

From  
Department of Public Health and Community Medicine Institute of Medicine  
The Sahlgrenska Academy, University of Gothenburg, Sweden  
and  
Hälsan & Arbetslivet, Occupational Health Care Unit  
Hälsan och Stressmedicin,  
Västra Götaland Region, Sweden

## **Classification, care-seeking behaviour and pre-hospital triage of patients exposed to a whiplash trauma**

by

**Artur Tenenbaum**



UNIVERSITY OF GOTHENBURG

Gothenburg 2019

Cover illustration: Decision by Magda Florczyk

Classification, care-seeking behaviour and pre-hospital triage of patients exposed to a whiplash trauma

© Artur Tenenbaum 2019  
artur.tenenbaum@vgregion.se  
artur.tenenbaum@telia.com

ISBN 978-91-7833-520-6 (PRINT)  
ISBN 978-91-7833-521-3 (PDF)

<http://hdl.handle.net/2077/60799>

Printed in Gothenburg, Sweden 2019  
Printed by BrandFactory

In memory of my mother Helena, who encouraged my education and choice of career, and to my beloved Rose-Marie, my life companion, my great love and my best friend, who is always by my side.

# Classification, care-seeking behaviour and pre-hospital triage of patients exposed to a whiplash trauma

Artur Tenenbaum

Department of Public Health and Community Medicine,  
Institute of Medicine  
Sahlgrenska Academy, University of Gothenburg  
Gothenburg, Sweden

## ABSTRACT

**Background:** Knowledge about the optimal first acute care level and classification after exposure to a whiplash trauma is important for the injured individual and for the healthcare system. Neck pain is ranked as the fourth most important condition in the “Global Burden of Disease Study”. Exposure to whiplash trauma is common and many individuals seek health care. Up to 50% of those with symptoms after whiplash trauma, labelled whiplash associated disorders (WAD), face chronic health problems.

**Aim:** The general aim of this thesis was to explore allocation of rehabilitation resources after a whiplash trauma by investigating if a Swedish classification model could be used as a complement to the Quebec Classification. Furthermore, to study gender differences in care-seeking behavior immediately after whiplash trauma. A subsequent goal was to develop a risk stratification model for individuals exposed to whiplash trauma, a practical tool for medical personnel in prehospital triage after a neck trauma that result in neck pain.

**Material and methods:** A prospective study was performed on 85 patients with WAD classified according to a new proposed classification system. Ten years of data from a database of injuries with more than 3000 patients exposed to whiplash trauma were used to construct an algorithm recommending the appropriate first level of care. Finally, a survey to 188 medical practitioners exploring their recommendations for pre-hospital triage of patients exposed to a traffic accident resulting in neck pain.

**Results:** Patients with whiplash-associated disorders grade II and neuropsychological symptoms seem to have a worse prognosis for spontaneous recovery than those without. A Swedish classification system seems to be a complement to the Quebec classification. Women sought healthcare later than men after a whiplash trauma and less frequently sought care at a hospital emergency department compared to men. Half of all individuals sought care at a hospital, but only 6.4 % were hospitalized, while the other half sought care at a primary health care centre. Four risk factors were identified in patients diagnosed with WAD to predict the presence of a potentially sinister injury requiring hospital care; commotio cerebri, fracture or luxation, serious injury, and attending health care the same day as trauma. An algorithm recommending the appropriate first level of care was made. A consensus around initial pre-hospital triage of patients with a very low or very high risk for sinister injury exist. This consensus correlates well to recent findings recommending appropriate pre-hospital triage and first level of care.

**Conclusion:** The right level of care and classification after whiplash trauma is important for the injured individual and for the healthcare system.

**Keywords:** Whiplash, WAD, pre-hospital triage, medical decision-making, clinical decisions.

ISBN 978-91-7833-520-6 (PRINT)

ISBN 978-91-7833-521-3 (PDF)

# SAMMANFATTNING PÅ SVENSKA

**Rätt vårdnivå och klassifikation i nära anslutning till whiplashtrauma är viktigt för den skadade individen och för hälso- och sjukvården.**

I Sverige finns en nollvision; att ingen ska behöva dö eller skadas allvarligt i trafiken. Det medför ett säkerhetstänkande i alla led.

De vanligaste skadorna vid trafikolyckor är whiplashskador. Olyckshändelser som orsakar whiplashskador kan medföra stort lidande för den enskilda individen, som kan drabbas av smärta och även andra symptom.

Hälften av de som skadas rapporterar kvarstående besvär sex månader efter skadan. Individen kan också påverkas ekonomiskt om skadan medför funktionsnedsättning och aktivitetsbegränsning som påverkar arbetsförmågan. Stora samhällskostnader genereras bland annat av sjukvårdskostnader och produktionsbortfall i relation till whiplashskador.

Denna avhandling belyser kunskapen om riskmarkörer som beskrivs i en Svensk klassifikation för långvariga besvär efter whiplashtrauma för att optimera rehabiliteringen för de som har kvarstående besvär (**studie 1**).

**Studie 2** fokuserar på var och när efter skadan den första sjukvårdskontakten sker, genom tillgång till ett högkvalitativt skaderegister med över 3000 individer med kliniskt diagnostiserade whiplashskador vid tidigare Landstinget Skaraborg numera del av Västra Götaland Region under åren 1999–2008. Vi har kunnat visa att det föreligger en könsskillnad där kvinnor söker vård senare än män, samt att män oftare söker vård vid sjukhusets akutmottagningar medan kvinnor söker vård vid vårdcentraler.

Endast 6% av de skadade individerna var i behov av sjukhusvård. Hälften av de 3000 skadade individerna sökte dock sjukhusets akutmottagningar, där de flesta skickades hem utan några omfattande medicinska åtgärder.

I **studie 3** utvecklades en algoritm för att hjälpa medicinsk personal vid triagering – vägval huruvida individen bör bedömas vid vårdcentralen eller sjukhusets akutmottagning efter skadan. Algoritmen visade att för individer som utsatts för whiplashtrauma utan tecken på hjärnskakning, benbrott eller allvarlig skada och som inte har sökt sjukvård under det första dygnet, är vårdcentral den optimala vårdnivån under förutsättning att vårdcentralen kan erbjuda läkartid samma dag som individen kontaktar sjukvården.

Då antalet patienter vid sjukhusets akutmottagningar är stort är det viktigt med optimal allokering av sjukvårdsresurser utan att det medför medicinska risker.

I **studie 4** undersöktes huruvida den framtagna algoritmen är praktiskt tillämpbar för läkare som arbetar inom primär- och slutenvården. 188 läkare besvarade tre kliniska skadescenarion och algoritmen följdes till 87%, samtidigt som det förelåg läkar-utbildningsbehov för de patientfall som var i gränslandet och varken hade låg eller hög risk för att ha svår skada. Läkare höll för det mesta med den bevisbaserade algoritmen för lämplig pre-hospital triagering.

Därför bör det vara möjligt att implementera den nya algoritmen och kunskapen från denna avhandling kan vara till nytta vid implementering i nya vårdprogram om whiplashskador i Sverige.



## LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

- I. Tenenbaum A, Rivano-Fischer M, Tjell C, Edblom M, Sunnerhagen KS. **The Quebec classification and a new Swedish classification for whiplash-associated disorders in relation to life satisfaction in patients at high risk of chronic functional impairment and disability.** J Rehabil Med. 2002 May;34(3):114-8.
- II. Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. **Gender differences in care-seeking behavior and healthcare consumption immediately after whiplash trauma.** PLoS One. 2017 Apr 25; 12(4):e0176328. doi: 10.1371/journal.pone.0176328. eCollection 2017.
- III. Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R: **A risk stratification tool for prehospital triage of patients exposed to a whiplash trauma.** PLoS One. 2019 May 14; 14(5):e0216694. doi: 10.1371/journal.pone.0216694. eCollection 2019.
- IV. Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. **Medical practitioners' recommendation for pre-hospital triage of patients exposed to a traffic accident resulting in neck pain.** 2019 May. Manuscript.

# CONTENTS

<b>ABBREVIATIONS</b> .....	<b>4</b>
<b>DEFINITIONS</b> .....	<b>5</b>
<b>1 “THE LONG AND WINDING ROAD”</b> .....	<b>6</b>
<b>2 INTRODUCTION TO WHIPLASH</b> .....	<b>8</b>
2.1 Guidelines and classification.....	10
2.1.1 QTF .....	10
2.1.2 The Swedish Whiplash Commission.....	13
2.1.3 Regional Swedish Guidelines.....	14
2.1.4 Pre-Hospital Triage .....	14
2.1.5 ICD10 - ICF.....	15
2.1.6 National Board of Health and Welfare in Sweden – Sick leave..	16
2.1.7 National Board of Health and Welfare in Sweden. Care of traffic injures with long-term pain.....	18
2.2 Rehabilitation the setting.....	19
2.2.1 Multimodal rehabilitation.....	19
2.2.2 CARF.....	21
<b>3 GENERAL AIM</b> .....	<b>23</b>
3.1 Specific Aims.....	23
<b>4 MATERIALS AND METHODS</b> .....	<b>24</b>
4.1 Sweden.....	24
4.1.1 The Västra Götaland Region .....	25
4.1.2 Skaraborg County.....	25
4.2 Skaraborg injury register.....	26
4.3 Participants.....	26
4.3.1 Participants Study I .....	27
4.3.2 Participants Study II and III .....	27
4.3.3 Participants study IV .....	28
<b>5 ETHICAL CONSIDERATIONS</b> .....	<b>29</b>



