 4842,99 $; as described previously) in the past and thus would purchase the JACO arm as an add-on technical aid; regardless that they will need to use the previous technical aids or not.

First will be presented the cost savings results for a single user, then will be presented the cost savings results for multiple users' cohort of 100, 300 and 500 users.

COST SAVINGS WITH THE JACO ARM FOR A SINGLE USER

Table 60 to Table 62 summarize the mean cost savings scenarios for a single user that could be encountered considering, respectively, a 7, 5 and 3 years lifetime of the JACO arm.

COST SAVINGS – SINGLE USER – CONTRACT PRICE – 7-YEAR PERIOD

Table 60 indicates the cost savings scenario's that could be encountered, for a single user, over a 7-year period, if a powered wheelchair user had access to a JACO arm. The results indicate that, over a 7–year period, third party payers could save, on average, the equivalence of 84 663 $ in attendants time per user, if JACO was available to powered wheelchair users with upper extremity disabilities; attendants cost savings ranging between 44 590 $ and 114 660 $ over a 7-year period, depending of the underlying assumptions of the model.

The net cost savings of purchasing JACO (total savings minus the cost of purchasing the JACO arm), over a 7-year period, are the following; depending of the underlying model assumption:

- De Novo technical aid users (w/attendant cost)
  - ➲ The mean net total cost savings that could be encountered, over the 7-year period, are expected to represent 54 663 $; where the net cost savings could range between 14 590 $ and 84 660 $ per participant, depending of the time savings assumptions.

- De Novo technical aid users (w/ attendant cost + sp. Ctr cost)
  - ➲ The mean net total cost savings that could be encountered, over the 7-year period, are expected to represent more than 60 080 $; where the net cost savings could range between 16 666 $ and 98 024 $ per participant, depending of the time savings assumptions.

- Actual technical aid users (w/attendant cost)
  - ➲ The mean net total cost savings that could be encountered, over the 7-year period, are expected to represent almost 49 820 $; where the net cost savings could range between 9 747 $ and 79 817 $ per participant, depending of the time savings assumptions.

- Actual technical aid users (w/ attendant cost + sp. Ctr cost)
  - ➲ The mean net total cost savings that could be encountered, over the 7-year period, are expected to represent more than 55 237 $; where the net cost savings could range between 11 823 $ and 93 181 $ per participant, depending of the time savings assumptions.

- De Novo technical aid users (all parameters)
  - ➲ The mean net total cost savings that could be encountered, over the 7-year period, are expected to represent almost 74 624 $; where the net cost savings could range between 27 574 $ and 116 204 $ per participant, depending of the time savings assumptions.

- Actual technical aid users (all parameters)
  - ➲ The mean net total cost savings that could be encountered, over the 7-year period, are expected to represent almost 69 781 $; where the net cost savings could range between 22 731 $ and 111 361 $ per participant, depending of the time savings assumptions.

COST SAVINGS – SINGLE USER – CONTRACT PRICE – 5-YEAR PERIOD

Table 61 indicates the cost savings scenario's that could be encountered, for a single user, over a 5-year period, if a powered wheelchair user had access to a JACO arm. The results indicate that, over a 5–year period, third party payers could save, on average, the equivalence of 60 474 $ in attendants time per user, if JACO was available to powered wheelchair users with upper extremity disabilities; attendants cost savings ranging between 31 850 $ and 81 900 $ over a 5-year period, depending of the underlying assumptions of the model.

The net cost savings of purchasing JACO (total savings minus the cost of purchasing the JACO arm), over a 5-year period, are the following; depending of the underlying model assumption:

- De Novo technical aid users (w/attendant cost)
  - ➲ The mean net total cost savings that could be encountered, over the 5-year period, are expected to represent 30 474 $; where the net cost savings could range between 1 850 $ and 51 900 $ per participant, depending of the time savings assumptions.

- De Novo technical aid users (w/ attendant cost + sp. Ctr cost)
  - ➲ The mean net total cost savings that could be encountered, over the 5-year period, are expected to represent 34 343 $; where the net cost savings could range between 3 333 $ and 61 445 $ per participant, depending of the time savings assumptions.

- Actual technical aid users (w/attendant cost)
  - ➲ The mean net total cost savings that could be encountered, over the 5-year period, are expected to represent 25 631 $; where the net cost savings could range between

13 104 $ and 47 057 $ per participant, depending of the time savings assumptions; except for the scenario at 0,7 hours. In this latter scenario, the JACO arm would generate an add-on cost of 2 993 $ over the 5-year period; representing 600 $ more a year for enabling powered wheel chair users to be more autonomous.

- Actual technical aid users (w/ attendant cost + sp. Ctr cost)
  - ➲ The mean net total cost savings that could be encountered, over the 5-year period, are expected to represent 29 500 $; where the net cost savings could range between 16 974 $ and 56 602 $ per participant, depending of the time savings assumptions; except for the scenario at 0,7 hours. In this latter scenario, the JACO arm would generate an add-on cost of 1500 $ over the 5-year period; representing 300 $ more a year for enabling powered wheel chair users to be more autonomous.

- De Novo technical aid users (all parameters)
  - ➲ The mean net total cost savings that could be encountered, over the 5-year period, are expected to represent 44 731 $; where the net cost savings could range between 11 124 $ and 74 431 $ per participant, depending of the time savings assumptions.

- Actual technical aid users (all parameters)
  - ➲ The mean net total cost savings that could be encountered, over the 5-year period, are expected to represent 39 888 $; where the net cost savings could range between 6 281 $ and 69 588 $ per participant, depending of the time savings assumptions.

COST SAVINGS – SINGLE USER – CONTRACT PRICE – 3-YEAR PERIOD

Table 62 indicates the cost savings scenario's that could be encountered, for a single user, over an unrealistic 3-year period, if a powered wheelchair user had access to a JACO arm. This time horizon has been generated to highlight JACO's rapid cost savings over a short time period for the majority of the scenarios.

The results indicate that, over a 3–year period, third party payers could save, on average, the equivalence of 36 284 $ in attendants time per user, if JACO was available to powered wheelchair users with upper extremity disabilities; attendants cost savings ranging between 19 110 $ and 49 140 $ over a 3-year period, depending of the underlying assumptions of the model.

The net cost savings of purchasing JACO (total savings minus the cost of purchasing the JACO arm), over a 3-year period, are the following; depending of the underlying model assumption:

- De Novo technical aid users (w/attendant cost)
  - ➲ The mean net total cost savings that could be encountered, over the 3-year period, are expected to represent 6 284 $; where the net cost savings could range between 4 125 $ and 19 140 $ per participant, depending of the time savings assumptions; except for the scenarios at 0,7 and 1,05 hour. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 1 232 $ and 10 890 $ over the 3-year period; representing approximately 400 $ - 3 500 $ more a year for enabling powered wheel chair users to be more autonomous.

- De Novo technical aid users (w/ attendant cost + sp. Ctr cost)
  - ➲ The mean net total cost savings that could be encountered, over the 3-year period, are expected to represent 8 606 $; where the net cost savings could range between 1 090

$ and 24 867 $ per participant, depending of the time savings assumptions; except for the scenario at 0,7 hours. In this latter scenario, the JACO arm would generate an add-on cost of 10 000 $ over the 3-year period; representing 3333 $ more a year for enabling powered wheel chair users to be more autonomous.

- Actual technical aid users (w/attendant cost)
  - ➲ The mean net total cost savings that could be encountered, over the 3-year period, are expected to represent 1 441 $; where the net cost savings could range between 1 441 $ and 14 297 $ per participant, depending of the time savings assumptions; except for the scenarios at 0,7, 1 and 1,25 hour. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 718 $ and 15 733 $ over the 3-year period; representing approximately 250 $ - 5 250 $ more a year for enabling powered wheel chair users to be more autonomous.

- Actual technical aid users (w/ attendant cost + sp. Ctr cost)
  - ➲ The mean net total cost savings that could be encountered, over the 3-year period, are expected to represent 3 763 $; where the net cost savings could range between 1 603 $ and 20 024 $ per participant, depending of the time savings assumptions; except for the scenarios at 0,7 and 1,05 hour. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 3 753 $ and 14 843 $ over the 3-year period; representing approximately 1 250 $ - 5 000 $ more a year for enabling powered wheel chair users to be more autonomous.

- De Novo technical aid users (all parameters)
  - ➲ The mean net total cost savings that could be encountered, over the 3-year period, are expected to represent 14 839 $; where the net cost savings could range between 7 323 $ and 32 659 $ per participant, depending of the time savings assumptions; except for the scenario at 0,7 hours. In this latter scenario, the JACO arm would generate an add-on cost of 5 325 $ over the 3-year period; representing 1 775 $ more a year for enabling powered wheel chair users to be more autonomous.

- Actual technical aid users (all parameters)
  - ➲ The mean net total cost savings that could be encountered, over the 3-year period, are expected to represent 9 996 $; where the net cost savings could range between 2 480 $ and 27 816 $ per participant, depending of the time savings assumptions; except for the scenario at 0,7 hours. In this latter scenario, the JACO arm would generate an add-on cost of 10 168 $ over the 3-year period; representing 3 400 $ more a year for enabling powered wheel chair users to be more autonomous.

Table 60: JACO's cost savings for a single user using 7-year period (contract price)

INCREMENTAL COST SAVINGS *(assumption for attendant time savings/day)*	COST SAVINGS SCENARIO'S PER POWERED WHEELCHAIR USER					
	0,7 hour (min)	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=7 yrs						
Actual attendant cost to the system without JACO	*44 590 $*	*67 126 $*	*79 625 $*	*84 663 $*	*101 920 $*	*114 660 $*
Net Cost savings of JACO - De Novo technical aid users (w/att. cost)	*14 590 $*	*37 126 $*	*49 625 $*	*54 663 $*	*71 920 $*	*84 660 $*
Net Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*16 666 $*	*42 543 $*	*55 042 $*	*60 080 $*	*77 337 $*	*98 024 $*
Net Cost savings of JACO - Actual technical aid users (w/att. cost)	*9 747 $*	*32 283 $*	*44 782 $*	*49 820 $*	*67 077 $*	*79 817 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*11 823 $*	*37 700 $*	*50 199 $*	*55 237 $*	*72 494 $*	*93 181 $*
Net Societal cost savings of JACO - De Novo technical aid users (all parameters)	*27 574 $*	*57 087 $*	*69 586 $*	*74 624 $*	*91 881 $*	*116 204 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*22 731 $*	*52 244 $*	*64 743 $*	*69 781 $*	*87 038 $*	*111 361 $*

Globally, the various scenarios generate an average net cost savings of the JACO arm, representing a value of 55 560 $ per user, over the 7-year period, with a standard deviation of 29 692 $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 50 657 $, with a standard deviation of 26 700 $.

Table 61: JACO's cost savings for a single user using 5-year period (contract price)

INCREMENTAL COST SAVINGS *(assumption for attendant time savings/day)*	COST SAVINGS SCENARIO'S PER POWERED WHEELCHAIR USER					
	0,7 hour (min)	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=5 yrs						
Actual attendant cost to the system without JACO	*31 850 $*	*47 947 $*	*56 875 $*	*60 474 $*	*72 800 $*	*81 900 $*
Net Cost savings of JACO - De Novo technical aid users (w/att. cost)	*1 850 $*	*17 947 $*	*26 875 $*	*30 474 $*	*42 800 $*	*51 900 $*
Net Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*3 333 $*	*21 817 $*	*30 744 $*	*34 343 $*	*46 669 $*	*61 445 $*
Net Cost savings of JACO - Actual technical aid users (w/att. cost)	*(2 993) $*	*13 104 $*	*22 032 $*	*25 631 $*	*37 957 $*	*47 057 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(1 510) $*	*16 974 $*	*25 901 $*	*29 500 $*	*41 826 $*	*56 602 $*
Net Societal cost savings of JACO - De Novo technical aid users (all parameters)	*11 124 $*	*32 205 $*	*41 133 $*	*44 731 $*	*57 058 $*	*74 431 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*6 281 $*	*27 362 $*	*36 290 $*	*39 888 $*	*52 215 $*	*69 588 $*

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 32 627 $ per user, over the 5-year period; with a standard deviation of 19 582 $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 28 428 $, with a standard deviation of 17 978 $.

