The Interaction Between Cognitive Reserve and Neuropsychological Variables, Variables Related to Psychological Well-being and Health Care Usage in Relation to Long-term Outcome After Stroke or Traumatic Brain Injury

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INTRODUCTION

Stroke and traumatic brain injury (TBI) are the most common causes of acquired brain injury, affecting 30000 and 25000 persons in Sweden per year respectively [1, 2]. According to a review article approximately 50 % of patients does not return to work after their stroke [3] and even among patients with the least severe form of TBI, mild TBI, 10-45 % report long-term impairments [4]. This is an indication that a considerable proportion of patients with stroke or TBI does not make a full recovery and live for many years with cognitive, physical and/or emotional impairments.

Earlier studies have found that long-term outcome after both TBI and stroke are determined by a complex combination of injury-related, demographic and neuropsychological factors [3, 5, 6]. This combination is complex enough to avoid revelation of any multivariable prognostic model that can adequately predict patient outcome, despite considerable efforts [6]. Further studies are therefore needed to improve the currently unsatisfactory possibilities of identifying patients at risk of poor outcome.

Previous research suggests that one of the reasons why people suffer differently from what appear to be similar brain injuries has to do with cognitive ability before injury, the so-called cognitive reserve [7]. According to the theory of cognitive reserve, a high premorbid level functions as a cognitive reserve and this leads to the brain network having greater resistance to damage [7]. The protective effect of cognitive reserve is seen in many neurological conditions e.g. Alzheimer's [7]. Common measures of cognitive reserve is education level before injury or measures of crystallized intelligence, so-called hold-tests, i.e. knowledge gained through prior learning, by for instance tests of vocabulary [7, 8].

At a group level, lower performance on cognitive tests indicates a lower probability of returning to work after injury [9] although this is not a consistent finding [10]. Lower education is also associated with lower probability of returning to work after both TBI and stroke [3, 11]. During a neuropsychological assessment it is an accepted fact that the same score on a cognitive test is interpreted differently depending on the individual being assessed. A person with a higher academic degree and an average performance on a language test indicates a disability, while the same performance for someone who has not completed compulsory school indicates a strength. An example of the potent effect education has on neuropsychological tests is that middle-aged people with low levels of education on average perform worse than a group of older, demented patients with higher education [12].

Given that education both seem to impact the susceptibility of the brain to injury and results on neuropsychological tests it is important to take education into consideration when studying the relationship between outcome on neuropsychological tests and return to work after brain injury. In previous studies it is common to control for educational level when investigating the relationship between return to work and results on neuropsychological tests [13, 14] but to our knowledge no-one has looked at whether neuropsychological variables have different significance för work return in different groups based on level of education.

Cognitive reserve is not only related to result on cognitive tests but also to psychological well-being after both TBI and stroke, were higher education is linked to higher life satisfaction and less depression [15, 16]. It would be of interest to investigate whether cognitive reserve interacts with measures of psychological well-being over time and how this is related to more functional measures of outcome after stroke and TBI.

Furthermore higher educational level has been found to be strongly related to better health overall but also to higher health care consumption [17-19]. This apparent contradiction can in part be explained by higher usage of preventive health care services and more use of specialized health care compared to general practitioners among people with higher levels of education [18, 20]. For brain injury, focus of studies of health care usage have frequently been the relationship between health care usage and insurance compensation processes [21, 22]. A better understanding of cognitive reserve influences health service utilization after brain injury, and how this is related to outcome, could be of value in ensuring more equal access to brain injury rehabilitation.

The aim of the current study is to examine the interaction of cognitive reserve with neuropsychological measures, variables related to psychological well-being and variables related to health care usage on long-term outcome after acquired brain injury (TBI or stroke). The study also aims to investigate whether there are differences in levels of fatigue and in health-care consumption based on educational level after stroke or TBI.

OBJECTIVES

Primary objective is to describe the interaction between measures of cognitive reserve and neuropsychological, psychological and healthcare usage in relation to outcome (i.e work return, satisfaction with life, psychological well-being and overall outcome) after stroke or traumatic brain injury.