<b>6</b>	<b>STUDY LOGISTICS.....</b>	<b>30</b>
6.1	Study logistics Study I .....	30
6.2	Study logistics Study II .....	32
6.3	Study logistics Study III.....	33
6.4	Study logistics Study IV.....	33
<b>7</b>	<b>STATISTICAL ANALYSIS.....</b>	<b>34</b>
7.1	Statistical Analysis – STUDY I .....	34
7.2	Statistical Analysis – STUDY II.....	34
7.3	Statistical Analysis – STUDY III.....	35
7.4	Statistical Analysis – STUDY IV.....	35
<b>8</b>	<b>RESULTS.....</b>	<b>37</b>
8.1	Results Study I .....	37
8.2	Results Study II.....	38
8.3	Results Study III.....	39
8.4	Results Study IV .....	45
<b>9</b>	<b>DISCUSSION.....</b>	<b>46</b>
9.1	Vision Zero Academy (Nollvision).....	49
9.2	Strengths.....	50
9.3	Weaknesses .....	50
<b>10</b>	<b>FUTURE PERSPECTIVES.....</b>	<b>52</b>
10.1	Human, Technology and Organisation.....	52
10.2	Future challenges – National Guidelines .....	52
<b>11</b>	<b>CONCLUSION.....</b>	<b>54</b>
	<b>ACKNOWLEDGEMENT.....</b>	<b>55</b>
	<b>REFERENCES.....</b>	<b>58</b>
	<b>APPENDIX - SUPPLEMENTAL MATERIAL STUDY III.....</b>	<b>70</b>
	<b>APPENDIX - SUPPLEMENTAL MATERIAL STUDY IV.....</b>	<b>72</b>
	<b>APPENDIX - ORIGINAL PUBLICATIONS.....</b>	<b>78</b>

# ABBREVIATIONS

- ADAPT Adaptive Process Triage
- AIS Abbreviated Injury Scale
- EHLASS European Home and Leisure Accident Surveillance System
- CARF Commission on Accreditation of Rehabilitation Facilities
- METTS Medical Emergency Triage and Treatment System
- NOMESCO Nordic Medicinal Statistical Committee
- PHCC Primary Health Care Centre
- QTF Quebec Task Force on Whiplash-Associated Disorders
  
- SoS Socialstyrelsen, The Swedish National Board of Health and Welfare
  
- SQRP The Swedish Quality Registry for Pain
- WAD Whiplash- Associated Disorders
- Vega Production database for health care services within Region Västra Götaland

## DEFINITIONS

- Whiplash  
Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck. It may result from rear-end or side-impact motor vehicle collisions but can also occur during diving or other mishaps. The impact may result in bony or soft-tissue injuries (whiplash injury), which in turn can lead to a variety of clinical manifestations labelled (Whiplash Associated Disorders, WAD).
- WAD  
Whiplash-Associated Disorders. A variety of clinical manifestations seen after a whiplash trauma.
- The Zero Vision  
A Road Transport System Free from Serious Health Losses (nobody should die in traffic accidents).

# 1 "THE LONG AND WINDING ROAD"

*När jag 1997 tillträdde tjänsten som klinikchef och överläkare för Rehabiliteringsmedicinska kliniken i Skövde kom jag i kontakt med flera patienter som inte sällan hade kvarstående besvär efter en trafikolycka. Dessa patienter rehabiliterades vid den tiden i flera olika team, smärtteamet, hjärnskadeteamet m.fl. För att fokusera och förbättra rehabiliteringen av whiplashskadade patienter skapade vi ett bedömnings- och rehabiliteringsteam för dessa. Jag fick uppdraget att i landstinget leda arbete med att utveckla ett vårdprogram för dessa patienter. Vårdprogrammet fick titeln "När framtiden kommer bakifrån" och antogs samma år (1).*

*Mitt intresse för forskning och utveckling hade redan för två decennier sedan väckts då jag utvecklade och byggde en kolorimetrisk pH-mätare som ung student och prisbelönades vid Unga Forskare i Stockholm med en resa till olika Universitet i USA "Bicentennial of American Science" och som avrundades med ett deltagande på Nobelmiddag i Stockholm 1976 (2, 3).*

*Under mina medicinstudier var det professor John-Gunnar Forsberg i Lund som introducerade och hjälpte mig in i den medicinska forskarvärlden (4-6). Det kändes därför naturligt att studera och utvärdera arbete med whiplashteamet (7). I nära samarbete med öronkliniken bidrog whiplashteamet även till ökad kunskap och patientmaterial till studier som kom att ingå i en avhandling av Dr Carsten Tjell (8).*

*När Västra Götalandsregionen bildades 1999 kunde vi bl.a. via det medicinska sektorsrådet gå vidare och skapa ett regionalt vårdprogram för dessa patienter (9).*

*Trettiofem års erfarenhet som läkare, varav tjugo av dessa som chef i olika positioner och organisationer har givit mig möjligheter att uppmuntra, utvärdera och utveckla rehabiliteringsinsatser, samt skattningsinstrument inom olika fält (10-17). Önskan och lusten att slutföra en forskarutbildning har alltid funnits där, dock har tiden inte alltid räckt till! Tack vare många, men framför allt en Professor Ronny Gunnarsson kan jag nu med stor ödmjukhet presentera denna avhandling.*

*Artur Tenenbaum,*

*Specialist i Ortopedisk Kirurgi, Allmän Kirurgi, Rehabiliteringsmedicin, Allmänmedicin, Företagshälsovård och Arbetsmedicin.*

## “THE LONG AND WINDING ROAD”

*When I entered the position as head of clinic and chief physician for the Rehabilitation Medical Clinic in the Swedish city Skövde in 1997, I came in contact with several patients who often had permanent injuries after traffic accidents. These patients were rehabilitated in several different teams, the pain team, the brain injury team and other teams. In order to focus and improve rehabilitation for these patients, we created a whiplash assessment and rehabilitation team. I was commissioned to lead work in the county council to construct a guideline entitled "When the future comes from behind" (1).*

*Two decades earlier, my interest in research and development grew when a colorimetric pH meter that I built as a young student was awarded at the Young Scientist seminar in Stockholm with a trip to various universities in the US ("Bicentennial of American Science") which rounded off with participation at the Nobel dinner in Stockholm (2, 3).*

*During my medical studies, Professor John-Gunnar Forsberg in Lund introduced and helped me in medical research (2-4). It therefore felt natural to study and evaluate the work with the whiplash team (5). In close cooperation with the ear clinic, we contributed to increased knowledge and patient material for some of the studies in a thesis by Dr. Carsten Tjell (6). When the Västra Götaland region was formed, we were able to create a regional guideline supported by medical sector council (7).*

*Thirty-five years as a doctor, with 20 of those years spent in management positions in different organizations, have given me opportunities to encourage evaluating and developing rehabilitation efforts and instruments in different fields (8-14). The desire and wish to complete a postgraduate education have always been there, although there has not always been enough time! Thanks to many, but above all, Professor Ronny Gunnarsson, I humbly present this thesis.*

*Artur Tenenbaum,*

*Specialist of Orthopedics, General Surgery, Rehabilitation medicine,  
Primary Health Care, Industrial Health and Occupational Medicine*

## 2 INTRODUCTION TO WHIPLASH

In 1997 the Swedish Parliament adopted the zero vision goal “Nollvisionen” (18).

The zero vision goal was created with the intention that nobody should die in traffic accidents. This vision affects decision makers, politicians and car companies in security thinking related to build better highways and safer cars (19). People surviving traffic accidents may live with functional and activity disturbances that affect the quality of live. The cost of whiplash injury in Sweden is over 4000 million Swedish crowns a year (20). A study by Professor Marian Radetzki included in The Whiplash Commission Final Report tries to estimate the total costs of whiplash damage to the Swedish economy in the early 2000s (20).

Neck injury and pain became societal problems with the introduction of new and mechanized transport, with the first reported whiplash trauma occurring in a train accident in 1866 (21). Erichsen described cervical spine injury for the first time in his paper “On Railway and Other Injuries of the Nervous System (21). In 1928 Harold Crowe described injuries to the cervical spine, naming them “whiplash injuries” (22). A study describing 50 individuals after whiplash injury in a car collision was published by Gay and Abbot in JAMA in 1953 (23). There has been enormous development in the scope and speed of mechanized transport during the 153 years that have passed since that first study in 1866. Simultaneously, healthcare diagnostics and our rehabilitation resources have also been developed. In 1995 the Quebec Task Force on Whiplash-Associated Disorders classified all acceleration/deceleration injuries to the cervical spine (24). Female gender, low education, previous neck problems and WAD grades were all found to be risks for chronic symptoms in the future (24).

The incidence of whiplash trauma in Sweden is between 100-420 cases per 100 000 person/year (20, 25-27). In other countries, a range from 16-600 cases per 100 000 person/year has been found (20, 26, 28-34).

The most common acute symptoms after whiplash trauma are: neck pain, neck stiffness with reduction of cervical mobility and headache. Symptoms that remain after six months are defined as chronic WAD or whiplash syndrome, which include neck pain, headache, pain in the arm, vertigo, dizziness, temporomandibular disorders and other symptoms (9, 35). In a systematic review of systematic reviews limited to publications in English,

Sarrami *et al* reported in 2017 that initial pain after whiplash injury and anxiety are factors that predict the outcome after acute whiplash injury (36). By structuring the medical and rehabilitation efforts according to the latest knowledge, there is a hope of being able to reduce the individual's suffering and to be able to allocate the resources of society's health care in an optimal way (37-40). An excellent example is a well-implemented guideline that has been in clinical use since 2015 in the Swedish Region Skåne which has chosen to deviate from the phrase whiplash injury, instead using the term neck injury and pain (41, 42).