Table 62: JACO's cost savings for a single user using 3-year period (contract price)

INCREMENTAL COST SAVINGS *(assumption for attendant time savings/day)*	COST SAVINGS SCENARIO'S PER POWERED WHEELCHAIR USER					
	0,7 hour (min)	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=3 yrs						
Actual attendant cost to the system without JACO	*19 110 $*	*28 768 $*	*34 125 $*	*36 284 $*	*43 680 $*	*49 140 $*
Net Cost savings of JACO - De Novo technical aid users (w/att. cost)	*(10 890) $*	*(1 232) $*	*4 125 $*	*6 284 $*	*13 680 $*	*19 140 $*
Net Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*(10 000) $*	*1 090 $*	*6 446 $*	*8 606 $*	*16 001 $*	*24 867 $*
Net Cost savings of JACO - Actual technical aid users (w/att. cost)	*(15 733) $*	*(6 075) $*	*(718) $*	*1 441 $*	*8 837 $*	*14 297 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(14 843) $*	*(3 753) $*	*1 603 $*	*3 763 $*	*11 158 $*	*20 024 $*
Net Societal cost savings of JACO - De Novo technical aid users (all parameters)	*(5 325) $*	*7 323 $*	*12 680 $*	*14 839 $*	*22 235 $*	*32 659 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*(10 168) $*	*2 480 $*	*7 837 $*	*9 996 $*	*17 392 $*	*27 816 $*

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 6 608 $ per user, over the 3-year period; with a standard deviation of 11 912 $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 4 088 $, with a standard deviation of 10 967 $.

COST SAVINGS WITH THE JACO ARM FOR A MULTIPLE USERS' COHORT

The following section describes the potential cost savings that the JACO arm could encounter if a certain cohort size had access to it. The cost savings calculations were simulated cost savings scenarios over the three (3) time horizons (e.g., 7, 5 and 3-year period) and extrapolated the results on three cohort sizes:

- ☑ N= 100 JACO users
- ☑ N= 300 JACO users
- ☑ N= 500 JACO users

The results hereunder will describe the cost savings scenarios that could be encountered for each study horizon.

COST SAVINGS – MULTIPLE USERS – CONTRACT PRICE – 7-YEAR PERIOD

Table 63 to Table 65 summarize the mean cost savings scenarios for the three cohort size described above that could be encountered over a 7 year period with the JACO arm.

- 100 users cohort – Gross savings
  - ➲ The mean results indicate that 8,5 million $ of attendant cost could be saved to third party payers, over a 7-year period, if 100 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 4,5 million $ up to 11,5 million $, depending of the scenarios and time savings assumptions.

- 100 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 5,5 million $ up to more than 7,5 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 1,5 million $ up to 11,6 million $; depending of scenarios and time savings assumption.

- 100 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 5 million $ up to near 7,0 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between near 974 701 $ up to 11,1 million $; depending of the scenarios and time savings assumptions.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 5,9 million $, over the 7-year period, for 100 users; with a standard deviation of 2,7 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 5,3 million $, with a standard deviation of 2,5 million $.

- 300 users cohort – Gross savings
  - ➲ The mean results indicate that 25,4 million $ of attendant cost could be saved to third party payers, over a 7-year period, if 300 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 13,4 million $ up to 34,4 million $, depending of the scenarios and time savings assumptions.

- 300 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 16,4 million $ up to 22,4 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between almost 4,4 million $ up to more than 34,9 million $; depending of the scenarios and time savings assumptions.

- 300 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 14,9 million $ up to 20,9 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 2,9 million $ up to more than 33,4 million $; depending of the scenarios and time savings assumptions.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 17,6 million $, over the 7-year period, for 300 users; with a standard deviation of 8,2 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 15,8 million $, with a standard deviation of 7,5 million $.

- 500 users cohort – Gross savings
  - ➲ The mean results indicate that 42,3 million $ of attendant cost could be saved to third party payers, over a 7-year period, if 500 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 22,3 million $ up to 57,3 million $, depending of the scenarios and time savings assumptions.

- 500 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 27,3 million $ up to 37,3 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 7,3 million $ up to more than 58,1 million $; depending of the scenarios and time savings assumptions.

- 500 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 24,9 million $ up to 34,9 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between almost 4,9 million $ up to 55,7 million $; depending of the scenarios and time savings assumptions.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 29,3 million $, over the 7-year period, for 500 users; with a standard deviation of 13,7 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 26,4 million $, with a standard deviation of 12,5 million $.

Table 63: JACO's cost savings for a cohort of 100 users using 7-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 100 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=7 yrs						
Actual cost to the system without JACO	*4 459 000 $*	*6 712 638 $*	*7 962 500 $*	*8 466 328 $*	*10 192 000 $*	*11 466 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*1 459 000 $*	*3 712 638 $*	*4 962 500 $*	*5 466 328 $*	*7 192 000 $*	*8 466 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*1 666 585 $*	*4 254 312 $*	*5 504 174 $*	*6 008 002 $*	*7 733 674 $*	*9 802 356 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*974 701 $*	*3 228 339 $*	*4 478 201 $*	*4 982 028 $*	*6 707 701 $*	*7 981 701 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*1 182 286 $*	*3 770 013 $*	*5 019 875 $*	*5 523 702 $*	*7 249 375 $*	*9 318 057 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*2 757 388 $*	*5 708 716 $*	*6 958 578 $*	*7 462 405 $*	*9 188 078 $*	*11 620 361 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*2 273 088 $*	*5 224 416 $*	*6 474 278 $*	*6 978 106 $*	*8 703 778 $*	*11 136 061 $*

Table 64: JACO's cost savings for a cohort of 300 users using 7-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 300 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=7 yrs						
Actual cost to the system without JACO	*13 377 000 $*	*20 137 915 $*	*23 887 500 $*	*25 398 983 $*	*30 576 000 $*	*34 398 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*4 377 000 $*	*11 137 915 $*	*14 887 500 $*	*16 398 983 $*	*21 576 000 $*	*25 398 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*4 999 755 $*	*12 762 937 $*	*16 512 522 $*	*18 024 005 $*	*23 201 022 $*	*29 407 068 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*2 924 102 $*	*9 685 016 $*	*13 434 602 $*	*14 946 085 $*	*20 123 102 $*	*23 945 102 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*3 546 857 $*	*11 310 038 $*	*15 059 624 $*	*16 571 107 $*	*21 748 124 $*	*27 954 170 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*8 272 163 $*	*17 126 148 $*	*20 875 733 $*	*22 387 216 $*	*27 564 233 $*	*34 861 082 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*6 819 265 $*	*15 673 249 $*	*19 422 834 $*	*20 934 317 $*	*26 111 334 $*	*33 408 183 $*

Table 65: JACO's cost savings for a cohort of 500 users using 7-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 500 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=7 yrs						
Actual cost to the system without JACO	*22 295 000 $*	*33 563 191 $*	*39 812 500 $*	*42 331 638 $*	*50 960 000 $*	*57 330 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*7 295 000 $*	*18 563 191 $*	*24 812 500 $*	*27 331 638 $*	*35 960 000 $*	*42 330 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*8 332 925 $*	*21 271 561 $*	*27 520 870 $*	*30 040 008 $*	*38 668 370 $*	*49 011 780 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*4 873 503 $*	*16 141 694 $*	*22 391 003 $*	*24 910 141 $*	*33 538 503 $*	*39 908 503 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*5 911 428 $*	*18 850 064 $*	*25 099 373 $*	*27 618 511 $*	*36 246 873 $*	*46 590 283 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*13 786 939 $*	*28 543 580 $*	*34 792 888 $*	*37 312 027 $*	*45 940 388 $*	*58 101 803 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*11 365 441 $*	*26 122 082 $*	*32 371 391 $*	*34 890 529 $*	*43 518 891 $*	*55 680 305 $*

COST SAVINGS – MULTIPLE USERS – CONTRACT PRICE – 5-YEAR PERIOD

Table 66 to Table 68 summarize the mean cost savings scenarios for the three cohort size described above that could be encountered over a 5 year period with the JACO arm.

- 100 users cohort – Gross savings
  - ➲ The mean results indicate that 6 million $ of attendant cost could be saved to third party payers, over a 5-year period, if 100 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 3,2 million $ up to 8,2 million $, depending of the scenarios and time savings assumptions.

- 100 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 3 million $ up to 4,5 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 185 000 $ up to 7,4 million $; depending of the scenarios and time savings assumptions.

- 100 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 2,6 million $ up to 4,0 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 1,3 million $ up to 7,0 million $; depending of the time savings assumption; except for the 0,7 hour scenario. In the latter scenario, the JACO arm would generate an add-on cost ranging between 151 024 $ and 299 299 $ over the 5-year period; representing approximately 30 000 $ - 60 000 $ more a year for enabling 100 powered wheel chair users to be more autonomous.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 3,3 million $, over the 5-year period, for 100 users; with a standard deviation of 2,0 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 2,8 million $, with a standard deviation of 1,8 million $.

- 300 users cohort – Gross savings
  - ➲ The mean results indicate that 18,1 million $ of attendant cost could be saved to third party payers, over a 5-year period, if 300 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 9,6 million $ up to 24,6 million $, depending of the scenarios and time savings assumptions.

- 300 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 9,1 million $ up to 13,4 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between almost 555 000 $ up to 22,3 million $; depending of the scenarios and time savings assumptions.

- 300 users cohort – Actual technical aid users net savings

- ➲ The mean net cost savings range from 7,7 million $ up to 12,0 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 3,9 million $ up to 20,9 million $; depending of the time savings assumption; except for the 0,7 hour scenario. In the latter scenario, the JACO arm would generate an add-on cost ranging between 453 073 $ and 897 898 $ over the 5-year period; representing approximately 90 000 $ - 180 000 $ more a year for enabling 300 powered wheel chair users to be more autonomous.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 9,8 million $, over the 5-year period, for 300 users; with a standard deviation of 5,9 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 8,5 million $, with a standard deviation of 5,4 million $.

- 500 users cohort – Gross savings
  - ➲ The mean results indicate that 30,2 million $ of attendant cost could be saved to third party payers, over a 5-year period, if 500 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 15,9 million $ up to 41 million $, depending of the scenarios and time savings assumptions.

- 500 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 15,2 million $ up to 22,4 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 925 000 $ up to 37,2 million $; depending of the scenarios and time savings assumptions.

- 500 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 12,8 million $ up to 19,9 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 6,6 million $ up to 34,8 million $; depending of the time savings assumption; except for the 0,7 hour scenario. In the latter scenario, the JACO arm would generate an add-on cost ranging between 755 122 $ and 1,5 million $ over the 5-year period; representing approximately 150 000 $ - 300 000 $ more a year for enabling 500 powered wheel chair users to be more autonomous.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 16,3 million $, over the 5-year period, for 500 users; with a standard deviation of 9,8 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 14,2 million $, with a standard deviation of 9,0 million $.