Secondary objectives are to describe differences in fatigue related to cognitive reserve after stroke or TBI and to describe differences in health-care usage related to cognitive reserve after stroke or TBI.

METHOD

STUDY SETTING

The Brain Injury Rehabilitation Team in Sandviken is the specialized outpatient rehabilitation team for patients of working age with an acquired brain injury in Region Gävleborg. Interviews with the participants was conducted by telephone.

PATIENT CHARACTERISTICS

Former patients at the Brain Injury Rehabilitation Team in Sandviken, Sweden, who had suffered a stroke or a traumatic brain injury, injury severity ranging from mild to severe according to Glasgow Coma Scale (GCS[26]), between the years 2003-2016 were invited to participate in the study. The study was approved by the Regionala Etikprövningsnämnden Uppsala (2018/242, 2020-05887, 2021-02002). All participants provided written informed consent.

ELIGIBILITY CRITERIA

The inclusion criteria are 1) Stroke or TBI between the years 2003-2016, 2) Previous or ongoing contact with the outpatient brain injury rehabilitation team in Region Gävleborg, 3) Currently living in Region Gävleborg. Patients with an intellectual disability (IQ>70) or who have acquired a new brain injury will be excluded.

OUTCOME VARIABLES

The primary outcome measures are return to work and life satisfaction-Secondary outcomes measures consist of overall outcome after brain injury, a measure of depression, self-rated fatigue and anxiety and health care consumption. Outcome measurements will be assessed during the telephone interview and through collection of health care utilization data. Outcome variables are summarized in table 1.

Table 1: Outcome measures

Outcome measure	Measures
Primary outcome measures	
Return to work	Degree of return to work according to degree of health insurance benefit received by the Swedish Social Insurance Agency
LiSat-11	Life Satisfaction with life overall as well as with specific areas of life. Each area is grade on a scale from 1 to 6 where higher score indicates better satisfaction.
Secondary outcome measures	
GOSE	Overall outcome after brain injury on a scale from 1 to 8, where 1 is death and 8 is upper level of good recovery

HADS	Screening of depression and anxiety, higher scores indicate more severe problems
Fatigue	Fatigue graded according on a VAS-scale by the patients at the time of the telephone interview. 1 is no fatigue, 10 is severe fatigue.
Health care consumption	Number of health care contacts as recorded by administrative systems in Region Gävleborg.

Sample Size

Multiple linear and logistic regression will be used in the statistical analysis. In order to achieve 80 % power, with a significance level set at $p<.05$ and 3 prognostic variables, 76 participants are needed to discern medium effects.

Recruitment

In total 236 patients fulfilled the inclusion criteria and were asked by mail if they wished to participate in the study. Of these 87 accepted and was booked for a telephone interview but only 83 were interviewed, as the remaining 4 was unreachable, in spite of repeated efforts. Chart review of the recruited participants showed that 2 of the recruited participants had an intellectual disability and one had suffered from a new brain injury. These 3 participants were therefore excluded.

Data Collection and Management

After receiving written consent a structured telephone interview were booked with the patient. The interview followed a standardized manual including questions about employment, overall outcome was assessed with Glasgow Outcome Scale – Extended (GOSE[23]) life satisfaction according to Life Satisfaction Questionnaire (LiSat-11[24]), anxiety and depression according to Hospital and Anxiety Scale (HADS[25]). The interview was approximately 30 minutes and was carried out by a social worker, psychologist or a psychology student with no previous relation to the patient. Information concerning profession, education and level of consciousness according to Glasgow Coma Scale (GCS[26]) or Reaction Level Scale (RLS[27]) at the time of injury where collected from patient charts. Neuropsychological variables (including working memory index, processing speed index, Vocabulary score, Information score, Block Design score, Matrices score and Similarities score from the Wechsler scales [28](Wechsler, 1997)) along with results on HADS and LiSat-11 at the time of admittance to the Brain Injury Team were also collected from patient charts through retrospective chart review. Data of health service utilization, containing information about number and type of contacts with health care services per year and clinic, were collected from the administrative records of Region Gävleborg. Data of health service utilization were collected from three years before injury until four years after injury.