The study base in article 2 and 3 is a quarter of a million inhabitants of Skaraborg County between 1999 and 2008 (43, 44). Using data from the Injury Registry in Skaraborg County, we found that over 3000 persons who were involved in accidents over this ten-year period (1999-2008) also had an ICD 10 diagnosis of S13.4 and, distortion in the cervical spinal column. We found gender differences in care-seeking behavior immediately after whiplash trauma and developed a risk stratification model for individuals exposed to whiplash trauma, a practical tool for medical personnel in prehospital triage after a neck trauma that results in neck pain.

The general aim in the first article (study I) published in 2002 was to explore allocation of rehabilitation resources after a whiplash trauma by investigating if a Swedish classification model could be used as a complement to the Quebec Classification (7). During 1998, a series of 85 consecutive patients with cervical distortion were referred to the Department of Rehabilitation Medicine, County Hospital, Skövde, Sweden, for examination and treatment (1, 45). The article increased our knowledge about the level of care using classification after whiplash trauma and showed that it is important for the injured individual and for the healthcare system.

One hundred eighty-eight medical practitioners' recommendations for pre-hospital triage of patients exposed to a traffic accident resulting in neck pain were investigated in study IV in 2018-2019.

This thesis investigates prehospital triage, the level of care needed, and classification of this level of care after whiplash trauma. All of which are important for the injured individual and for the healthcare system, allowing for the appropriate level of care to be given to every injured person involved in an accident occasioning whiplash trauma.

## 2.1 GUIDELINES AND CLASSIFICATION

By systematizing and standardizing care processes and rehabilitation efforts, healthcare providers aim to achieve an optimal allocation of resources. One way of doing this is developing international, national, regional or local guidelines. As an example, an international approach was made in 1995 by the Quebec Task Force on Whiplash-Associated Disorders to classify all acceleration /deceleration injuries to the cervical spine and the results were published in *Spine* (24). A national approach was made in Sweden between 2002-2005 by The Whiplash Commission (46). Regional approaches in Sweden were made in the Västra Götaland region in 2003 (9) and in the Skåne Region in 2015 (41), and local Swedish approaches in Skaraborg in 1997 (1) and in Linköping in 1998 (45). These are some examples of many guidelines created, over many years and in different regions, with the ambition of improving care for this particular patient group. However, implementing these guidelines in clinical practice and keeping them updated has proved difficult.

### 2.1.1 QTF

The Quebec Task Force (QTF) separated patients' symptoms from their whiplash injury mechanism in 1995 and introduced a new term Whiplash-Associated Disorders (WAD) using a five-grade clinical based scale (Table 1) (24).

**Table 1.** *QTF Clinical classification of whiplash-associated disorders (WAD) (24).*

WAD Grade	Clinical Presentation
0	No neck complaint No physical sign(s)
1	Neck complaint of pain, stiffness or merely tenderness No physical sign(s)
2	Neck complaint and musculoskeletal sign(s)*
3	Neck complaint and neurological sign(s)**
4	Neck complaint and fracture or dislocation

\* *Musculoskeletal signs include restricted range of motion and point tenderness.*

\*\* *Neurological signs include decreased or absent deep tendon reflexes, weakness and sensory deficits.*



Symptoms and disorders that can be manifest in all grades include deafness, dizziness, tinnitus, headache, memory loss, dysphagia and temporomandibular joint pain (7).

As the QTF WAD grade increased, so did the risk for WAD at 6, 12, 18, and 24 months, demonstrating the prognostic capacity of this grading system. Hartling *et al* analyses supported modification of the classification to distinguish between WAD Grade II cases of normal or limited range of motion (Table 2) (47). The Hartling *et al* study supports the use of the Quebec Classification of Whiplash-Associated Disorders as a prognostic tool for emergency department settings.

**Table 2.** Proposed modification of QTF Clinical classification by Hartling *et al* 2001(47).

<b>WAD Grade</b>	<b>Clinical Presentation</b>
0	No neck complaint No physical sign(s)
1	Neck complaint of pain, stiffness or merely tenderness No physical sign(s)
2 A	Neck complaint and normal range of motion*
2 B	Neck complaint and limited range of motion*
3	Neck complaint and neurological sign(s)**
4	Neck complaint and fracture or dislocation

\* Musculoskeletal signs include normal or restricted range of motion and point tenderness.

\*\* Neurological signs include decreased or absent deep tendon reflexes, weakness and sensory deficits.

Due to the high variability in outcome for WAD patients in the same classification group (WAD II), Sterling suggested a reclassification of WAD, particularly WAD II, in a paper published in 2004 (48). This reclassification was based on measurable disturbances in motor, sensory and psychological functions (Table 3) (48).

**Table 3.** Proposed modification of QTF Clinical classification by Sterling 2004 (48).

<b>WAD Grade</b>	<b>Impairment present, physical and psychological</b>
WAD 0	No complaint about neck pain and no physical sign
WAD 1	Neck complaint of pain, stiffness or tenderness only and no physical sign (48)
WAD 2 A	Neck pain with motor and sensory impairment (48)
WAD 2 B	Neck pain with motor, sensory and psychological impairment (48)
WAD 2 C	Neck pain with motor and (major) sensory and psychological impairment (48)
WAD 3	Neck pain motor, sensory, psychological impairment and neurological signs (48)
WAD 4	Fracture or dislocation

The Bone and Joint Decade (BJD) was an international initiative between 2000-2010 and reach consensus that the exact pathophysiology of WAD is not known (30). A systematic search of Medline was conducted for studies on neck pain and its associated disorders published 1980-2006, with the conclusion that WAD after traffic collisions affects many people, the evidence regarding risk factors for WAD seems included personal, societal, and environmental factors (30). BJD proposed using a clinical classification similar to the QTF (Table 1) for neck pain (Table 4).

**Table 4.** The Bone and Joint Decade (BJD) clinical classification of neck pain (30).

<b>Grade</b>	<b>Clinical Presentation</b>
1	Neck pain and associated disorders with no signs or symptoms suggestive of major structural pathology and no or minor interference with activities of daily living
2	No signs or symptoms of major structural pathology, but major interference with activities of daily living
3	No signs or symptoms of major structural pathology, but presence of neurologic signs such as decreased deep tendon reflexes, weakness, or sensory deficits
4	Signs or symptoms of major structural pathology*

\* Major structural pathologies include fracture, vertebral dislocation, injury to the spinal cord, infection, neoplasm, or systemic disease including the inflammatory arthropathies.

## 2.1.2 THE SWEDISH WHIPLASH COMMISSION

The Whiplash Commission started in Sweden in 2002 and was led by the former Swedish Prime Minister Ingvar Carlsson. It delivered a report in 2005 (46). The reason it started was an increase of whiplash related injuries reported during the 1990s (46). The final report was based on the current scientific knowledge in the following areas; societal costs of whiplash trauma, whiplash related injuries in other countries, preventative traffic safety measures, the importance of early intervention rehabilitation of people with long term problems as a result of whiplash trauma, as well as an evaluation of the treatment given to whiplash related injuries in the press. The final report describes the need for more and better scientific knowledge within the area of whiplash trauma. Whiplash-related injuries were classified in the scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders (WAD) using a five-grade scale 0-4 (24), which was modified by a consensus group by The Swedish Society of Medicine (Table 5) (20).

**Table 5.** *Clinical classification of whiplash-associate disorders by The Commission and Swedish consensus group by The Swedish Society of Medicine (20).*

WAD Grade	Clinical Presentation
1	Neck complaint of pain, stiffness or merely tenderness No physical sign(s)
2	Neck complaint and musculoskeletal sign(s) *
3	Neck complaint and neurological sign(s) **

\* *Musculoskeletal signs include restricted range of motion and point tenderness.*

\*\* *Neurological signs include decreased or absent deep tendon reflexes, weakness and sensory deficits.*

In this modified scale, WADs are divided into grades 1–3, with a special focus on neurological problems and stress symptoms (Table 5) (20). The most common whiplash injuries are minor or moderate according to the Abbreviated Injury Scale (AIS) 1-2 (49). The AIS is used in research of the epidemiology of injuries (50).

### 2.1.3 REGIONAL SWEDISH GUIDELINES

Several initiatives have been taken for the development of guidelines in Sweden, for example through the involvement of the Injury Association (Personskadeförbundet, RTP) 2008 (51), a politically independent civil rights organization along, with government agencies. No Swedish national guideline for WAD that can be used in all regions in Sweden has been developed in the same way like the National Guideline for Breast Cancer 2014 (Nationellt vårdprogram bröstcancer) (updated in 2019) (52). In contrast, there are Swedish regional guidelines in the Skåne region (1,4 million inhabitants in 2015) (41), and in the Västra Götaland region (1,9 million inhabitants in 2003), which have not been updated for a long time (9). As far as the author could determine, there are no other regional guidelines in Sweden beyond the two named, and none have been updated in 2019. What the regional guidelines that do exist have in common is that there is a clinical guide for how individuals who are acutely injured or individuals who have residual disabilities as a result of whiplash trauma should be investigated, treated and rehabilitated. The successful work in Skåne has meant that waiting times for investigation and rehabilitation for this patient group have been reduced (53).