Table 66: JACO's cost savings for a cohort of 100 users using 5-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 100 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=5 yrs						
Actual cost to the system without JACO	*3 185 000 $*	*4 794 742 $*	*5 687 500 $*	*6 047 377 $*	*7 280 000 $*	*8 190 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*185 000 $*	*1 794 742 $*	*2 687 500 $*	*3 047 377 $*	*4 280 000 $*	*5 190 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*333 275 $*	*2 181 652 $*	*3 074 410 $*	*3 434 287 $*	*4 666 910 $*	*6 144 540 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*(299 299) $*	*1 310 442 $*	*2 203 201 $*	*2 563 077 $*	*3 795 701 $*	*4 705 701 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(151 024) $*	*1 697 352 $*	*2 590 111 $*	*2 949 987 $*	*4 182 611 $*	*5 660 241 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*1 112 420 $*	*3 220 511 $*	*4 113 270 $*	*4 473 147 $*	*5 705 770 $*	*7 443 115 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*628 120 $*	*2 736 212 $*	*3 628 970 $*	*3 988 847 $*	*5 221 470 $*	*6 958 815 $*

Table 67: JACO's cost savings for a cohort of 300 users using 5-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 300 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=5 yrs						
Actual cost to the system without JACO	*9 555 000 $*	*14 384 225 $*	*17 062 500 $*	*18 142 131 $*	*21 840 000 $*	*24 570 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*555 000 $*	*5 384 225 $*	*8 062 500 $*	*9 142 131 $*	*12 840 000 $*	*15 570 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*999 825 $*	*6 544 955 $*	*9 223 230 $*	*10 302 861 $*	*14 000 730 $*	*18 433 620 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*(897 898) $*	*3 931 326 $*	*6 609 602 $*	*7 689 232 $*	*11 387 102 $*	*14 117 102 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(453 073) $*	*5 092 056 $*	*7 770 332 $*	*8 849 962 $*	*12 547 832 $*	*16 980 722 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*3 337 259 $*	*9 661 534 $*	*12 339 809 $*	*13 419 440 $*	*17 117 309 $*	*22 329 344 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*1 884 361 $*	*8 208 636 $*	*10 886 911 $*	*11 966 541 $*	*15 664 411 $*	*20 876 446 $*

Table 68: JACO's cost savings for a cohort of 500 users using 5-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 500 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=5 yrs						
Actual cost to the system without JACO	*15 925 000 $*	*23 973 708 $*	*28 437 500 $*	*30 236 885 $*	*36 400 000 $*	*40 950 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*925 000 $*	*8 973 708 $*	*13 437 500 $*	*15 236 885 $*	*21 400 000 $*	*25 950 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*1 666 375 $*	*10 908 258 $*	*15 372 050 $*	*17 171 435 $*	*23 334 550 $*	*30 722 700 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*(1 496 497) $*	*6 552 211 $*	*11 016 003 $*	*12 815 387 $*	*18 978 503 $*	*23 528 503 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(755 122) $*	*8 486 761 $*	*12 950 553 $*	*14 749 937 $*	*20 913 053 $*	*28 301 203 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*5 562 099 $*	*16 102 557 $*	*20 566 349 $*	*22 365 733 $*	*28 528 849 $*	*37 215 573 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*3 140 602 $*	*13 681 059 $*	*18 144 851 $*	*19 944 236 $*	*26 107 351 $*	*34 794 076 $*

COST SAVINGS – MULTIPLE USERS – CONTRACT PRICE – 3-YEAR PERIOD

Table 66 to Table 68 summarize the mean cost savings scenarios for the three cohort size described above that could be encountered over a 3 year period with the JACO arm.

- 100 users cohort – Gross savings
  - ➲ The mean results indicate that 3,6 million $ of attendant cost could be saved to third party payers, over a 3-year period, if 100 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 1,9 million $ up to 4,9 million $, depending of the scenarios and time savings assumptions.

- 100 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 628 426 $ up to 1,5 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 108 991 $ up to 3,3 million $; depending of the time savings assumption; except for the 0,7, and 1,05 hours scenarios. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 123 155 $ and 1,1 million $ over the 3-year period; representing approximately 41 000 $ - 367 000 $ more a year for enabling 100 powered wheel chair users to be more autonomous.

- 100 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 144 127 $ up to $1,0 million, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 144 127 $ up to 2,8 million $; depending of the time savings assumption; except for the 0,7, 1 and 1,25 hours scenarios. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 71 799 $ and 1,6 million $ over the 3-year period; representing approximately 24 000 $ - 533 000 $ more a year for enabling 100 powered wheel chair users to be more autonomous.3-year.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 660 781 $, over the 3-year period, for 100 users; with a standard deviation of 1,2 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 408 835 $, with a standard deviation of 1,1 million $.

- 300 users cohort – Gross savings
  - ➲ The mean results indicate that 10,9 million $ of attendant cost could be saved to third party payers, over a 3-year period, if 300 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 5,7 million $ up to 14,7 million $, depending of the scenarios and time savings assumptions.

- 300 users cohort – De Novo technical aid users net savings

- ➲ The mean net cost savings range from 1,9 million $ up to 4,5 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 326 973 $ up to 9,8 million $; depending of the time savings assumption; except for the 0,7 and 1,05 hours scenarios. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 369 465 $ and 3,3 million $ over the 3-year period; representing approximately 123 000 $ - 1,1 million $ more a year for enabling 300 powered wheel chair users to be more autonomous.

- 300 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 432 380 $ up to 3,0 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 432 380 $ up to 8,3 million $; depending of the time savings assumption; except for the 0,7, 1 and 1,25 hours scenarios In the latter scenarios, the JACO arm would generate an add-on cost ranging between 215 398 $ and 4,7 million $ over the 3-year period; representing approximately 72 000 $ - 1,6 million $ more a year for enabling 300 powered wheel chair users to be more autonomous.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 2,0 million $, over the 3-year period, for 300 users; with a standard deviation of 3,6 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 1,2 million $, with a standard deviation of 3,3 million $.

- 300 users cohort – Gross savings
  - ➲ The mean results indicate that 18,1 million $ of attendant cost could be saved to third party payers, over a 3-year period, if 500 powered wheelchair users had access to a JACO arm; where the mean cost savings attendant cost could range between 9,6 million $ up to 24,6 million $, depending of the scenarios and time savings assumptions.

- 300 users cohort – De Novo technical aid users net savings
  - ➲ The mean net cost savings range from 3,1 million $ up to 7,4 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 544 955 $ up to 16,3 million $; depending of the time savings assumption; except for the 0,7, and 1,05 hours scenarios. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 615 775 $ and 5,4 million $ over the 3-year period; representing approximately 205 000 $ - 1,8 million $ more a year for enabling 500 powered wheel chair users to be more autonomous.

- 300 users cohort – Actual technical aid users net savings
  - ➲ The mean net cost savings range from 720 633 $ up to 5,0 million $, depending of the model's parameters in the various scenarios. The table indicates that savings could range between 720 633 $ up to 13,9 million $; depending of the time savings assumption; except for the 0,7, 1 and 1,25 hours scenarios. In the latter scenarios, the JACO arm would generate an add-on cost ranging between 358 997 $ and 7,9 million $ over the 3-year period; representing approximately 120 000 $ - 2,6 million $ more a year for enabling 500 powered wheel chair users to be more autonomous.

Globally, the various scenarios generate an average net cost savings of the JACO arm representing a value of 3,3 million $, over the 3-year period, for 500 users; with a standard deviation of 6,0 million $. The average net savings of the various scenarios, when the societal perspective is excluded, represents a value of 2,0 million $, with a standard deviation of 5,5 million $.

Table 69: JACO's cost savings for a cohort of 100 users using 3-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 100 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=3 yrs						
Actual cost to the system without JACO	*1 911 000 $*	*2 876 845 $*	*3 412 500 $*	*3 628 426 $*	*4 368 000 $*	*4 914 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*(1 089 000) $*	*(123 155) $*	*412 500 $*	*628 426 $*	*1 368 000 $*	*1 914 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*(1 000 035) $*	*108 991 $*	*644 646 $*	*860 572 $*	*1 600 146 $*	*2 486 724 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*(1 573 299) $*	*(607 455) $*	*(71 799) $*	*144 127 $*	*883 701 $*	*1 429 701 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(1 484 334) $*	*(375 309) $*	*160 347 $*	*376 273 $*	*1 115 847 $*	*2 002 425 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*(532 548) $*	*732 307 $*	*1 267 962 $*	*1 483 888 $*	*2 223 462 $*	*3 265 869 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*(1 016 848) $*	*248 007 $*	*783 662 $*	*999 588 $*	*1 739 162 $*	*2 781 569 $*

Table 70: JACO's cost savings for a cohort of 300 users using 3-year period (contract price)

INCREMENTAL COST SAVINGS	TIME SAVINGS SCENARIO'S (n = 300 users)					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=3 yrs						
Actual cost to the system without JACO	*5 733 000 $*	*8 630 535 $*	*10 237 500 $*	*10 885 278 $*	*13 104 000 $*	*14 742 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*(3 267 000) $*	*(369 465) $*	*1 237 500 $*	*1 885 278 $*	*4 104 000 $*	*5 742 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*(3 000 105) $*	*326 973 $*	*1 933 938 $*	*2 581 716 $*	*4 800 438 $*	*7 460 172 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*(4 719 898) $*	*(1 822 364) $*	*(215 398) $*	*432 380 $*	*2 651 102 $*	*4 289 102 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(4 453 003) $*	*(1 125 926) $*	*481 040 $*	*1 128 818 $*	*3 347 540 $*	*6 007 274 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*(1 597 644) $*	*2 196 920 $*	*3 803 886 $*	*4 451 664 $*	*6 670 386 $*	*9 797 606 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*(3 050 543) $*	*744 022 $*	*2 350 987 $*	*2 998 765 $*	*5 217 487 $*	*8 344 708 $*

Table 71: JACO's cost savings for a cohort of 500 users using 3-year period (contract price)

INCREMENTAL COST SAVINGS	**TIME SAVINGS SCENARIO'S (n = 500 users)**					
(assumption for attendant time savings/day)	**0,7 hour (min)**	***1,05 hour***	**1,25 hours**	**1,33 hours (main result)**	**1,6 hours**	**1,8 hours (max)**
Over the lifetime of JACO; assumption n=3 yrs						
Actual cost to the system without JACO	*9 555 000 $*	*14 384 225 $*	*17 062 500 $*	*18 142 131 $*	*21 840 000 $*	*24 570 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. cost)	*(5 445 000) $*	*(615 775) $*	*2 062 500 $*	*3 142 131 $*	*6 840 000 $*	*9 570 000 $*
Cost savings of JACO - De Novo technical aid users (w/att. + sp. Ctr cost)	*(5 000 175) $*	*544 955 $*	*3 223 230 $*	*4 302 861 $*	*8 000 730 $*	*12 433 620 $*
Cost savings of JACO - Actual technical aid users (w/att. cost)	*(7 866 497) $*	*(3 037 273) $*	*(358 997) $*	*720 633 $*	*4 418 503 $*	*7 148 503 $*
Cost savings of JACO - Actual technical aid users (w/att. + sp. Ctr cost)	*(7 421 672) $*	*(1 876 543) $*	*801 733 $*	*1 881 363 $*	*5 579 233 $*	*10 012 123 $*
Societal cost savings of JACO - De Novo technical aid users (all parameters)	*(2 662 741) $*	*3 661 534 $*	*6 339 809 $*	*7 419 440 $*	*11 117 309 $*	*16 329 344 $*
Societal cost savings of JACO - Actual technical aid users (all parameters)	*(5 084 238) $*	*1 240 037 $*	*3 918 312 $*	*4 997 942 $*	*8 695 812 $*	*13 907 847 $*

9) TIME TO RETURN ON INVESTMENT (CONTRACT PRICE)

This section presents the time to reaching a break even if the decision-maker chose to purchase the JACO arm for a powered wheelchair user with upper-extremity; where the break even time is dependent of the model's underlying assumptions and parameters. For each time to return on investment (RoI) calculation, the three following JACO prices will be evaluated:

- ☑ 30 000 $ - referred to as the contract price; when considering multiple group purchases.
- ☑ 40 000 $ - referred to as the basic model price at the time of the study.
- ☑ 50 000 $ - referred to as the premium model price; when considering the purchase of JACO with different maintenance and accessories option.

To assess the RoI, various scenarios will be depicted. These are:

- ☑ Main scenarios
  - When considering only the cost from attendant's daily time saving;
  - When considering the cost from attendant's daily time saving and the reduced risk of transferring the powered wheelchair user to a specialized center;
  - When considering the cost savings from all the study parameters: the attendants' and natural caregivers' time savings parameters and reducing the risk of transferring the powered wheel chair user to a specialized center.
- ☑ Particular scenarios
  - When considering that the risk of being transferred to a specialized center becomes 100%.
  - When reviewing the time assumptions to consider more optimistic value of reduction of caregiving time.

Each of those scenarios is evaluated following the fact that the user is a "De Novo" or an "Actual" technical aid user. It should be reminded that "De Novo" technical aid users represent powered wheelchair users that never purchased technical aids prior to receiving a JACO arm while "Actual" technical aid users represent powered wheelchair users that purchased technical aids (mean value of 4842,99 $; as described previously) in the past and thus would purchase the JACO arm as an add-on technical aid; regardless that they will need to use the previous technical aids or not.

MAIN SCENARIOS

TIME TO RETURN ON INVESTMENT (CONTRACT PRICE OF 30 000 $)

Table 72 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when only the attendants cost savings parameter is considered, the model infers that third party payers could expect 2,48 years prior to reaching a break even cost. The break even time is down to 2,33 years when the risk of being transferred to a specialized center (due to a lack of homecare attendants) is added into the model and down to 2,01 years for the societal perspective.

When only the attendants cost savings parameter is input into the model, the model forecasts an average of 2,81 ± 1,04 years, where time savings range from 1,83 to 4,71 years. It is also important to note that the addition of the specialized center cost diminishes the mean time to the RoI of 6% for all the main scenarios. When all the time savings scenarios are combined, the model forecasts an average of 2,55 years ± 0,93 prior to reaching a break even, where time savings range from 1,44 years up to 4,71 years.