Measures

Glasgow Outcome Scale-Extended (GOSE)

Glasgow Outcome Scale Extended is a global assessment of functioning after acquired brain injury[23]. It is considered the measure of choice in TBI but is also commonly used after stroke and covers areas of independence, work, social, and leisure activities, and participation in social life [23, 29]. The scale consists of an 8-point ordinal scale divided into upper and lower levels of good recovery (7, 8), moderate disability (5, 6), severe disability (3, 4), vegetative state (2), and death (1).

Life Satisfaction Questionnaire (LiSat-11)

Life Satisfaction Questionnaire (LiSat-11) consists of 11 questions. The instrument assesses overall satisfaction with life with one question as well as domain-specific satisfaction within ten domains, for instance mental health, ability to manage oneself, finances, with one question each [24]. The response options extend over six levels from “Very unsatisfactory” to “Very satisfactory”. LiSat-11 has been found to be valid for the general population

[30] as well as for people with acquired brain injury [31]. The answers can be dichotomized into two groups, satisfied (options 5 and 6) and unsatisfied (options 1 to 4).

Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (HADS) comprises of two separate scales for anxiety and depression. Scores range from 0 to 21, with scores from 0 to 7 representing a "normal," 8–10 a "mild," 11–14 a "moderate," and 15–21 a "severe" level of anxiety or depression. The HADS has been widely used to assess anxiety and depression following TBI [32].

Wechsler Scales

The Wechsler Adult Intelligence scale (WAIS) and Wechsler Memory Scale (WMS) are well-known instruments for measuring cognitive function [28]). Both WAIS and WMS are translated and standardized för a Swedish population, In WAIS you can calculate a full scale IQ-score as well as four different indices, verbal understanding, perceptual organization, speed and working memory. In WMS-III eight primary memory indices can be calculated, one of which is a working memory index, comparable with the working memory index in WAIS. Speed index has been shown to be especially sensitive to brain damage [33]. Also on working memory index, people with brain damage generally perform worse than controls [34]. The individual tests subtests Vocabulary and Information seem less sensitive to brain damage and have in previous studies been used as measures of pre-morbid IQ [35, 36].

Data Management

All data material will be recorded with a participant ID and will be unidentifiable. Only the principal investigator will have access to the list that link participant ID with names. De-identified data will be electronically stored on the server at Region Gävleborg and will be deleted 5 years after the project has ended. The final dataset will be available to researchers actively contributing to statistical analyses and publications. Data entry will be controlled by initial exploratory analyses, including range checks, in order to promote data quality.

Confidentialty

Information on participants will be handled by health care professionals adhering to Swedish Law ensuring confidentiality and data protection. Results and data will be presented at a group level in publications, rendering identification of individual patients impossible. All data will be stored in accordance with the General Data Protection Regulation (GDPR).

Statistical Analysis

Descriptive statistics will be used to depict demographics, injury characteristics, results on neuropsychological tests and psychological screening instruments. Multiple linear and logistic regression will be used in order to detect any interaction effect between measures of cognitive reserve and neuropsychological variables, injury-related variables and variables related to psychological well-being on the outcome variables. Power analysis show that in order to achieve 80 % power, with an alpha-level of 0.05, and three controlling variables in the regression model, the regression analysis require 76 participants.

Plans for communicating important protocol amendments to relevant parties

Important protocol modifications will be reported to the Ethics committee in Sweden and amendments will be made to the trial registry (Clinicaltrials.gov).

Dissemination plans

Publications are planned for journals in the fields of neuropsychology, and rehabilitation. Results will further be spread at relevant conferences, national and international meetings, and expert forums. The results will be shared with user organizations and its members as well as relevant policy makers.

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