### 2.1.4 PRE-HOSPITAL TRIAGE

Common to patients who seek care at a hospital emergency department is that they have concerns about their health and feel the need for help. Only a minor proportion are actually severely ill and need immediate medical care of those who seek care at a hospital emergency department after a whiplash trauma. The challenge for the health service is to ensure individuals in need of care have the right information to seek that care at the right level for their specific needs, so as to best make use of the resources available and allow those in most acute need to receive care first. A safe way to ensure those in the most need are seen first is to prioritize patients to the emergency department based on their medical needs using a prioritizing system - triage. The United Kingdom (54), the United States (54), Canada (54) and Australia (54) are countries that have launched various triage systems in their hospital emergency departments. With the aim of improving systems for patient assessment (focused on patient safety) and improving the processes at the emergency department focused on patient flows, two different systems for

triage and flow processes, METTS (Medical Emergency Triage and Treatment System) (55) and ADAPT (Adaptive Process Triage) have been developed in Sweden (56, 57). However, none of these focus specifically on patients exposed to a whiplash trauma.

## 2.1.5 ICD10 - ICF

Assessment of injuries and symptoms is usually done by doctors at the hospital emergency department or a primary health care centre (PHCC) resulting in a diagnosis based upon the International Classification of Diagnoses version 10 (ICD 10) (58).

In the acute phase after whiplash the ICD 10 diagnosis code S13.4 is the most accurate to use. Patients seeking medical care later after whiplash trauma with pain symptoms in the head or neck are often given the diagnosis code M53.0 Cervicocranial syndrome or M53.1 Cervicobrachial syndrome. The T91.8 classification is used after for those who suffer late disability from other specified injuries (such as whiplash) in the neck. (41).

The International Classification of Functioning, Disability and Health (ICF) (Figure 1) (59-61) applies a biopsychosocial model, used in rehabilitation medicine and by the Swedish National Board of Health and Welfare guidelines, to determine the recommended time for sick leave after distortion in the cervical spine including ICD10 diagnosis S.13.4, Whiplash injury (62).

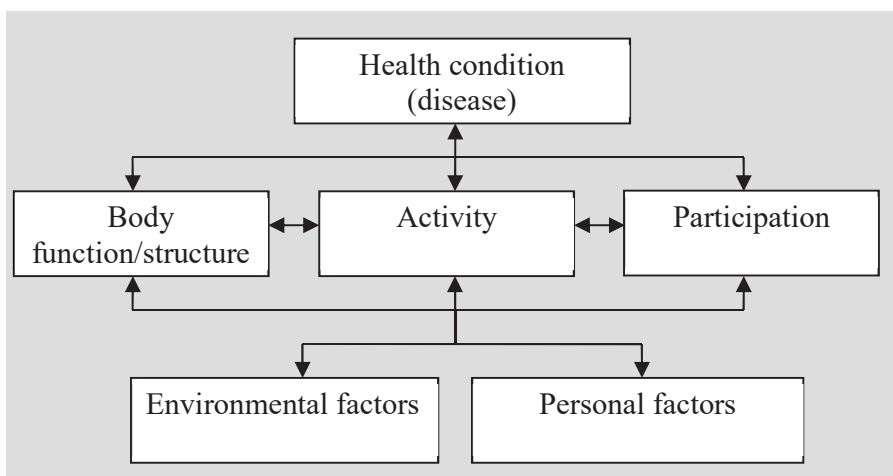


Figure 1. The ICF model, (WHO 2001) (58)

## 2.1.6 NATIONAL BOARD OF HEALTH AND WELFARE IN SWEDEN – SICK LEAVE

The Swedish National Board of Health and Welfare (Socialstyrelsen - SoS) published a guideline in 2007 on the recommended time for a patient to be on sick leave in general and also for specific ICD 10 diagnoses (63). A doctor's assessment of disability with activity limitations that affect an individual's ability to work are used as a tool in the treatment, rehabilitation, and care of a patient. These guidelines act as a support for decision making with regards to recommendations given by medical professionals about the appropriate length of sick leave. Guidelines about the length of sick leave and information on disability, activity limitation and rehabilitation after distortion in the cervical spine including specifically ICD10 diagnosis S.13.4 (62). SoS initially recommends sick leave up to one week full-time (62). If the person injured has a job with heavy lifting, sick leave is recommended for up to six weeks full-time (62). SoS points out that individual variation exists on how a given disease or injury affects the working ability and the ability to perform various activities of any given person (62). Therefore, the assessment of working ability must be done individually, based on the individual's unique conditions and employment. The patient often needs support to return to normal activities.

According to SoS the initial symptoms of WAD are pain in the neck, back and shoulders (62). Most injuries are mild and cause a slight stretch in the muscles. Depending on the strength and direction of the impact, it may affect, for example, the nervous tissue, ligaments and cartilage of the cervical spine (24).

The SoS guideline are from 1<sup>st</sup> of October 2007 and based on the current knowledge at that time. However, many individuals have persistent complaints after the injury. Looking at WAD in a longer perspective 30–50% of patients exposed to a whiplash trauma face chronic health problems (26, 47, 64-67). Agnew *et al* reported in a study in 2015 of 166 working patients with chronic WAD using the Work Ability Index that 52% of WAD patients had work ability that was determined to be poor or poor or moderate (68). The SoS statement that “*The forecast is full recovery for most people*” (62) therefore needs to be updated. Treatment for WAD is, if the patient needs it, painkillers at the beginning, in order for the patient to be able to return to

normal activity as soon as possible (64). *For some patients* who are afraid of resuming activity, instructions and support from physiotherapists are important (9, 69). These SoS recommendations also seem to be in need of an update. For all *patients who are afraid of resuming activity*, the instructions and support from physiotherapists are important (9, 41). In the event of a high workload, a gradual return to work is recommended by SoS (62).

### *Disability*

Distortion of the cervical spine including whiplash causes pain that may result in reduced mobility. The pain can impair sleep and affect cognitive functions (such as thinking ability, abstract thinking ability, mental flexibility, time management, and emotional lability) especially if the pain is persistent. SoS stated in 2007 “*Most regain normal function within 3–6 weeks* (62). However, this is not supported by later published research by Borenstein *et al* (70) they found that the condition can also result in reduced muscle strength, muscle tone and muscle endurance, as well as reduced physical endurance (70). They also reported that post-traumatic cognitive dysfunction is likely to adversely affect healing (70).

### *Activity Limitation*

Distortion in the cervical spine including whiplash causes difficulty in maintaining posture (for example, sitting or standing), as well as lifting and carrying objects from one place to another. Patient may also find it difficult to handle stress and other psychological demands (70).

It is important to quickly establish contact with the workplace to ensure an effective adjustment of work tasks and the return to work for this patient group. If the injury does not improve within 6 weeks, it is worth considering a referral to a medical or neurological rehabilitation clinic (9). Long-term complaints are often associated with psychosocial factors and work-related problems. It is therefore important to review the patient's workplace conditions and psychosocial situation. Re-examining the diagnosis and treatment if the injury does not show improvement within four weeks (62).

## 2.1.7 NATIONAL BOARD OF HEALTH AND WELFARE IN SWEDEN. CARE OF TRAFFIC INJURES WITH LONG-TERM PAIN

In 2017 the SoS presented report called “*Care of traffic injures with long term pain*” (71). Injuries caused by accidents during transport, which amounted to about 100,000 in the OECD nations in 2013, are decreasing, with the largest decrease seen in those travelling by car (71,72). The Organisation for Economic Co-operation and Development (OECD) consist of 35-member nations. Many injuries can be prevented and traffic safety for car travel has increased (72). Despite the zero vision goal (Nollvisionen), 270 people were killed in traffic in Sweden in 2016, and more than 19,000 were injured (71). According to data from SoS, the number of people admitted to hospital care in Sweden as a result of traffic accidents decreased by nearly 40% between the years 2000 and 2016 (71). A total of 8400 people were admitted to Swedish hospitals for injuries sustained in road traffic accidents in 2016 (73). Following a road traffic accident which has caused a whiplash trauma, up to 50% of the injured individuals may develop WAD with symptoms of long-standing pain (64). This often requires multimodal care, and a biopsychosocial view of the patient appears to be most important, and is thoroughly described in regional guidelines in Sweden (9, 41). The goal is to strengthen the healthy aspects of the individual, encourage appropriate and physical activities, and supporting normal activities of daily life in order to increase quality of life (41, 71).



## 2.2 REHABILITATION THE SETTING

Rehabilitation medicine (Medical rehabilitation) is a new specialty in Sweden, formally acknowledged in 1969. During recent decades, all university clinics in every part of Sweden have Rehabilitation Medical Clinics with the main task of working with medical rehabilitation for several patient groups such as after severe trauma and brain injuries and residual severe pain, one group obviously being WAD patients (74). Several of these clinics are currently accredited by the Swedish Commission on Accreditation of Rehabilitation Facilities (CARF) (75).

### 2.2.1 MULTIMODAL REHABILITATION

Multimodal rehabilitation is the gold standard for managing the consequences of chronic pain such as chronic WAD (76). One Swedish study showed gender differences with the strongest effects in female patients indicating better return to work outcomes for women, with a reduction of sick leave in women of about two thirds of a working year, whereas rehabilitating men seemed to have no effect on their health or related sick leave costs (77). Another study indicated better outcomes on return to work using multimodal rehabilitation compared to unimodal interventions (78). A study published 2019 by Rivano Fisher *et al* was based on 7297 patients and follow-up based on the Swedish Quality Registry for Pain rehabilitation (SQPR) and concluded that multimodal rehabilitation may positively influence sick-leave benefits for patients with chronic pain, regardless of their sick-leave situation or gender (78).

The International Association for the Study of Pain (IASP) definition of pain is: *Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage* (79).