Table 72: Time to break even – De novo group – Main study scenarios (Contract Price)

Parameter used for the break even cost	Time to break even cost - *De novo* user of technical aids (yrs)					
	0,7 hr (min)	1,05 hr	1,25 hrs	1,33 hrs (main result)	1,6 hrs	1,8 hrs (max)
Attendants time savings/day	4,71	3,13	2,64	2,48	2,06	1,83
Attendants time savings/days + sp. center	4,50	2,89	2,47	2,33	1,96	1,64
Societal cost (incl. unpaid caregivers)	3,65	2,41	2,11	2,01	1,72	1,44

Table 73 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1.33 hours), when only the attendants cost savings parameter is considered, the model infers that third party payers could expect 2.88 years prior to reaching a break even cost. The break even time is down to 2.71 years when the risk of being transferred to a specialized center (due to a lack of homecare attendants) is added into the model and down to 2.33 years for the societal perspective.

When only the attendants cost savings parameter is input into the model, the model forecasts an average of 3,26 years ± 1,20 prior to reaching a break even, where time savings range from 2.13 years up to 5.47 years. When all the time savings scenarios are combined, the model forecasts an average of 2,97 years ± 1,07 prior to reaching a break even, where time savings range from 1,67 years up to 5,47 years.

Table 73: Time to break even – Actual technical aid users group – Main study scenarios (Contract Price)

Parameter used for the break even cost	Time to break even cost - Actual user of technical aids (yrs)					
	0,7 hr (min)	1,05 hr	1,25 hrs	1,33 hrs (main result)	1,6 hrs	1,8 hrs (max)
Attendants time savings/day	5,47	3,63	3,06	2,88	2,39	2,13
Attendants time savings/days + sp. center	5,23	3,36	2,87	2,71	2,27	1,91
Societal cost (incl. unpaid caregivers)	4,24	2,80	2,45	2,33	2,00	1,67

TIME TO RETURN ON INVESTMENT (BASIC MODEL PRICE OF 40 000 $)

Table 74 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when only the attendants cost savings parameter is considered, the model infers that third party payers could expect 3,31 years prior to reaching a break even cost. The break even time is down to 3,11 years when the risk of being transferred to a specialized center (due to a lack of homecare attendants) is added into the model and down to 2,68 years for the societal perspective.

When only the attendants cost savings parameter is input into the model, the model forecasts an average of 3,74 years ± 1,38 prior to reaching a break even, where time savings range from 2,44 years up to 6,28 years. When all the time savings scenarios are combined, the model forecasts an average of 3,41 years ± 1,23 prior to reaching a break even, where time savings range from 1,92 years up to 6,28 years.

Table 74: Time to break even – De novo group – Main study scenarios (Basic Model Price)

Parameter used for the break even cost	Time to break even cost - *De novo* user of technical aids (yrs)					
	0,7 hr (min)	1,05 hr	1,25 hrs	1,33 hrs (main result)	1,6 hrs	1,8 hrs (max)
Attendants time savings/day	6,28	4,17	3,52	3,31	2,75	2,44
Attendants time savings/days + sp. center	6,00	3,86	3,29	3,11	2,61	2,19
Societal cost (incl. unpaid caregivers)	4,86	3,22	2,81	2,68	2,30	1,92

Table 75 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when only the attendants cost savings parameter is considered, the model infers that third party payers could expect 3,71 years prior to reaching a break even cost. The break even time is down to 3,48 years when the risk of being transferred to a specialized center (due to a lack of homecare attendants) is added into the model and down to 3,0 years for the societal perspective.

When only the attendants cost savings parameter is input into the model, the model forecasts an average of 4,20 years ± 1,55 prior to reaching a break even, where time savings range from 2,74 years up to 7,04 years. When all the time savings scenarios are combined, the model forecasts an average of 3,82 years ± 1,38 prior to reaching a break even, where time savings range from 2,15 years up to 7,04 years.

Table 75: Time to break even – Actual technical aid users group – Main study scenarios (Basic Model Price)

Parameter used for the break even cost	Time to break even cost - Actual user of technical aids (yrs)					
	0,7 hr (min)	1,05 hr	1,25 hrs	1,33 hrs (main result)	1,6 hrs	1,8 hrs (max)
Attendants time savings/day	7,04	4,68	3,94	3,71	3,08	2,74
Attendants time savings/days + sp. center	6,73	4,33	3,69	3,48	2,92	2,45
Societal cost (incl. unpaid caregivers)	5,45	3,60	3,15	3,00	2,58	2,15

TIME TO RETURN ON INVESTMENT (PREMIUM MODEL PRICE OF 50 000 $)

Table 76 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when only the attendants cost savings parameter is considered, the model infers that third party payers could expect 4,13 years prior to reaching a break even cost. The break even time is down to 3,89 years when the risk of being transferred to a specialized center (due to a lack of homecare attendants) is added into the model and down to 3,35 years for the societal perspective.

When only the attendants cost savings parameter is input into the model, the model forecasts an average of 4,68 years ± 1,73 prior to reaching a break even, where time savings range from 3,05 years up to 7,85 years. When all the time savings scenarios are combined, the model forecasts an average of 4,26 years ± 1,54 prior to reaching a break even, where time savings range from 2,39 years up to 7,85 years.

Table 76: Time to break even – De novo group – Main study scenarios (Premium Model Price)

Parameter used for the break even cost	Time to break even cost - *De novo* user of technical aids (yrs)					
	0,7 hr (min)	1,05 hr	1,25 hrs	1,33 hrs (main result)	1,6 hrs	1,8 hrs (max)
Attendants time savings/day	7,85	5,21	4,40	4,13	3,43	3,05
Attendants time savings/days + sp. center	7,50	4,82	4,12	3,89	3,26	2,73
Societal cost (incl. unpaid caregivers)	6,08	4,02	3,51	3,35	2,87	2,39

Table 77 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when only the attendants cost savings parameter is considered, the model infers that third party payers could expect 4,53 years prior to reaching a break even cost. The break even time is down to 4,26 years when the risk of being transferred to a specialized center (due to a lack of homecare attendants) is added into the model and down to 3,67 years for the societal perspective.

When only the attendants cost savings parameter is input into the model, the model forecasts an average of 5,13 years ± 1,89 prior to reaching a break even, where time savings range from 3,35 years up to 8,61 years. When all the time savings scenarios are combined, the model

forecasts an average of 4,67 years ± 1,69 prior to reaching a break even, where time savings range from 2,63 years up to 8,61 years.

Table 77: Time to break even – Actual technical aid users group – Main study scenarios (Premium Model Price)

Parameter used for the break even cost	Time to break even cost - Actual user of technical aids (yrs)					
	0,7 hr (min)	1,05 hr	1,25 hrs	1,33 hrs (main result)	1,6 hrs	1,8 hrs (max)
Attendants time savings/day	8,61	5,72	4,82	4,53	3,77	3,35
Attendants time savings/days + sp. center	8,23	5,29	4,51	4,26	3,58	3,00
Societal cost (incl. unpaid caregivers)	6,67	4,41	3,85	3,67	3,15	2,63

SPECIAL SCENARIO: AVOIDED TRANSFER TO SPECIALIZED CENTER

A sensitivity analysis was performed as to denote the impact on the break even, when the risk of being transferred to a specialized center becomes 100% for certain power wheelchair users with upper-extremity disabilities; the results are indicated in Table 78 to Table 83. This sensitivity analysis has a mean to inform third party payers about the impact of the JACO arm for those that would have to be transferred to a specialized center due to a lack of attendants, if they did not own a JACO arm.

It should be mentioned that this sensitivity analysis obviously has no impact (NI) on the scenario limited to attendants' time savings. Hence, for transparency reasons, the "Attendants" scenario were not removed from the tables; rather an "NI" mention was captured for this scenario.

TIME TO RETURN ON INVESTMENT (CONTRACT PRICE OF 30 000 $)

Table 78 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when the attendants and specialized center cost savings parameter are considered, the model infers that third party payers could expect 1,09 years prior to reaching a break even cost. The break even time is down to 1,01 years for the societal perspective. When all scenarios are combined, the savings range from 0,79 years up 1,65 years.

Table 78: Time to break even – De novo group – assured transfer to sp. Ctr scenario (Contract Price)

Parameter used for the break even cost	Time to break even cost - *De novo* user of technical aids (yrs)					
	0,7 hr	1,05 hr	1,25 hrs	1,33 hrs	1,6 hrs	1,8 hrs
Attendants time savings/day	NI[7]	NI	NI	NI	NI	NI
Attendants time savings/days + sp. center	1,65	1,20	1,12	1,09	1,00	0,85
Societal cost (incl. unpaid caregivers)	1,52	1,11	1,04	1,01	0,93	0,79

Table 79 indicates the various time period (years) to reach a break even cost for the actual technical aid user group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving

[7] NI = No impact on the "Attendants" time savings scenario.

and efficient alternative. For the main time savings scenario (time savings = 1,33 hours), when the attendants and specialized center cost savings parameter are considered, the model infers that third party payers could expect 1,26 years prior to reaching a break even cost. The break even time is down to 1,18 years for the societal perspective. When all scenarios are combined, the savings range from 0,92 years up 1,91 years.

Table 79: Time to break even – Actual technical aid users group – assured transfer to sp. Ctr scenario (Contract Price)

Parameter used for the break even cost	Time to break even cost - Actual user of technical aids (yrs)					
	0,7 hr	**1,05 hr**	**1,25 hrs**	**1,33 hrs**	**1,6 hrs**	**1,8 hrs**
Attendants time savings/day	NI	NI	NI	NI	NI	NI
Attendants time savings/days + specialized center	1,91	1,39	1,30	1,26	1,16	0,98
Societal cost (incl. unpaid caregivers)	1,76	1,28	1,20	1,18	1,08	0,92

TIME TO RETURN ON INVESTMENT (BASIC MODEL PRICE OF 40 000 $)

Table 80 indicates the various time period (years) to reach a break even cost for the de novo group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when the attendants and specialized center cost savings parameter are considered, the model infers that third party payers could expect 1,45 years prior to reaching a break even cost. The break even time is down to 1,351 years for the societal perspective. When all scenarios are combined, the savings range from 1,05 years up 2,19 years.

Table 80: Time to break even – De novo group – assured transfer to sp. Ctr scenario (Basic Model Price)

Parameter used for the break even cost	Time to break even cost - *De novo* user of technical aids (yrs)					
	0,7 hr	**1,05 hr**	**1,25 hrs**	**1,33 hrs**	**1,6 hrs**	**1,8 hrs**
Attendants time savings/day	NI[8]	NI	NI	NI	NI	NI
Attendants time savings/days + sp. center	2,19	1,60	1,49	1,45	1,33	1,13
Societal cost (incl. unpaid caregivers)	2,02	1,47	1,38	1,35	1,25	1,05

Table 81 indicates the various time period (years) to reach a break even cost for the actual technical aid user group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the main time savings scenario (time savings = 1,33 hours), when the attendants and specialized center cost savings parameter are considered, the model infers that third party payers could expect 1,63 years prior to reaching a break even cost. The break even time is down to 1,51 years for the societal perspective. When all scenarios are combined, the savings range from 1,18 years up 2,46 years.

[8] NI = No impact on the "Attendants" time savings scenario.

Table 81: Time to break even – Actual technical aid users group – assured transfer to sp. Ctr scenario (Basic Model Price)

Parameter used for the break even cost	Time to break even cost - Actual user of technical aids (yrs)					
	0,7 hr	1,05 hr	1,25 hrs	1,33 hrs	1,6 hrs	1,8 hrs
Attendants time savings/day	NI	NI	NI	NI	NI	NI
Attendants time savings/days + specialized center	2,46	1,79	1,67	1,63	1,49	1,26
Societal cost (incl. unpaid caregivers)	2,27	1,65	1,55	1,51	1,40	1,18

TIME TO RETURN ON INVESTMENT (PREMIUM MODEL PRICE OF 50 000 $)

Table 82 indicates the various time period (years) to reach a break even cost for the actual technical aid user group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when the attendants and specialized center cost savings parameter are considered, the model infers that third party payers could expect 1,81 years prior to reaching a break even cost. The break even time is down to 1,69 years for the societal perspective. When all scenarios are combined, the savings range from 1,31 years up 2,74 years.