The pain experience for patients with WAD who are in need of rehabilitation consists of sensory, emotional and thinking aspects that are important to consider in multimodal rehabilitation. Long-standing pain that is difficult to treat is classified according to ICD code R52 which can further be divided as follows

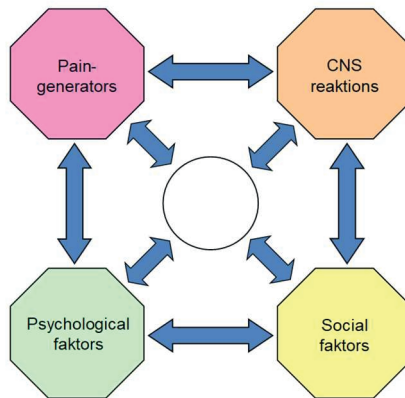
- R52.1: Chronic intractable pain
- R52.2: Other chronic pain
- R52.2A: Prolonged pain, nociceptive
- R52.2B: Long-term pain, neuropathic
- R52.2C: Prolonged pain without know cause (after investigation)
- R52.9: Pain, unspecified

Long-standing pain exceeding a period of three months is usually defined as residual pain after the expected normal course of healing.

For long-standing pain in patients with WAD, a multimodal investigation is needed to provide the right treatment (41, 71). In long-standing pain that is not malignant, multimodal care from a multi-professional team with a biopsychosocial approach is most important for achieving positive treatment outcomes (80, 81). The goal for WAD with long-standing pain is to strengthen their healthy sides through structured psychological and physiotherapeutic methods, while also encouraging appropriate physical activity to increase their quality of life and enable them to return to work and normal pursuits, and mitigate the negative effects of long-standing pain (81). Adequate drug treatment may have its place in the treatment but is not an obvious (treatment) for long-standing pain. Medicines should be used as part of multimodal care and should be selected as far as possible based on the pain mechanism present in the individual (i.e. if an individual has neuropathic pain, a medicine active against neuropathic pain should be chosen (80). In 2014 Westergren *et al* suggested an algorithm (Key-areas) for multidisciplinary teams (Figure 2) (42).

- **Pain generators** with structural muscles changes.
- **Central nervous system's** reactions to pain like sensitization, mental fatigue, cognitive and sensory etc.
- **Psychological factors**, anxiety, depression and posttraumatic stress disorder (PTSD).
- **Social factors**, including society's demands.

Key-areas for assessment of komplex persisting pain  
Department of Painrehabilitation , Lund, Sweden



**Figure 2.** Key-areas for assessment of complex persisting pain. Approach used for team assessment and communication with the patients at the Department of Painrehabilitation, Lund, Sweden. Westergren Scand J Pain, 2014 (42). Reproduced with kind permission from Dr Hans Westergren and Scand J Pain.

## 2.2.2 CARF

The Commission on Accreditation of Rehabilitation Facilities (CARF) is an international, independent, non-profit organization focused on advancing the quality of services and rehabilitation for the best possible outcomes (75). CARF states that its mission is to promote the quality, value, and optimal outcomes of rehabilitation through a consultative accreditation process and continuous improvement services that centre on enhancing the lives of the persons served. CARF follow core values that are in line with Swedish goals at rehabilitation medical units, emphasizing the right of patients to be treated with dignity and respect, have access to necessary services that achieve optimum outcomes and empowerment to exercise informed choice. In 1996, Rehab Centrum Lund-Orup at Lund University Hospital in Sweden became the first organisation outside North America to be accredited by CARF programs.

Professor Bengt Sjölund and associate professor Marcelo Rivano Fischer were instrumental in opening the doors for CARF in Sweden. The first private, non profit rehabilitation clinic to undergo a CARF survey in Sweden for an oncological rehabilitation program was Mösseberg Rehabcenter, Falköping, which became CARF-accredited in 2004, under the leadership of Artur Tenenbaum and Bengt Pettersson. Several other clinics in Sweden are currently working actively with CARF to become accredited.

## 3 GENERAL AIM

The general aim of this thesis was to explore allocation of rehabilitation resources after a whiplash trauma by investigating if a Swedish classification model could be used as a complement to the Quebec Classification. Furthermore, to study gender differences in care-seeking behavior immediately after whiplash trauma. A subsequent goal was to develop a risk stratification model for individuals exposed to a whiplash trauma, a practical tool for medical personnel in prehospital triage after a neck trauma that results in neck pain.

### 3.1 SPECIFIC AIMS

The aim of study I was to investigate whether the new Swedish classification could be used as a complement to the Quebec Classification concerning functional impairment and disability on quality of life outcomes. Another aspect was to see whether the new classification system could assist in the allocation of rehabilitation resources to the patients most in need.

The aim of study II was to study gender differences in care-seeking behavior and treatment provided immediately after whiplash trauma.

The aim of study III was to develop a risk stratification model to predict the presence of a potentially more sinister injury in patients exposed to a whiplash trauma.

The aim of study IV was to create a current image of medical doctors working in the Western Region in Sweden and their recommendations for level of care.

## 4 MATERIALS AND METHODS

### 4.1 SWEDEN

Sweden is a high-income country with 10 million citizens and a mixture of urban and rural areas. Traffic has been intense for decades and WAD common. Hence, several Swedish guidelines about management of patients exposed to a whiplash trauma have been published:

- 2005 The Whiplash Commission delivered a report (46).
- 2006 Swedish Agency for Health Technology Assessment and Assessment of Social Service (SBU) presented a systematic literature overview of the methods for treatment of long-term pain (79).
- 2007 SoS produced a guideline on the recommended time for a patient to be on sick leave for distortion in the cervical spine (including whiplash injury) – ICD 10 diagnosis code S13.4 and long-term pain in the locomotor system including fibromyalgia – ICD 10 diagnosis codes M79 and R52 (63).
- 2010 SBU Indication for multimodal rehabilitation in long-term pain (82).
- 2011 SoS in cooperation with Swedish Medical Society and Swedish Association of Local Authorities and Regions (SKL) Pain and disturbed jaw function associated with whiplash injury (WAD) from Socialstyrelsen (83).
- 2015 Physiotherapists presented FYSS is an evidence based handbook that describes how physical activity can be used to prevent and treat a number of different illnesses– a chapter on physical activity in long-term widespread pain conditions (84).
- 2017 Swedish Medical Products Agency treatment recommendations for medicinal treatment of long-term pain in children and adults (85).
- 2017 SoS Care of traffic injures with long-term pain (86).
- 2019 SKL is a member run employer and interest organization for all municipalities and regions in Sweden and the Swedish “Vårdguiden” 1177 have updated their care guide on whiplash injury (87).

## 4.1.1 THE VÄSTRA GÖTALAND REGION

The Västra Götalands county in Sweden was formed in 1998 by merging Göteborg, Bohus län, Skaraborgs län and Älvsborgs län. In 1999, these counties joined and formed Västra Götaland Region. The population in the region in 2018 was 1.9 million. Seventeen hospitals with emergency and planned treatment. The regional hospital is Sahlgrenska University Hospital in Gothenburg. Primary Health Care Centre (PHCC) organization that does not require hospitals resources.

## 4.1.2 SKARABORG COUNTY

Skaraborg County has approximately 260 000 inhabitants and is a part of the larger region of Västra Götaland in the south-western part of Sweden, encompassing Skaraborg Hospital and PHCC represent all healthcare facilities in this geographical area treating patients immediately after a whiplash trauma. Skaraborg County is a rural and agricultural area with four midsized cities.



**Figure 3.** Skaraborg County is a rural and agricultural area with four midsized cities. Reproduced with kind permission from Morot, Sweden.

## 4.2 SKARABORG INJURY REGISTER

Injury registration in Skaraborg County began in 1997, covering four hospitals; Skaraborgs Sjukhus in Skövde, Lidköping, Falköping and Mariestad; four emergency primary healthcare units, and 25 standard PHCCs. Data registration to the database was as follows: after the injured patient gave consent, information given by the patient or attending medical personnel about the trauma was entered into the database. The physician in charge documented the diagnosis according to ICD-10 and recorded any treatment given, up to including hospitalization. Regardless of any delay in seeking treatment, a patient's first attendance at any healthcare facility related to the trauma was registered. All clinic visits due to any type of injury were compared with registry entries, showing that 80% of all presenting injuries were properly included into the database during the ten-year period. Of these, 15% were due to traffic collisions (43, 44, 88). Registration was carried out using computer software developed by the Swedish National Board of Health and Welfare. In 2014 all relevant data from the Skaraborg injury registry was collated in order to be used for studies II and III. The registry was discontinued in 2016.

## 4.3 PARTICIPANTS

In study I, 131 individuals with WAD were assessed at the clinic of rehabilitation medicine (Rehabiliteringsmedicinska kliniken in Skövde), of which 85 were included in the study (Table 6) (7). In study II, 3368 were registered and included if, following injury, they had sought health care in Skaraborg during the years between 1999 and 2008 and were registered in the injury registry under the diagnosis whiplash ICD 10 S13.4 (Table 6) (43). In study III, 3115 individuals were included who had sought health care in Skaraborg in the first week following injury, during the years between 1999 and 2008 and were registered in the injury registry under the diagnosis whiplash ICD 10 S13.4 (table 6) (44). In study IV, 188 doctors who answered a questionnaire during 2018 – 2019 were included (Table 5) (89).



**Table 6.** *Participants for study I-IV in this thesis.*

<b>Study Number</b>	<b>Period Year</b>	<b>Analysed Individuals</b>	<b>Gender Women (%)</b>	<b>Gender Men (%)</b>	<b>Gender Other (%)</b>
1	1998	85	50 (59)	35 (41)	
2	1999-2008	3368	1719 (51)	1649 (49)	
3	1999-2008	3115	1588 (51)	1527 (49)	
4	2018-2019	188	84 (46*)	96 (53*)	1 (1*)

\*197 were asked to complete the survey.

188 responded and, 180 of these answered the question about gender.

### 4.3.1 PARTICIPANTS STUDY I

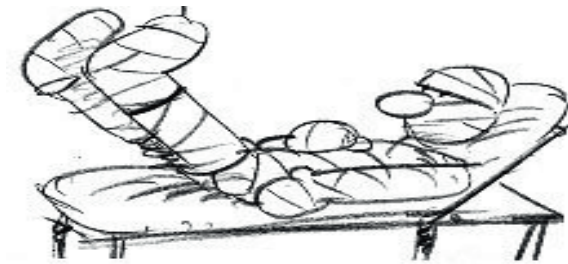
During 1998, a series of 131 consecutive patients with cervical distortion were referred to the Department of Rehabilitation Medicine, County Hospital, Skövde, Sweden, for examination and treatment. Eighty-five patients were included in this study, 35 men and 50 women. The inclusion criterion was WAD grade II whiplash injury. The interval between accident and examination varied from three to 36 months (median = 9.3 months) without a significant difference between subgroups in the study. Exclusion criteria were a history of central nervous system trauma (estimated using patient chart and computer tomography of the brain with findings of trauma) or associated psychiatric findings according to DSM IV (26).

### 4.3.2 PARTICIPANTS STUDY II AND III

These were two retrospective observational studies using an accident and injury register in Skaraborg County. In study II, 3368 patients from between 1999 and 2008 were included. The process of registering data to the Skaraborg database and study extracted the following data from the database: gender, age, type and circumstances of the collision, time elapsed before seeking care, healthcare contact, treatment, and number of days of hospitalization.

A patient's first attendance at any healthcare facility related to the trauma was registered irrespective of delay after exposure to the trauma.

In study III, 3115 patients from between 1999 and 2008 were included. The 3115 patients given a diagnosis of whiplash injury with the ICD 10 code S13.4, irrespective of injury mechanism, and who sought first healthcare contact within one week after trauma. Study III extracted nineteen variables deemed relevant from the database: hospital admission, age, gender, healthcare contact, seeking medical care day- or night time, seeking medical care weekdays or weekend, seeking medical care in summer or winter, time elapsed between trauma and seeking care, if it happened during leisure time or while at work, trauma in the same direction of travel or not, car accident or another type of trauma, if the patient was the driver or front seat passenger, use of a seat belt. Some of these patients also had other diagnoses (Figure 4).



*Figure 4. Some patients in study III had whiplash and other diagnoses such as contusion, commotio cerebri, wounds, fracture or luxation and other serious injury. Reproduced with kind permission from Morot, Sweden.*

### 4.3.3 PARTICIPANTS STUDY IV

Study IV is a prospective cross-sectional study where data was collected by distributing a survey to 197 medical practitioners in both PHCC and hospitals. They were informed about the study and asked questions about their age, gender, education, speciality and work place. They were also provided with nine questions regarding three different injury scenarios. The time period for data collection from 1<sup>st</sup> of December 2018 to 28<sup>th</sup> of February 2019. The questionnaire was responded to by 188 medical practitioners. Data collection took place at 16 PHCC in the Västra Götaland Region, Sweden and at two publicly run hospitals.

## 5 ETHICAL CONSIDERATIONS

Study I was a clinical quality-control follow-up within the rehabilitation clinic in Skövde, Sweden performed before the Swedish law about mandatory ethics review was introduced in 2004. Hence study I was not reviewed by The Regional Ethical Review Board of Gothenburg, Sweden. However, study I was performed in accordance with the Helsinki Declaration. It is included in this thesis after consultation and decision from Director of Studies at Gothenburg University Lennart Bergfeldt 22<sup>nd</sup> of February 2016.

The Regional Ethical Review Board of Gothenburg, Sweden approved Studies II and III (Registration number: 138-08, decision date 28<sup>th</sup> of April 2008) and study IV (Registration number: 850-18, decision date 19<sup>th</sup> of October 2018).

## 6 STUDY LOGISTICS

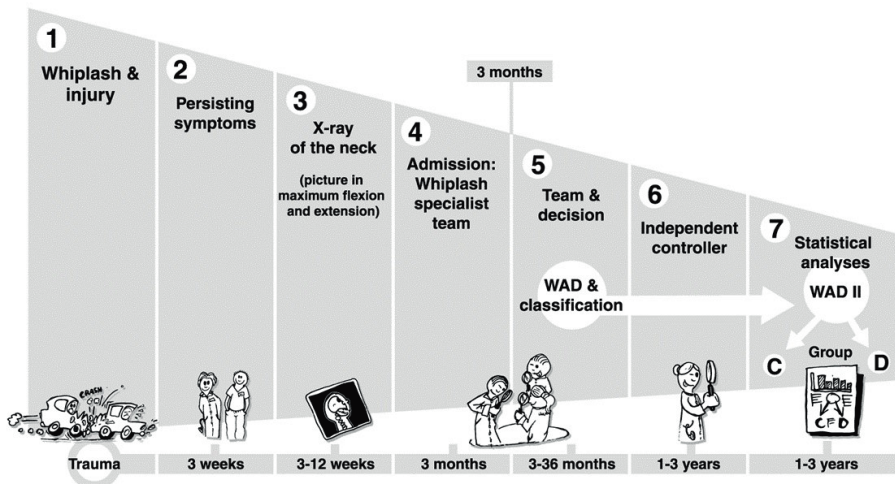
Study I- IV as follow.

### 6.1 STUDY LOGISTICS STUDY I

Injuries were registered according to a structured form adapted from a local guideline (1).

When symptoms persisted longer than 3 months, the patient was referred to Hospital for assessment by a team (Figure 5).

### Study Design



**Figure 5.** Study I design. When symptoms persisted longer than 3 months, the patient was referred to Hospital for assessment by a team. The team consisted of a physician specialized in rehabilitation and orthopedics surgery, a nurse, a social worker, an occupational therapist, a physiotherapist and a neuropsychologist. Reproduced with kind permission from Morot, Sweden.

#### Structured management organizational procedure.

On the day of assessment, the patient met with all the team members to objectively verify the patient's subjective complaints. The combined findings of the physiotherapist, the occupational therapist and the physician formed the basis for the classification.

### *Classification*

The three step classification system for WAD (45) involves using codes for the area(s) of impairment, categorization of the condition of the patient, and grouping patients according to time since trauma, >12 weeks is considered chronic (Table 7).

**Table 7.** Steps of a Swedish classification after whiplash trauma by Gerdle et al in 1998 (45). The table is structured with three steps.

<b>Step 1. Determination of impairment</b>	
<b>Area</b>	<b>Code</b>
Head / neck / shoulder	a
Arm	b
Neuropsychological	c
<b>Step 2. Categorization of condition on area of impairment</b>	
<b>Code</b>	<b>Category</b>
a	A
a+b	B
a+c	C
a+b+c	D
<b>Step 3. Time after trauma</b>	
Acute	≤ 12 weeks
Chronic	>12 weeks

The team nurse administered the life satisfaction questionnaire. Patients were instructed to answer one questionnaire about their quality of life before the accident and one about their current situation.

# LIFE SATISFACTION CHECK LIST

① =Very dissatisfactory      ④ =Fairly satisfactory  
 ② =Unsatisfactory            ⑤ =Satisfactory  
 ③ =Rather unsatisfactory    ⑥ =Very satisfactory

- 1 My life as a whole is
- 2 My vocational situation is
- 3 My financial situation is
- 4 My leisure situation is
- 5 My contacts with friends and acquaintances are
- 6 My sexual life is
- 7 My ability to manage my own self-care is
- 8 My family life is
- 9 My partner relationship is
- 10 My physical health is
- 11 My mental health is

**Figure 6.** Life satisfaction check list (90). Reproduced with kind permission from Morot, Sweden.

All the 11 dimensions for life satisfaction (Figure 6), were asked for in all patients before (retrospective) and after trauma.

## 6.2 STUDY LOGISTICS STUDY II

Data was registered to the database as follows: after informed consent was given, information provided by the patient or attending person about the trauma was entered into the database. The diagnosis according to ICD-10 and any treatment, including hospitalization was recorded. Study II extracted data from 3368 patients between 1999-2008 after whiplash trauma: gender, age, type and circumstances of the collision, time elapsed before seeking care,

healthcare contact, treatment, and days of hospitalization from the database for the period using the statistical software for statistical analyses.

### 6.3 STUDY LOGISTICS STUDY III

Study III extracted data from 3115 patients given a diagnosis of whiplash injury with the ICD 10 code S13.4, who sought first healthcare contact within a week of trauma, irrespective of injury mechanism.

### 6.4 STUDY LOGISTICS STUDY IV

Medical practitioners in both PHCC and hospitals were informed about the study and asked questions about their age, gender, education, speciality and work place (Appendix/Supplemental material 1).

They were provided with nine questions regarding three different scenarios (Appendix/Supplemental material 2). These scenarios, taken from study III establishing risk factors for having a sinister injury (44), represented cases with low, moderate or high risk for sinister injury. Questionnaires were distributed at various meetings and returned anonymously. The time period for data collection was 3 months and data collection took place at 16 PHCC in the Västra Götaland Region, Sweden. Data collection also took place at two publicly run hospitals.

## 7 STATISTICAL ANALYSIS

The statistical analyses from studies I-IV are summarized in Table 8.