Table 82: Time to break even – De novo group – assured transfer to sp. Ctr scenario (Premium Model Price)

Parameter used for the break even cost	Time to break even cost - *De novo* user of technical aids (yrs)					
	0,7 hr	1,05 hr	1,25 hrs	1,33 hrs	1,6 hrs	1,8 hrs
Attendants time savings/day	NI[9]	NI	NI	NI	NI	NI
Attendants time savings/days + sp. center	2,74	1,99	1,86	1,81	1,66	1,41
Societal cost (incl. unpaid caregivers)	2,53	1,84	1,73	1,69	1,56	1,31

Table 83 indicates the various time period (years) to reach a break even cost for the actual technical aid user group (*status quo* vs JACO arm purchase), for rendering JACO a cost saving and efficient alternative. For the base-case time savings scenario (time savings = 1,33 hours), when the attendants and specialized center cost savings parameter are considered, the model infers that third party payers could expect 1,99 years prior to reaching a break even cost. The break even time is down to 1,85 years for the societal perspective. When all scenarios are combined, the savings range from 1,44 years up 3,01 years.

Table 83: Time to break even – Actual technical aid users group – assured transfer to sp. Ctr scenario (Premium Model Price)

Parameter used for the break even cost	Time to break even cost - Actual user of technical aids (yrs)					
	0,7 hr	1,05 hr	1,25 hrs	1,33 hrs	1,6 hrs	1,8 hrs
Attendants time savings/day	NI	NI	NI	NI	NI	NI
Attendants time savings/days + specialized center	3,01	2,19	2,04	1,99	1,83	1,55
Societal cost (incl. unpaid caregivers)	2,77	2,02	1,90	1,85	1,71	1,44

[9] NI = No impact on the "Attendants" time savings scenario.

10) SELECTING THE RIGHT TECHNICAL AID

According to a publication by the Public Health Agency of Canada (PHAC) (Canada 2009), the selection of a technical aid requires to assess the need of each technical aid user. PHAC dressed a list of 16 pertinent questions, presented hereunder, to help selecting the right solution to a problem. Considering the reduced level of autonomy for powered wheelchair users with upper-extremity disabilities as being the problem and the JACO arm as being the solution, the proposed questions were answered.

Question 1 Does it solve your problem?
(e.g. reduced level of autonomy for powered wheelchair users with upper-extremity disabilities)

☐ No ☑ Yes ☐ Not applicable

The study results indicate that JACO could increase significantly the level of autonomy of the participants. The study results indicate that less than 20% and 15%, respectively, of the participants believed that a caregiver was very important for drinking/preparing a drink and being able to eat on their own; and only 30% believed that the caregiver would be very important for preparing a meal. Finally, only 4% believed that a caregiver would be very important for picking up objects and opening/closing doors. This latter result will be important for powered wheelchair users as, according to Holliday (2005), the ability to reach adequately for objects was rated as the most important concern related to wheelchair use.

The results of the study clearly indicate, even though 50% of participants live alone and 42% live with 1-2 persons, that JACO reduces significantly the risk of being transferred to a specialized center by enabling them to increase significantly their level of autonomy for daily essential ADLs. Clearly, this increased level of autonomy, in the mid- to long-term, could generate significant positive externalities, that would need to be documented; such as the increased quality of life of the participants and their natural caregivers, the potential impact of returning to school or going back on the work force, for both the caregivers and the participant, reducing co-morbidities secondary to anxiety and stress issues generated by the reduced level of autonomy.

Question 2 Does it fulfill your needs?
(e.g. reduced level of autonomy for powered wheelchair users with upper-extremity disabilities)

☐ No ☑ Yes ☐ Not applicable

The study results indicate that there appears to be a medical need for such a device for individual with upper-extremity disabilities as more than 70% were willing to increase their level of autonomy, to learn new methods and all of the general tasks involved in activities of daily living are considered very important by more than 94% of the participants (except for playing games). Also, more than 50% of the participants are very frustrated about their limitations to perform all of the essential activities of daily living (except playing cards).

Although a certain proportion of participants were able to perform movements and tasks, it was interesting to note the high level of participants that still remained either frustrated or were looking for new solutions to increase their level of autonomy. It is believed that this frustration

and quest is probably related to the low muscle capacity; rendering performance of the movement or a given task tiresome, difficult or discouraging, especially in a context where the participant has to repeat in a short time period, the movement or the given task (such as eating, dialling or picking up an object). In Europe, a participant that purchased the JACO arm can now succeed to have his dinner on his own in 20 minutes times; only after one week daily use with the JACO arm[10].

Question 3 If not, can you exchange it?

☐ No ☑ Yes ☐ Not applicable

According to Kinova (Canada), if the user is not satisfied with the JACO arm, due to less performance of the product than expected, and/or due to malfunctioning and depending on each specific situation, the user could return the arm. However, considering the actual feedback from their actual users in Europe, it appears less than likely that it would occur.

Question 4 Is it well designed and easy to use?

☐ No ☑ Yes ☐ Not applicable

The study results indicate that after a short trial period with the JACO arm and a proper training on its utilization, all (100%) of the participants were able to perform all of JACO's movements. Almost all of the participants thought that the JACO arm was very easy to operate; most of the participants thought that combining a series of JACO's movement was fairly easy to operate. Also, the study results indicate that almost all participants (97%) believed that JACO represented a significant technical aid for powered wheelchair users with upper extremity disabilities. All participants (100%) believed that JACO represented an inspiration for taking up projects that had been abandoned.

During the early part of the study, there were 3 participants that experienced engineering issues with the JACO arm. Kinova exchanged the older version for an updated one at the study centers. Following this exchange, no other engineering issues occurred with the JACO arm. Also, JACO has a control mode that enables to program some pre-defined tasks, such as pouring a glass of water or taking a straw. These pre-programmed modes will enable users to be more effective when conducting frequent daily ADL tasks.

When the trial occurred, the Kinova's three (3) axis joystick was the only mode of command for the JACO arm. However, Kinova developed in 2010 a universal adapter to enable users to control the arm with their own wheelchair controller, so there are more users that can benefit the advantages of the JACO arm.

Over the past decades, medical devices have evolved significantly; moving from single task, complex or ineffective instruments to robotic arms. Two robotic arms are on the market presently: the Manus arm and JACO. Presently in Europe, many Manus users are switching to the JACO arm. The reasons being mostly that, contrary to the Manus arm, JACO is light weight (5kg vs 12-14kg) and the base size does not oversize the powered wheelchair and thus, does not add barriers to wheelchair mobility; as JACO is fixed on the seat base of the powered wheelchair, whereas the Manus arm has a large base fixed to the exterior of the wheelchair, extending its width by approximately 6-8 cm).

[10] Kinova internal document.

In Europe, the first client to purchase the JACO arm in 2009 had one of the first Jaco version. This client mentioned to the JACO distributor that he encountered some engineering issues similar to the ones reported in this present study. Regardless of these engineering issues, the distributor in charged asked the user, if he had the choice to keep JACO or to change to his old arm, what would he prefer to do so? He answered without any hesitation: "No way! I want to keep JACO!!!"[11]. The main reasons he mentioned were the smooth way JACO moved and the very easy way to control it.

On Kinova's web site, a JACO user mentions that his muscular dystrophy condition has always been a significant caveat for his ADLs. The evolution of his disease renders his life with a great level of complexity; taking a glass of water, bringing a plate closer by and eating represent tasks that become harder every day. For this user, this is when technology, such as the JACO arm, becomes a life buoy.

Question 5 Do you like it?

☐ No ☑ Yes ☐ Not applicable

The study results indicate that almost all participants (97%) believed that JACO represented a significant technical aid for powered wheelchair users with upper extremity disabilities. All participants (100%) believed that JACO represented an inspiration for taking up projects that had been abandoned. Almost all participants (90%-93%) were very satisfied with JACO's easiness for the overall training and the safety for people nearby. After this first experience with the JACO arm, almost all participants (87%) were very satisfied with the possibilities of use for fine motor control (precision capabilities).

Also, 100% of the evaluators (n=6) were very satisfied with seven (7) of the following features of JACO that were assessed during the study: safety (users, people nearby, powered wheelchair), technical aid that could enable to achieve a greater level of autonomy to their participants, technical aid that could enable to achieve a greater quality of life (participants and caregivers) and the summary sheets for the command modes. The majority (83%) of the evaluators were very satisfied with the following features: JACO's ease of use features and JACO's possibilities of use. The only aspect that evaluators were not as overwhelmed with was regarding JACO's possibility of use for fine motor control; although 67% were very satisfied with this aspect even after a short single experience with the JACO arm. However, Kinova's goals are to pursue studies as to answer participants, caregivers, healthcare professional, payers and other main stakeholders about key issues such as long term efficacy, safety, quality of life and other significant issues. Presently, there are many JACO arm users in the Netherlands. All users have declared to Kinova or the distributor their great satisfaction with the arm.

According to healthcare professionals working with arm users in Europe, they have indicated to Kinova: "the main finding is that JACO's functionality is more than satisfactory so that will help us all to keep smiling!"[12]. One parent of an actual user is so delighted with the JACO arm that he has made a movie for the healthcare center.

[11] Kinova internal document.
[12] Kinova internal document.

Question 6 Is it easy for your personal assistant to use?

☐ No ☑ Yes ☐ Not applicable

This question was not assessed through the study. However, it appears unlikely that the personal assistant will use it; as the JACO arm has been designed for the daily use of ADL for the powered wheel chair user with upper-extremity disabilities.

Question 7 Can you manage to clean it yourself? If not, who can?

☐ No ☑ Yes ☐ Not applicable

The only parts that will require regular cleaning are the fingers as they may come into contact with food or filthy objects. Users may clean the fingers themselves by approaching JACO's hand from their own. To clean the fingers, it is recommended to use slightly damp (not wet) cloth with light detergent as soap dishes to clean the external surface of JACO. It is recommended not to immerse in water. The rest of the arm doesn't require any cleaning.

Question 8 Can you manage the maintenance yourself? If not, who can? AND
Question 9 Can you handle repairing it yourself? If not, who can?

☑ No ☐ Yes ☐ Not applicable

The answer to questions 8 and 9: It is recommended to have the gripper's finger lubricated every 6 months for optimal performance. The JACO arm itself should not require any maintenance during its lifetime except if the apparatus has been damaged in any way. Whenever service, maintenance or repair is necessary, the user should refer to the rehabilitation center or the distributor. There is no "home serviceable" part inside the JACO arm and it should never be open by the user itself.

Question 10 Do you have the instructions?

☐ No ☑ Yes ☐ Not applicable

The JACO arm comes with a user manual that was validated through the study. Its purpose is to understand the use of the JACO arm and its limitations, consisting of instructions and images to ease the understanding for the commands for each movement. The user manual was used to train the evaluators during the study. Results indicated that 5 evaluators out of 6 were very satisfied with the manual.

Question 11 Can you be trained on its use?

☐ No ☑ Yes ☐ Not applicable

Kinova has a corporate policy of training healthcare centers, distributors and/or future users about the use of the JACO arm; since their main goal is that JACO can be used regularly on a daily basis and that JACO becomes a daily technical aid for them to perform almost fluidly essential ADLs and more.

Kinova has set a corporate priority to create a community of JACO users through his internet (blog, website etc.) in order to group together all users and enable them to exchange about their

knowledge with the device and to share different way to use it. Kinova intends to actively participate in these groups and by offering suggestions and training through these networks. This can enable users to get rapid and ongoing access. With the JACOSOFT (software developed by Kinova for the JACO arm configuration), it will be possible for users to access the updates on the device by simply connecting the JACO arm to the computer.

Question 12 Can you easily get help and advice if you have problems with the assistive technology?

☐ No ☑ Yes ☐ Not applicable

Kinova has a customer service using business hours; directly through the distributor or Kinova. However, over and above the customer service, the user can refer to the network, blogs, websites; where all these services are available 24/7 so every user can easily and rapidly obtain help and advices (please refer to question 11).

Question 13 If the assistive device breaks, can you get a substitute quickly?

☐ No ☑ Yes ☐ Not applicable

Kinova has trained their distributors /service center to repair the JACO arm within 24 hours. The arm is modular which makes it rather easy to repair. Also, the Jacosoft software, that is part of the JACO arm package, analyzes the problem in the arm and enables the distributor/service center to exchange this specific part. Following a problem with the arm, if required, Kinova will investigate further the issue; without penalizing the user of a JACO arm. Every part in the arm is exchangeable in less than 30 minutes. Its assembly has been designed to be simple to change parts if a repair was required.

Question 14 Can you afford it?

☐ No ☑ Yes ☐ Not applicable

The study results indicate that, when all of the model's scenarios were combined, that the average time to generating a break even cost is 2,48 ± 0,94 years for the de novo users and 2,89 ± 1,10 for the actual technical aid users; where the time to the break even cost range from 1,35 years up to 5,47, depending on the study assumptions.

Kinova is actually in discussions with health authorities in various countries as to enable governments and private payers to reimburse the JACO arm. Many associations are presently active to influence the reimbursements process.

Question 15 Do you have room to store it when not in use?

☐ No ☐Yes ☑ Not applicable

As JACO is recommended to remain at all times on the powered wheelchair, storing the medical device is unlikely as the JACO arm has been designed for the daily use of ADL for the powered wheelchair user with upper-extremity disabilities. But in case of travelling and need to store it for a short period of time, there is a rigid NANUK case that comes with the arm when delivered. Hence it is feasible to store it in an adapted case.

Question 16 Will it fit?
(e.g. through the door, in your car)

☐ No ☑ Yes ☐ Not applicable

The JACO arm has been designed to fit on any powered wheelchair without extending its width. The device does not oversize the wheelchair and should not add any barriers to the wheelchair mobility. Furthermore, the JACO arm can be installed or removed very quickly by personal assistance due to its conception and is transportable due to its low weight.

Plus, the arm can have several home positions so the user can hide it when he goes in a car or in restricted area. The arm has been made to fit anywhere the wheelchair can go, without thinking about logistic or space.

IN SUMMARY
If the answers to some of these questions are "no," the PHAC recommend to discuss the problems with their advisor to find a better solution or change the conditions.

However, the results of the study participants assess that the JACO arm can easily answer yes to all of these questions, except those concerning repair and maintenance. Hence making the JACO arm a relevant technical aid for users that are eager to increase their level of autonomy, especially in a context of shortage of resources for home care; ranging from being able to pick up their glasses on the floor if they fall to reconsidering going back to the workforce.

Future work will include more detailed measurements of the cost savings and increased quality of life of subjects and their caregivers with the long-term utilization of JACO.

11) DISCUSSION AND STUDY LIMITATIONS

The population of wheelchair users is dependent on external assistance to help them get through most of their activities of daily living. It has been inferred that this population needs more than four hours of human assistance time (paid and unpaid) to get through each day. For some, this help can be mandatory to their survival whereas for others, it is an aid to ease daily activities. Therefore, there is an enormous pressure put on caregivers, who may be paid caregivers (aka attendants) or unpaid (natural caregivers, mostly members of the family or friends). Often, those natural caregivers are driven to leave their full time job to carry out daily tasks necessitated by the disabled one. Adding this to the fact that there has been a significant increase in attendant needs in the province of Quebec over the last decade, it becomes critical to implement short and long term solutions to increase the autonomy of the disabled population.

Evaluation of the motorized wheelchair user population has showed that their level of autonomy is suboptimal for accomplishing ADL-related tasks. Most of them feel frustrated with their ability to accomplish ADL and are searching for new methods of accomplishing them. Although many are able to perform most basic ADL on their own, the repetitivity of accomplishment was not assessed, the global physical state after doing those tasks was not measured, and no resistance was applied to the movements. An efficient solution may be found in JACO, a multifunction manipulative robotic assistance. Entirely controlled by the wheelchair user, this assistive device has been proven to be able to carry out most important tasks of daily activities, as preparing and taking meal and beverages, in a repetitive way and with payload of up to 1,5 kg.

The participants to the study were educated and showed interest in enhancing their global autonomy and independence level. The physical ability of the participants prevented most of them from walking or standing alone from their wheelchair. The muscular muscle testing showed that approximately 60% of the participants could not achieve most of the upper body movements against a resistance greater than gravity. As physical limitation was an excuse for 60% and 80% of the study participants to respectively stop their study and work, it seems crucial to provide the necessary tools to promote autonomy and social reinsertion to the disable population, but not without proof of safety and efficacy.

Through the trial, the JACO arm system was proven to be a safe, efficacious and easy device to help carry out tasks considered as very important by the participants for daily living. Indeed, with a fundamental training of about 30 minutes, all of the participants were able to carry out all of the JACO arm basic movements. The control of the JACO arm comes naturally as it was developed to help reproduce the human arm functionality and intuitive control. The easiness of use of the manipulator was perceived as very high by a great majority of the participants, even if the control over the device was accomplished with Kinova's standard joystick. General satisfaction and ease of use represents important factors in the adoption of the device by its user. The general satisfaction with the JACO arm fine motor control, general tasks and appearance was impressively high and 97% thought it was a significant technical aid for people suffering with upper limb impairment.

Most of the ADL-related tasks conducted by the participants were considered as highly important and they could all achieve them with the help of the JACO arm. The device is

expected to greatly enhance their level of autonomy in daily living and in their natural environment. Even though achieving ADL-related tasks on their own could be somewhat more time consuming than if they were done by some caregiver, 85% of the participants expected they could achieve the daily activities with a JACO arm; except for preparing a meal and personal care where respectively 62% and 50% expected to be able to perform them with the JACO arm. This enhancement of personal autonomy could drive up to 97% to take back abandoned projects.

Increasing their level of autonomy may result in the decreased need, but not elimination, of human assistance. It was inferred that the JACO arm could reduce about 42% of the daily total care time, value that has been corroborated by literature (Romer, Stuyt et al. 2005). Even though the values used in the calculation were considered as conservative, this reduction of care time generated important cost savings. The total cost saving inferred for a single JACO user over a year of utilization, considering only the reduction of attendant's care time, is approximately 12 000$ for the base-case scenario. The cost savings may be increased when the model integrates the avoided costly transfer to a specialized center, the annual cost saving may jump to 27 000$ per participant. This interest lies within the consensus of the advantages of maintaining a person in their natural

The societal cost savings represents the point of when the contribution of natural caregivers is considered. As mentioned previously, the burden implied to the disabled' friends and family is significant and many have to give up full time employment and/or studies to supply necessary care. Some studies on the burden of illness also talk about erosion of caregivers, causing chronic health problems and depressive symptoms, implicit to the stress related to the natural caregivers (Group 1994; Hux, O'Brien et al. 1998). Their possible return to work/study was not measured by the cost savings calculation that only considered the possible time saving associated with minimal wage. The annual societal cost saving for one participant is about 15 000$.

Time and cost inferences were made with conservative values. Time to return on investment calculation could be optimized by considering diminish residential adaptation costs and savings of other technical aids purchase. But even with these cost savings assumptions, the time to RoI is quite rapid. For a JACO bought at contract price, the time to RoI ranges between 1,44 to 5,47 years. For a JACO bought at basic model price, the time to RoI ranges between 1,92 to 7,04 years. For a JACO bought at premium model price, the time to RoI ranges between 2,39 to 8,61 years. When the JACO arm may avoid the transfer of participant in a specialized care center, the time to RoI range between 10 months and 3 years, no matter which model price is paid for the device.

Results indicate that almost all (97%) participants believed that JACO could considerably increase their level of autonomy for performing basic ADL-related tasks. However, reality is that financial resources are scarce and thus, allocation to JACO users' cohort must be defined. Analysis of study results enabled to establish the model's main cost drivers: attendant's care time and transfer to a specialized center. In other words, supplying the JACO arm firstly to users at greater the risk of being transferred to a specialized center without the JACO arm and to those where greater amount of time savings that could be incurred through JACO arm, will enable to generate tremendously rapid RoIs; the lower threshold of less than 2 years. Obviously, the quicker an RoI is reached, it is logic to assume it could encourage third party payers a greater supply of JACO arms to those in need; as the JACO arm could save up to $111 000 over a 7 life year period.

The primary objective of the study was to establish whether or not participants were able to perform JACO's movements; individually or in a sequence. Considering that all participants could achieve all movements, even in a sequence, it now becomes interesting to assess JACO's impact in their natural environment and evaluate impact on their natural caregivers.

One of the issues of performing this study was to find adequate validated tools that would answer the study objectives. However, considering that JACO represents a new class of technical aid, new tool were required. Valid assessments were used whenever possible and internal validity of specifically developed tools was performed through beta-tests.

As study results were mainly based on expectations of the participants after a short experience with the JACO arm, future environmental and long term studies will help improve the validity of the presented results. This trial enabled to enhance some of JACO's engineering issues and complementary tools that would be unrestrictive to user in term of control mode, which was a significant barrier to recruitment. Kinova developed a universal adapter to adapt the wheelchair control to the JACO arm. It is now possible for every motorized wheelchair user to accomplish a control over all functionalities. Also, the user manual and training methods were refined following evaluators' comments.

The JACO arm ability to perform ADL has been proven. It is, to this day, in Canada, the only on-board, multifunctional device that could help all of the powered wheelchair users to gain in daily autonomy. It is perceived to be esthetical enough to fit in one's natural environment and safe for the people and surroundings. But potential reduction of care time may frighten the wheelchair user population as it could be perceived as enhancement of isolation and solitude. Therefore, it is important to note that tasks as washing, dressing, preparing of complex meals and more will always have to be carried out by a caregiver. Besides, the JACO arm should provide the user with sufficient autonomy to become an active member of the society (work, study, etc) and increase social participation. The perspective of going out in a less adapted environment should become less scaring as most of it is reachable with the JACO arm.

The JACO arm should not only be perceived as a device but more as a reassuring companion, a prolongation of the disabled person and a partner to success. It should not only change the user's point of view but also the perception of impairment by the outside population. The slick and sultry appearance of the JACO arm is expected to arouse curiosity and to bring a changed look on its user. As normally limbed persons, we are unaware of the daily struggle that may represents little things as to scratch our head when it itches, to replace our glasses or to replace our arm from an uncomfortable position. And when one has to wait for help to perform those little things, it may weaken his self-esteem. But when the JACO arm is given to that person, it represents much more than functionalities and numbers; it opens a whole new world of opportunity and his may at last reach his potential.

12) ROLE OF TEAM MEMBERS

Data collection was performed by an occupational therapist at the CRCL and by a summer student at the IRDPQ.

Laurie Paquet is a manager at Kinova. She was responsible for the general supervision of the data collection, including contacting and informing potential participants about the project after they have been contacted by the clinical center, as well as coordinating the visits at both sites. She also collaborated to the data analysis.

Philippe Archambault,PhD, is an occupational therapist and assistant professor at the School of Physical and Occupational Therapy, McGil University. He is also a researcher at the Centre de Recherche Interdisciplinaire de Réadaptation (CRIR). He supervised the data collection at the CRCL.

François Routhier, PhD, is an engineer and a researcher at the Centre interdisciplinaire de recherche en réadaptation et intégration sociale (CIRRIS) of the Institut de Recherche en Défiecience Physique du Québec (IRDPQ). He supervised the data collection at the IRDPQ.

Julie Frappier is a health economist and lecturer at l'Université du Québec à Montréal (UQAM). She was the project leader and responsible for of the following tasks:

- ☑ Protocol writing
- ☑ Drafting data collection form
- ☑ Drafting the coding for data entry
- ☑ Drafting the study manual
- ☑ Drafting the patient consent form
- ☑ Managing the kick-off meeting with the study sites
- ☑ Managing the database
- ☑ Analyzing and reporting study results

13) NEXT STEPS AND RECOMMENDATIONS

Numerous user evaluations and studies have shown the social and personal benefits of rehabilitation robots, and of the Manus ARM ((Dynamics 2010)) in particular. These benefits include improved independence of the user, as well as the spouse and relatives, etc., improved quality of life, increased self-esteem and increased participation in society (Romer 2005). In the study reported by Romer (2005), ARM users reported an increased feeling of independence and autonomy, which led to a higher level of satisfaction and pride when they accomplished these activities unassisted. Although these benefits of the ARM cannot be expressed in terms of money, they are of course of great value. The author stated that the indirect benefits of the ARM were such as:

- ☑ The professional ADL assistance is optimized
- ☑ Users move to a cheaper residence
- ☑ Users (or their natural caregiver) can start to work (again)
- ☑ Users (or their natural caregiver) can return to school (again)
- ☑ Increased level of quality of life
- ☑ Reduction of the level of anxiety and stress

Through a long-term prospective trial of the effectiveness of the JACO, it would be recommended to assess these parameters as to determine the true holistic impact of the JACO arm; not only on the participant but also on the natural caregivers. Assessing the safety on the powered wheelchair would also be important as participants and evaluators indicated the need of validating this impact.