**Table 8.** Overview of statistical test in studies I-IV.

Statistical test	Study 1	Study 2	Study 3	Study 4
Descriptive statistics	X	X	X	X
Chi square		X		
Student's T-test		X		
Mann-Whitney's U-test		X		
Spearman Rank Correlation		X		
Binary multivariable logistic mixed model				X
Multiple linear regression		X		
Logistic regression	X	X	X	X

### 7.1 STATISTICAL ANALYSIS – STUDY I

Logistic regression, using a proportional odds model for life satisfaction (ordinal scales), was used to ascertain differences in self-reported life satisfaction, when classified using a new Swedish classification system. Being in group C or D was the main explanatory (independent) variable. A similar analysis, using gender, age and baseline score (i.e. the difference between pre- and post-traumatic grading on the life satisfaction scale), was also made to establish the possible influence of these factors on life satisfaction.

### 7.2 STATISTICAL ANALYSIS – STUDY II

The following descriptive statistics were used for this study, a chi-square test to analyze differences between men and women in care-seeking behavior and the type of care received; Mann Whitney's U-test was used to analyze differences between genders concerning the time elapsed between trauma and seeking care; Student's t-test was used to compare the length of hospital stay between men and women; Multivariate linear regression was used to analyze the relation between the dependent variable patient delay between trauma and



seeking care (days) and gender while adjusting for confounding variables such as age, work related accident and car traffic accident. Prior to the multivariate linear regression, the variables were evaluated for the assumptions of linear regression. Blom's formula was used to transform the dependent variable to a ranked normal score as it was not normally distributed. Spearman Rank Correlation was used to decide which variables to put into the multivariate regression. All variables with significant correlation  $p < 0.05$  with the dependent variable in Spearman's rank correlation were put forward into the final multivariate linear regression. The direction of the correlation is presented as either above (positive) or below (negative) zero. Statistical significance was set at  $p < 0.05$ . The statistical software IBM SPSS version 22 was used.

### 7.3 STATISTICAL ANALYSIS – STUDY III

Multivariable logistic regression was used to analyse the relationship between the dependent variable (hospital admission), and the other 17 independent variables. A sensitivity analysis was done on the multivariable regression and based on this analysis a decision was made on which multivariable model should be used going forward. Independent variables with significance of  $p < 0.05$  in the chosen multivariable model were put into a new similar multivariable logistic regression to obtain a final model with adjusted odds ratios. Internal validation of the final multivariable regression model was done using the Area Under curve (AUC), with 95% confidence interval. A lookup table for hospital admission after whiplash trauma was created by ranking the predicted probabilities of all possible permutations of the final predictors. The level of statistical significance was set to 0.05. The statistical software used was IBM SPSS windows version 25.

### 7.4 STATISTICAL ANALYSIS – STUDY IV

#### *Sample size estimation*

A sample size calculation was made using simple logistic regression as a surrogate technique. The estimation assumed a level of significance at 0.05 and a power of 0.95 and this estimated at least 143 responses were required. We intended to continue data collection until at least 150 surveys were

returned. The software G \* Power version 3.1.9.2 (University of Kiel) was used for estimating the sample size.

### *Statistical analysis*

A two-step procedure was used to estimate the odds ratio for factors associated with suggesting an inappropriate care level (44). Firstly, a new data set was created with one row for each question, giving nine times more rows than the initial dataset. The second step used the new dataset in a binary multivariable logistic mixed model to estimate the odds ratio for factors associated with suggesting an inappropriate level of care. IBM SPSS statistics version 25 was used.

## 8 RESULTS

In study I we saw advantages of an additional Swedish classification from 1988, presented in the Linköping guidelines, to complement the WAD classification according to QTF in rehabilitation planning (7). In study II we saw differences between when and where men and women sought care following whiplash trauma between the years 1999 and 2008, noticeably that men more often sought care at hospital (43). In study III, we found that PHCC can be used in a larger extent as a first level of care following whiplash injury than is currently the case. We have developed an algorithm to be used by medical personnel (44). In study IV, we examined how doctors chose which initial level of care to recommend following different trauma scenarios, and found that it corresponded well with the algorithm that was developed in study III (44, 89). The present thesis will be available electronically. Therefore, the results for study IV are presented briefly so as not to hinder later publication. The result tables are presented in detail in the attached manuscript for study IV.

### 8.1 RESULTS STUDY I

The 85 patients fulfilled the inclusion criterion and their vocational situation before and at the time of assessment are described in Tenenbaum *et al* (7). Patients were classified according to the new Swedish classification as follows: 3 patients in category A, 2 patients in category B, 39 in category C and 41 in category D.

Life satisfaction scores before and after whiplash trauma in categories C and D are shown in Tenenbaum *et al* (7). The 11 dimensions tested for life satisfaction were worse after the trauma in category C and more so in category D.

The influence of symptoms in the arms is evidenced in the differences in test scores between categories C and D as shown in Tenenbaum *et al* (7).

Results in study I indicate that the life satisfaction of the patients in category D was worse than that in category C (Table 9) (7).

**Table 9.** Odds ratio for an increase in life satisfaction in patients with symptoms in the head/neck/shoulder and neuropsychological symptoms compared to those also having arm symptoms (7).

<b>Dimension (dependent variable)</b>	<b>Unadjusted odds ratio (95% confidence interval)</b>	<b>p-value</b>
Life as a whole	2.1 (0.95-4.7)	0.068
Vocational situation	2.5 (1.1-5.5)	0.028*
Financial situation	1.0 (0.47-2.2)	0.97
Leisure time	3.1 (1.4-7.0)	0.0056*
Contact friends/acquaintances	2.8 (1.3-6.3)	0.012*
Sexual life	1.3 (0.61-2.9)	0.48
Ability to manage own self-care	4.2 (1.8-9.8)	<0.001*
Family life	1.6 (0.73-3.6)	0.24
Partner relationship	0.7 (0.34-1.7)	0.49
Physical health	2.3 (1.0-5.0)	0.045*
Mental health	2.4 (1.1-5.3)	0.036*

*\*Significant at the  $p < 0.05$  level*

## 8.2 RESULTS STUDY II

Between 1999 and 2008 3 368 persons were diagnosed with whiplash ICD 10 code S 13.4. The average age for participating women was 34.0 and for men 33.0 years (43). Women with whiplash trauma sought care later than men ( $p = 0.00074$ , Table 10) and there was a statistically significant difference in care-seeking behavior between women and men (43). 51% persons first sought care at a hospital.

**Table 10.** Care-seeking behavior after whiplash trauma (n = 3,368) (43).

	<b>Women (n=1,719)</b>	<b>Men (n=1,649)</b>	<b>P-value</b>
Sought care at PHCC	884 (51%)	769 (47%)	0.0060*
Patient delay (days) between trauma and seeking care	3.2	2.6	0.00074*

*\*Significant at the  $p < 0.05$  level.*

There was no difference between women and men in the type of treatment after trauma (Table 11) (43). 6.4% were admitted to a hospital and women were hospitalized for longer than men ( $p = 0.022$ , Table 10) (43).

**Table 11.** Care-treatment given, and hospital stay after whiplash trauma (n = 3,368) (43).

	<b>Women (n=1,719)</b>	<b>Men (n= 1,649)</b>	<b>P-value</b>
Sought care at hospital	835 (49%)	880 (53%)	<0.05*
Discharged without treatment	107 (6.2%)	111 (6.4%)	>0.5
Discharged after treatment	1.506 (88%)	1.423 (86%)	>0.5
Admitted to hospital	106 (6.2%)	109 (6.4%)	>0.5
Days admitted to hospital	2.70	2.10	0.022*

*\*Significant at the  $p < 0.05$  level.*

### 8.3 RESULTS STUDY III

Between 1999 and 2008, 3 115 patients sought first healthcare contact within one week after injury. The average age for these 3 115 patients was 33 years (Table 12) (44).

**Table 12.** Description of included patients (N = 3115) (44).

	<b>Analysed</b>	<b>Distribution</b>	<b>(%)</b>
<b>Demographic factors</b>			
Age (years)	3,115	Mean 33 (SD 16) Median 30(20–44)	—
Gender: Female / Male	3,115	1,588 / 1,527	51 / 49
<b>Circumstances of first contact</b>			
Primary health care / Hospital	3,115	1,440 / 1,675	46 / 54
Attending Daytime / Night	1,924	1,303 / 621	68 / 32
Attending weekdays / Weekend	3,115	2,328 / 787	75 / 25
Attending Summer / Winter	3,115	1,529 / 1,586	49 / 51
Days from trauma to attending health care	3,115	Mean 0.89 (SD 1.4) Median 0.0 (0.0–1.0)	—
Attending Same day as trauma / day 2–7	3,115	1,843 / 1,272	59 / 41
<b>Circumstances</b>			
Leisure time / Work related	3,079	2,123 / 956	69 / 31
Collision in the same direction of travel / Another direction of trauma	3,115	1,184 / 1931	38 / 62
Car accident / Another type of trauma	3,115	2,240 / 875	72 / 28
Driver/ Passenger front seat	2,250	1,799 / 451	80 / 20
Seat belt on / Seat belt not on	1,967	1,628 / 339	83 / 17
<b>Diagnosis</b>			
Only whiplash injury (WAD)	3,115	2,620	84
WAD + Contusion	3,115	374	12
WAD + Commotio cerebri	3,115	89	2.9
WAD + Wound	3,115	123	3.9
WAD + Fracture or luxation	3,115	41	1.3
WAD + Other serious injury	3,115	9	0.29

Mean values (standard deviation) and median. (25<sup>th</sup> - 75<sup>th</sup> percentile).

Two hundred and fifteen patients (6.9%) were admitted to hospital (Table 13) (44).