Kinova (Canada) is interested, in the near future, to perform a long-term trial of the JACO arm, when used on daily basis in the natural environment of the participant and using their own wheelchair controller; the latter being possible through the use of Kinova's universal adapter. Also, an actual pilot study has been performed with 7 children. The results indicate that the JACO arm could represent a significant influence in the environment and the development of the child. This study gave the opportunity to Kinova to participate with rehabilitation centers in a second trial. Kinova is planning to repeat this trial with a more substantial sample size; where the participants will use the JACO arm at home, over a 3-month period. This study is expected to enrol approximately 40 to 60 participants.

Finally, it would be interesting to repeat the efficacy result of the JACO arm when alternative controls to the joystick are used. The transition to another control mode should be eased through Kinova's universal adapter to wheelchair's controller. It has been tested on few participants and results appear interesting to the users. Further studies will use Kinova's novel universal adapter; the latter easing the enrolment, as the control mode for the study will not become an inclusion/exclusion criteria.

14) CONCLUSION

The study objectives of the study were to answer the following questions for the two following objectives.

OBJECTIVE 1: EFFICACY OF JACO

- ☑ Can the participants succeed in performing each of JACO's movement (basic operation)?
- ☑ Can the participants succeed in performing ADL-related tasks (consecutive combination of JACO's basic operations)?
- ☑ Do participants and evaluators appreciate their experience with JACO?
- ☑ Is JACO easy to use?
- ☑ Is JACO safe for the users and caregivers?

OBJECTIVE 2: ECONOMIC BENEFITS OF JACO

- ☑ Does JACO have an expected impact on the level of autonomy of the participants?
- ☑ Is there a medical need of such a device for individuals with upper-extremity disabilities?
- ☑ Is JACO an efficient alternative (cost-effectiveness, cost-consequence)?

To the preceding questions, the study results indicate that:

- Can the participants succeed in performing each of JACO's movement (basic operation)?

☐ No ☑ **Yes**

The study results indicate that after a short trial period with the JACO arm and a proper training on its utilization, all (100%) of the participants were able to perform all of JACO's movements. Almost all of the participants thought that the utilization of the JACO was very easy to operate.

Hence, the results indicate clearly that participants succeed in performing each of JACO's movements (basic operations)

- Can the participants succeed in performing ADL-related tasks (consecutive combination of JACO's basic operations)?

☐ No ☑ **Yes**

The study results indicate that after a short trial period with the JACO arm and a proper training of its utilization, all (100%) of the participants were able to perform all of JACO's pre-defined ADL-related tasks. Most of the participants thought that combining a series of JACO's movement was fairly easy to operate.

Hence, the results indicate clearly that participants succeeded in performing a series of JACO's movements (basic operations) leading to an ADL task.

- Did participants and evaluators appreciate their experience with JACO?

☐ No ☑ **Yes**

The study results indicate that almost all participants (97%) believed that JACO represented a significant technical aid for powered wheelchair users with upper extremity disabilities. All participants (100%) believed that JACO represented an inspiration for taking up projects that had been abandoned.

Also, 100% of the evaluators (n=6) were very satisfied with seven (7) of the following features of JACO that were assessed during the study: safety (users, people nearby, powered wheelchair), technical aid that could enable to achieve a greater level of autonomy to their participants, technical aid that could enable to achieve a greater quality of life (participants and caregivers) and the summary sheets for the command modes. The majority (83%) of the evaluators were very satisfied with the following features: JACO's ease of use features and JACO's possibilities of use.

- Is JACO easy to use?

☐ No ☑ **Yes**

The study results indicate that all (100%) of the participants believed that JACO was very easy to use with the joystick. More than 80% believed that the controls were very easy to use. However, it should be noted that for this clinico-economic trial, a standard joystick was used; as the universal adapter was under development at the time of the study. Hence, for the JACO arm to be used by everyone, it is important for the controller to be adapted to one's physical abilities. The universal adapter, recently developed by Kinova Canada, enables the user to control the JACO arm system via its wheelchair's controller. The universal adapter is linked to the wheelchair's electrical control unit (ECU) and to the JACO arm system.

- Is JACO safe for the users and caregivers?

☐ No ☑ **Yes**

The study results indicate that more than 90% of participants felt as though that JACO would be safe for users and people nearby.

- Does JACO have an expected impact on the level of autonomy of the participants?

☐ No ☑ **Yes**

The study results indicate that JACO could increase significantly the level of autonomy of the participants. The study results indicate that less than 20% and 15%, respectively, of the participants believed that a caregiver was very important for drinking/preparing a drink and being able to eat on their own; and only 30% believed that the caregiver would be very important for preparing a meal. Finally, only 4% believed that a caregiver would be very important for picking up objects and opening/closing doors. This latter result will be important for powered wheelchair users as, according to Holliday (2005), the ability to reach adequately for objects was rated as the most important concern related to wheelchair use.

- Is there a medical need of such a device for individuals with upper-extremity disabilities?

☐ No ☑ **Yes**

The study results indicate that there appears to be a medical need for such a device for individual with upper-extremity disabilities as more than 70% were willing, to increase their level of autonomy, to learn new methods and all of the general tasks involved in activities of daily living are considered very important for the subjects for more than 94% of the participants (except for playing games). Also, more than 50% of the participants are very frustrated about their limitations to perform all of the essential activities of daily living (except playing cards).

- Is JACO an efficient alternative (cost-consequence, cost savings)?

☐ No ☑ **Yes**

The cost-consequence study results clearly indicate that JACO represents a safe, efficacious alternative for powered wheelchair user with upper extremities disabilities that are searching for an efficient medical device that is easy to use and safe for them and their environment.

According to Kinova, JACO's life-year is expected to last at least 7 years. Hence, the cost savings model, based on JACO's lifetime, indicates that the JACO arm could enable to generate a net savings of 50 000 $ per participant over a 7-year period; where the sensitivity analysis scenarios indicate that the cost savings could range between 9 747 $ and 120 451 $, depending on the model's assumptions. When all the net cost savings are combined, the results indicate that, over a 7-year period, JACO could generate savings of 62 283 $ ± 30 319 $ per participant.

In order to consider a more conservative life-year to the JACO arm, JACO's lifetime was reduced to 5 years. Hence, the cost savings model, based on JACO's lifetime, indicates that the JACO arm could enable to generate a net savings of 25 000 $ - 30 000 $ per participant over a 5-year period. The sensitivity analysis scenarios indicate that the cost savings could range between 1 850 $ and 76 081 $, depending on the model's assumptions, except for two (2) scenarios. These scenarios indicate that JACO could generate an add-on cost up to 2 993 $ over a 5-year period. When all the net cost savings are combined, the results indicate that, over a 5-year period, JACO could generate savings of 35 224 $ ± 21 725 $ per participant.

In order to highlight the rapid impact of the JACO arm on the cost savings, the model was generated on an unrealistic life-year to the JACO, where JACO's lifetime was reduced to 3 years. Hence, the cost savings model, based on JACO's lifetime, indicates that the JACO arm could enable to generate a net savings of 1 500 $ - 6 000 $ per participant over a 3-year period. The sensitivity analysis scenarios indicate that the cost savings could range between 1 090 $ and 36 554 $, depending on the model's assumptions, except for 20% of the scenarios. These scenarios indicate that JACO could generate an add-on cost up ranging from 1 232 $ to 15 733 $ over a 3-year period. When all the net cost savings are combined, the results indicate that, over a 3-year period, JACO could generate savings of 8 166 $ ± 13 182 $ per participant.

If these cost savings were extrapolated to a certain cohort of powered wheel chair users, the results indicate that the JACO arm could generate the following mean net cost savings, when all the scenarios results are combined:

Over a 7-year period, JACO could generate a mean net cost savings of:

☑ 6,2 million $ ± 3 million $ for 100 powered wheelchair users

- ☑ 18,7 million $ ± 9,1 million $ for 300 powered wheelchair users
- ☑ 31,1 million $ ± 15,2 million $ for 500 powered wheelchair users

The study results indicate that, when all of the model's scenarios were combined, that the average time to generating a break even cost is 2,48 ± 0,94 years for the de novo users and 2,89 ± 1,10 for the actual technical aid users; where the time to the break even cost range from 1,35 years up to 5,47, depending on the study assumptions.

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APPENDIX 1) TABLE OF UPPER-EXTREMITY ASSISTIVE DEVICES

A document referring to the list of similar products and competitors has been produced by Kinova. As the document is rather exhaustive (26 pages), the table of content has been inserted in the Appendix I. Please refer to the Study Binder for the exhaustive document.

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Contents

APPENDIX 2) SPECIFICATIONS OF THE JACO ARM

The JACO robot arm, developed by Kinova at its state-of-the-art R&D department, is a revolutionary device designed for multiple professional applications. It is a leading product in a new generation of lightweight portable robotic tools that enables users to interact with their environment with complete safety, freedom, and effectiveness.

Multiple, redundant safety features have been integrated in the design and control of the JACO arm to avoid potential harmful events. The JACO arm passed security tests with private well known firms. The JACO arm is now CE mark and CSA.

THE ARM

JACO moves smoothly and silently around 6 degrees of freedom with unlimited rotation on each axis. The axes are aluminum compact actuator discs (CADs) of a unique design. Each JACO robot arm consists of 2 distinct sets of 3 identical, interchangeable, and easy-to-replace CADs linked together by a ZIF (zero insertion force) cable. Its main structure, entirely made of carbon fibre, delivers optimal robustness and durability as well as a cutting-edge look-and-feel. The arm is mounted on a standard aluminum extruded support structure that can be affixed to almost any surface. It is capable of producing 30 Nm with a gripper force of up to 7N and moving at a velocity of up to 15 cm/s.

THE GRIPPER

The gripper consists of 3 under actuated fingers that can be individually controlled. Their unique bi-injected plastic structure (patent pending) endows them with great flexibility and unrivalled grip. JACO technology allows the fingers to adjust to any object whatever its shape; as a result, they can gently pick up an egg or firmly grasp a jar.

CONTROL

JACO can be controlled with a computer (see the “Software” section below) or Kinova’s 3-axis, 7-button joystick. Control is intuitive and allows users to navigate using 3 different modes: translate, rotate, and grip. Also, Kinova’s Intelligent Singularity Avoidance System always keeps JACO safely away from unwanted locations. JACO is highly flexible and can adapt to all user needs.

UNIVERSAL ADAPTER

The universal adapter, recently developed by Kinova Canada, enables the user to control the JACO arm system via its wheelchair’s controller. The universal adapter is linked to the wheelchair’s ECU and to the JACO arm system.

SOFTWARE

JACO features an advanced application programming interface (API), enabling programmers to raise their experience to another level. The API, linked to JACO through a USB 2.0 connector, allows programmers to configure advanced parameters and integrate the robot to their own systems. In addition, JACO can be controlled with any one of many navigation systems,

providing a broad range of applications from analyzing central system data to programming automated paths.

The API comes with complete documentation and several code examples. It is compatible with Windows (XP, Vista, 7) and Ubuntu (end 2010). In addition, new and exciting updates are available on a regular basis.

DETAILED SPECIFICATIONS

☑ Mechanical

- Total weight: 6Kg
- Maximum Load : 1.5kg
- Reach : 90cm
- Back drivable when shutdown
- Zero backlash on axis
- Finger force limited to 7N (1.54 lb_f)
- Flexible fingers for durability and security
- Absolute position tolerance: 8 mm
- Relative position tolerance: 1.6 mm
- Maximum linear arm speed: 15 cm/s
- Maximum joint rotation speed: 8 rpm
- Average joint torque: 30 N.m
- Ambient temperature from 0°C to 30°C
- Water resistance (IPX2 rating)
- Two emergency switches to turn off the JACO arm, one on the controller and the other on the arm itself

☑ Electronic

- 2 connectors for expansion cards
- 100 Hz control system
- 1 Mb/s CANBUS
- [x,y,z] Accelerometer

☑ Electrical

- Input Power
  - Voltage: 24V ± 20% DC
  - Current : 1.7A in normal use, 10A max (less than 15 seconds)
- Output Power (controller port)
  - Voltage: 24V ± 20% DC
  - Current : 1.5A continuous (3A less than 2 seconds)

☑ Firmware

- Each axis controlled independently
- Redundant security on each axis / fingers

- Redundant error check in joints and in control system
- Position and error calculation every 0.01 second
- Automatic recovery on system fault

☑ **Software and API**

- USB 2.0 connector
- API
- Different control interface
- Configuration (speed & force limit, protection zones when the Jaco is near to the user, no go zones)
- Diagnostic tools
- Development tools

APPENDIX 3) TABLE OF CONTENT OF THE STUDY BINDER

- Clinico-economic study summary: PowerPoint slides
- Information and informed consent form for the study and ethical committee documentation
- Final Report
- List of answers for the participant
- Coding: Case report from 1A and 1B
- Appendix 1 of the Case Report Form : Minor adverse event
- Appendix 2 of the Case Report Form : Serious adverse event
- Appendix 3 of the Case Report Form : Premature exit of the study
- Appendix 4 of the Case Report Form : Attestation de fin d'étude de l'évaluateur
- List of JACO's movements and tasks
- User manual for the utilization of the JACO arm
- Evaluators manual for the utilization of the JACO arm
- Evaluators responsibilities for the clinco-economic study *JACO-FRM-JS1*
- Internal documents for the study sites

APPENDIX 4) ASSUMPTIONS UNDERLYING THE COST OF AN ATTENDANT

The hourly price of a homecare attendant will vary depending of the attendant's experience level. However, the total cost of an attendant is based on the sum of three parameters:

1. The hourly fee (where no overtime fee was allocated within the model)
2. Overhead charges
3. Transportation fees:
   - Mileage (assumption: 0,45 $/km)
   - Parking

1. HOURLY FEE

An internet search was performed to find actual salary of a homecare attendant, the job offers (Québec 2010) were indicating the following salaries:

- 15 $/hour for a homecare attendant with 1-2 years of experience
- 19 $/hour for a homecare attendant with 5 years of experience or more

Hence, the average value of both hourly fees represents a salary of 17 $ per hour; even though it is believed that most homecare attendants have more than 3-5 years of experience.

2. OVERHEAD CHARGES

Usually, the overhead charges of an employee represent approximately 20% of their salary.

3. TRANSPORTATION FEES

And finally, it was assumed that, on average, a conservative hourly transportation cost was 4,50 $/hour; where various scenarios can generate this amount:

☑ Scenario 1:
   - 10 km drive for the next home care
   - No parking fees

☑ Scenario 2:
   - 5,56 km drive for the next home care
   - 2 $ parking fee (Montreal meters cost 3 $/hour).

ATTENDANT COST CALCULATION

Table 84 presents the calculations that lead to a mean hourly fee of 25 $/hour for an average attendant.

Table 84: Summary of the assumptions underlying the hourly total cost of a homecare attendant

Hourly Salary	Experience	Overhead	Mileage & parking	Total Cost
15,0 $	1-2 yrs	3,0 $	4,5 $	22,5 $
19,0 $	5+ yrs	3,8 $	4,5 $	27,3 $
17,0 $	Average	3,4 $	4,5 $	24,9 $

APPENDIX 5) EDINBURGH HANDEDNESS INVENTORY

The Edinburgh Handedness Inventory (MacKenzie 2007) is a measurement scale used to assess the dominance of a person's right or left hand in everyday activities. The inventory can be used by an observer assessing the person, or by a person self-reporting hand use. The latter method tends to be less reliable due to a person over-attributing tasks to the dominant hand. The Edinburgh Handedness Inventory was published in 1971 by R.C. Oldfield and has been used in various scientific studies.

EDINBURGH HANDEDNESS INVENTORY

Please indicate your preferences in the use of hands in the following activities *by putting a check in the appropriate column*; where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, *put 2 checks*. If in any case you are really indifferent, *put a check in both columns*.

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.
Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	☐ ☐	☐ ☐
2. Drawing	☐ ☐	☐ ☐
3. Throwing	☐ ☐	☐ ☐
4. Scissors	☐ ☐	☐ ☐
5. Toothbrush	☐ ☐	☐ ☐
6. Knife (without fork)	☐ ☐	☐ ☐
7. Spoon	☐ ☐	☐ ☐
8. Broom (upper hand)	☐ ☐	☐ ☐
9. Striking Match (match)	☐ ☐	☐ ☐
10. Opening box (lid)	☐ ☐	☐ ☐
TOTAL(count checks in both columns)		

Difference	Cumulative TOTAL	Result

SCORING:

Add up the number of checks in the “Left” and “Right” columns and enter in the “TOTAL” row for each column. Add the left total and the right total and enter in the “Cumulative TOTAL” cell. Subtract the left total from the right total and enter in the “Difference” cell. Divide the “Difference” cell by the “Cumulative TOTAL” cell (round to 2 digits if necessary) and multiply by 100; enter the result in the “Result” cell.

Interpretation (based on Result):

- below -40 = left-handed
- between -40 and +40 = ambidextrous
- above +40 = right-handed

APPENDIX 6) MANUAL MUSCLE TESTING

Muscle testing (Pedersen 2001) is an important part of physical examination. It is useful for establishing a diagnosis, prognosis, and treatment of neuromuscular and musculoskeletal disorders. It is also effective in determining if progress is being made during rehabilitation and from that if adjustments need to be made. Muscle testing consists of strong, static, isometric muscle contraction. Limiting joint motion and focusing on the muscle allows for determination of a problem with a muscle or muscles or possibly if it is a condition in the inert tissues (all tissue not considered contractile or neurological.

MANUAL MUSCLE TESTING AND RATING SCALE

* When performing muscle tests, be sure to evaluate for asymmetry of the muscle groups (i.e. atrophy on one side and not the other) and landmarks prior to testing.

Grading Scale: (Daniel & Worthingham 1995)

Rating muscle tests is a skill that takes a long time to learn and perform with reliability. It is important to learn how much resistance a "normal" muscle can tolerate to know when a muscle is not performing to its potential. All tests must be performed bilaterally and the unaffected side should be tested first. This is crucial because the tester can then get an accurate idea of how much resistance the unaffected side can tolerate and what would be considered normal for the patient.

The scale below is comprised of both subjective and objective factors. The subjective is the examiner knowing how much resistance to give and how much resistance the patient can tolerate. The objective factors include: if the patient can complete the available range of motion, move against gravity, and if he/she can hold this position. All of these factors make accuracy in rating a muscle test difficult, but with practice intra-tester error can be kept at a minimum.

MANUAL MUSCLE TEST SCALE:

Grade 5: Patient can hold the position against maximum resistance and through complete range of motion.

Grade 4: Patient can hold the position against strong to moderate resistance, has full range of motion.

Grade 3: Patient can tolerate no resistance but can perform the movement through the full range of motion.

Grade 2: Patient has all or partial range of motion in the gravity eliminated position.

Grade 1: The muscle/muscles can be palpated while the patient is performing the action in the gravity eliminated position.

Grade 0: No contractile activity can be felt in the gravity eliminated position.

APPENDIX 7) TEMPA VALIDATED FORM

Tempa (Desrosiers, Hebert et al. 1995) is based on the observation of the 9 following tasks:

1. To open a coffee pot and take a spoon of coffee
2. To unlock and open a cabinet for taking a medication enclosed in a medication dispenser
3. To write on an envelope and put a stamp on it.
4. To shuffle and deal cards
5. To take and move a glass jar
6. To take a water jug and pour water in a glass
7. To take money
8. To move small objects.

APPENDIX 8) SPECIAL SCENARIO: REVIEW OF TIME SAVING ASSUMPTIONS

The time savings calculations were made striving to use the most conservative assumptions. The time savings result of 1.33 hours per day is likely under-estimated, as explained in the following tables. First, Table 85 presents the proposed average ability of participants of doing the tasks included in the new "other" ADL-related task; where the latter is based on the average of the ability rates listed in the table.

Table 85: Average ability of the cohort to perform new "other" ADL-task

ADL	% Fully able	% Very able	Mean (%)	Delta
Personal care	27%	50%	39%	23%
Picking up objects	65%	96%	81%	31%
Opening and closing doors /drawers	68%	96%	82%	28%
Playing games	58%	84%	71%	26%
Using an audio/video system/computer/switch	57%	81%	69%	24%
New "other" category	55%	81%	68%	26%

It is possible to note that the new perceived ability to perform the "other" ADL-task category jumped from 30% to 68%. This new result is used in Table 86 to calculate the caregiving time savings possibility.

Table 86: New average weighted time savings with the JACO arm

Average total hours by type of caregiver	Devoted time by CG (hrs)	Average: "Fully & Very able"	Weighted time savings (hrs)
Feeding / Helping drink	0,28	65%	0,18
Preparing meals / beverages	0,69	57%	0,39
New "other"	2,23	68%	1,52
Total hours (daily)			**2,09**

When the "other" category is adjusted, the attendants' time saving becomes 2,09 hours per day; rather than 1,33 hours and thus representing 48% attendants time reduction to actual standard care without the JACO arm. We believe that time savings outcomes will occur somewhere between these range of time savings.

APPENDIX 9) JACO'S CONTROLLABLE MOVEMENTS

Table 87 presents a list of the basic movements of the robotic manipulator.

Table 87: JACO's basic movements

Movement number	Definition
1	Right gripper translation
2	Left gripper translation
3	Front gripper translation
4	Backward gripper translation
5	Upward gripper translation
6	Downward gripper translation
7	Wrist rotation – Finger tips orientation to the left
8	Wrist rotation – Finger tips orientation to the right
9	Wrist rotation – Upside finger tips orientation
10	Wrist rotation – Downside finger tips orientation
11	Gripper rotation – clockwise
12	Gripper rotation – anticlockwise
13	Finger opening – 3 fingers
14	Finger closing – 3 fingers
15	Return of the JACO arm to home position

APPENDIX 10) COMPLEMENTARY ANALYSIS

This appendix presents some additional analysis to compare results acquired through formal and informal sites. Note that four subjects came from informal sites.

Table 88: Comparison between results from formal and informal sites

EFFICACY OF PERFORMING JACO'S MOVEMENTS	*Attempt 1*		*Attempt 2*		Ease of accomplishing the exercise	
					Absolutely	
	Formal	Informal	Formal	Informal	Formal	Informal
Touch a target on your left	1,36	1,00	1,36	1,00	82%	100%
Touch a target on your right	1,36	1,00	1,36	1,00	82%	100%
Touch a target in front of you	1,33	1,00	1,36	1,00	79%	100%
Touch your shoulder (target)	1,39	1,00	1,39	1,00	79%	67%
Touch a target above you	1,36	1,00	1,36	1,00	79%	67%
Touch a target on the floor	1,33	1,00	1,36	1,00	76%	67%
Turn the opening of the fingers toward the left side	1,38	1,00	1,38	1,00	84%	67%
Turn the opening of the fingers toward the right side	1,38	1,00	1,38	1,00	82%	67%
Turn the opening of the fingers upwards	1,31	1,00	1,31	1,00	82%	67%
Turn the opening of the fingers downwards	1,34	1,00	1,34	1,00	88%	67%
Turn the thumb upwards	1,34	1,00	1,34	1,00	81%	67%
Turn the thumb downwards	1,34	1,00	1,38	1,00	84%	67%
Close the fingers	1,34	1,00	1,34	1,00	88%	67%
Open the fingers	1,34	1,00	1,34	1,00	88%	67%
Point a target	1,38	1,00	1,38	1,00	88%	67%
Initial position	1,38	1,00	1,48	1,00	81%	100%

Table 88 compares the level of success, between the formal and the informal group, for achieving JACO's given movements. The results indicate that all of the informal participants achieved to perform all of JACO's movement at the first attempt; whereas it took an average of 1,36 attempts for the formal group.

For the informal group, it was a representative of Kinova that acted as the evaluator and thus the trainer for the utilization of the JACO arm. These success levels probably result from the fact that the Kinova representative masters the utilization of the JACO arm and thus felt more comfortable with the explanations towards the participants. It should be stressed that prior to the study kick-off meeting, the study evaluators had never experienced the JACO arm. Although the evaluators were provided with a manual of utilization and were assigned the exact procedure to follow through to actualize a JACO arm movement, it is rational to expect that greater ease with the procedure could influence the success outcome. Therefore, although limited experience with the JACO leads to high success rate (n=1,36 attempts), the results seem to infer that the

greater experience with the JACO arm by the trainer, the greater the expected success level with the JACO arm could be encountered by the user.