**Table 13.** Description of included patients admitted to hospital ( $N = 215$ ) (44).

	<b>Distribution</b>	<b>(%)</b>
<b>Demographic factors</b>		
Age (years)	Mean 36 (SD 19) Median 31 (20–48)	—
Gender: Female / Male	105 / 110	49 / 51
<b>Circumstances of first contact</b>		
Primary health care / Hospital	1 / 214	0.46 / 100
Attending Daytime / Night	87 / 81	52 / 48
Attending weekdays / Weekend	146 / 69	68 / 32
Attending Summer / Winter	114 / 101	47 / 53
Days from trauma to attending health care	Mean 0.19 (SD 0.69) Median 0.0 (0.0–0.0)	—
Attending Same day as trauma / day 2–7	192 / 23	89 / 11
<b>Circumstances</b>		
Leisure time / Work related	153 / 53	74 / 26
Collision same direction of travel / Another direction of trauma	24 / 191	11 / 89
Car accident / not car accident	108 / 107	50 / 50
Driver / Passenger front seat	107 / 25	81 / 19
Seat belt on / Seat belt not on	58 / 44	57 / 43
<b>Diagnosis</b>		
Only whiplash injury (WAD)	92	43
WAD + Contusion	60	28
WAD + Commotio cerebri	58	27
WAD + Wound	18	8.4
WAD + Fracture or luxation	21	9.8
WAD + Other serious injury	6	2.8

Mean values (standard deviation) and median. (25<sup>th</sup> - 75<sup>th</sup> percentile).

Four independent variables were statically significant predictors of hospital admission (Table 14). These four variables were found to be associated with hospital admission: commotio cerebri (OR 31, 19–51), fracture / luxation (OR 11, 5.1–22), serious injury (OR 41, 8.0–210), and the patient sought care during the same day as the trauma (OR 5.9, 3.7–9.5) (Table 14) (44). These four risk factors explained 27% of the variation for hospital admission and the area under curve (AUC) was 0.77 (44).

**Table 14.** Potential risk factors for hospital admission.

	<i>Multivariable logistic regression</i>			
	<i>First regression (n = 1,033)</i>		<i>Second regression (n = 3,115)</i>	
	<b>P</b>	<b>Odds ratio</b>	<b>P</b>	<b>Odds ratio</b>
<b><i>Demographic factors</i></b>				
Increased age (one decade)	0.11	1.2(0.96–1.5)		
Female gender	0.35	1.4 (0.70–2.7)		
<b><i>Circumstances of first contact</i></b>				
Attending at Night	0.095	1.8 (0.90–3.5)		
Attending at Weekend	0.12	1.8 (0.84–4.0)		
Attending in Summer	0.17	1.6 (0.80–3.3)		
Attending same day as trauma	0.0012	23 (3.5–150)	<0.001	5.9 (3.7–9.5)
<b><i>Circumstances</i></b>				
Work related	0.11	1.9 (0.87–4.4)		
Trauma not in the same direction of travel	0.22	1.7 (0.74–3.7)		
Car accident	0.88	0.92 (0.31–2.7)		
Being passenger in front seat	0.88	1.1 (0.42–2.7)		
Not using seat belt	0.19	1.9 (0.72–5.2)		
<b><i>Clinical diagnosis</i></b>				
Only whiplash injury (WAD)	0.95	1.1 (0.15–7.4)		
WAD + Contusion	0.11	4.5 (0.71–29)		
WAD + Commotio cerebri	<0.001	73 (9.3–570)	<0.001	31 (19–51)
WAD + Wound	0.14	2.5 (0.75–8.0)		
WAD + Fracture or luxation	0.010	7.4 (1.6–33)	<0.001	11 (5.1–22)
WAD + Other serious injury	0.012	30 (2.1–420)	<0.001	41 (8.0–210)



2 985 (96%) patients turned out to have a low risk for hospital admission (Table 15). 1 737 (56%) patients attending health care the same day as the trauma with a 7.1% risk for hospital admission, and those attending health care later, 1 248 (40%) with a 1.3% risk for hospital admission (Table 15) (44). Lookup table predicting the probability for hospital admission after whiplash trauma was made for pre-hospital triage (Table 15) (44). Patients, who contacted the health care the same day as the trauma, should be referred to a hospital emergency department for evaluation if they can't get an appointment in PHCC the same day (44).

**Table 15.** Abbreviated lookup table predicting the probability for hospital admission after whiplash trauma (N=3,115).

Probability of hospital admission %	Attending same day as trauma	Serious injury	Fracture luxation	Commotio cerebri	Prevalence (n) % (95% CI)
100	yes	yes	yes	yes	0 0 (0-100) %
99	no	yes	yes	yes	0 0 (0-100) %
99	yes	yes	no	yes	0 0 (0-100) %
97	yes	yes	yes	no	2 0.064 (0.018-0.23) %
96	yes	no	yes	yes	5 0.16 (0.069-0.38) %
94	no	yes	no	yes	0 0 (0-100) %
84	no	yes	yes	no	0 0 (0-100) %
80	no	no	yes	yes	2 0.064 (0.018-0.23) %
75	yes	yes	no	no	4 0.13 (0.050-0.33) %
70	yes	no	no	yes	68 2.2 (1.7-2.8) %
45	yes	no	yes	no	27 0.87 (0.60-1.3) %
34	no	yes	no	no	3 0.096 (0.033-0.28) %
28	no	no	no	yes	14 0.45 (0.27-0.75) %
12	no	no	yes	no	5 0.16 (0.069-0.38) %
7.1	yes	no	no	no	1,737 56 (54-58) %
1.3	no	no	no	no	1,248 40 (38-42) %

## 8.4 RESULTS STUDY IV

Evidence from study III recommends >90% of patients exposed to a whiplash trauma to contact PHCC for the first assessment. Study IV adds that this new recommendation is in agreement with most medical practitioners' opinion. The questionnaire was responded to by 188 medical practitioners. They were working in public hospitals and PHCC. Medical practitioners agreed with the recommended algorithm if the risk for hospitalisation was very low (scenario 1) or very high (scenario 3). The overall agreement with scenario 1 and 3 was > 89%. The practitioners' gender and age, medical experience, and current workplace was not associated with their ability to agree with the recommended algorithm.

## 9 DISCUSSION

### *Classification and prognosis*

There are several classification systems that attempt to improve the quality and optimize the allocation of resources for the treatment of neck injuries (24, 45-47, 49, 65). These systems focus on the localization and type of injury, loss of function and survival probability. The cervical distortions occurring most frequently in traffic accidents are the AIS 1 and AIS 2 (49). The QTF was created with the intention of better describing these types of injuries, focusing primarily on WAD.

The QTF WAD classification has been discussed in terms of its predictive role and its adequacy as a classification system (24). The analyses of Hartling *et al* 2001 studied 380 patients 12, 18, and 24 months post whiplashtrauma support the use of the QTF WAD Classification as a prognostic tool for emergency department settings, and the authors propose a modification of the WAD 2 Classification using a subdivision (47). When first presented, the QTF was a significant breakthrough by structuring the gradually increasing problems with WAD.

The new Swedish classification presented by Gerdle *et al* in 1998 for whiplash-associated disorders (45) involves determination of the area(s) of impairment and disability, using code for symptoms: from head/neck/shoulder, arm and neuropsychological symptoms. This classification system seems to be a complement to the Quebec classification concerning functional impairment and disability on quality of life outcomes.

The Swedish whiplash commission and a Swedish consensus group by The Swedish Society of Medicine have proposed in 2005 that: WADs be divided into grades 1–3 (exclude WAD 0 and 4), quite logical, WAD 0 has no symptoms or pain and WAD 4 have another ICD 10 diagnosis such as fracture (46).

Borenstein *et al* evaluate pain, cervical range of motion and cognitive symptoms of 97 WAD patients in a study published in 2010 (70). The aim was to determine prognosis and sick leave 3 years after trauma. Pain intensity and reduced cervical range of motion were not clinically useful as predictors of later sick leave (70). The best predictors were presence within 4 days after injury of two cognitive symptoms, being easily distracted and easily irritated

(70). A positive answer to either of the two questions; “Are you currently easily irritated?” and “Are you currently easily distracted?” indicates an increased risk for poor prognosis, which was defined as sick leave 3 years after trauma (70). This knowledge should be taken into account in future clinical classification models so that even cognitive symptoms are included.

### *Quality of life and rehabilitation outcome*

Quality of life is unavoidably a subjective measure both individual experiences and sociocultural values of the time. Life satisfaction can be considered a measure of how successfully people cope with their life situation. Life satisfaction measurement is included in the SQPR today (2019) when evaluating pain rehabilitation program in Sweden (90, 91).

The relationship between trauma and life satisfaction was considered in study I by focusing on the various dimensions of a Life Satisfaction validated scale (90). Rehabilitation can be viewed as the learning of coping processes to achieve of meaning in life. Rehabilitation is therefore intended to improve quality of life. The presence of arm symptoms affects life satisfaction. An arm that functions without pain makes it easier for the individual to carry out ADL functions, both at work and in leisure activities. This may be one of the reasons why arm symptoms particularly affect life satisfaction.

### *Gender*

In study II we found that women sought healthcare later than men, women sought care at primary care facilities slightly more often than men who more often went directly to a hospital. Nothing indicated that women had a milder injury than men. This may also potentially affect insurance outcomes, based on the theoretical link between care sought later and the willingness of insurance companies to award compensation.

One possible explanation for the difference in seeking level of care could be that in Sweden women visit a PHCC facility during pregnancy for antenatal care and postnatal care after childbirth, making it more likely that they would utilize a PHCC facility with other healthcare needs, like a whiplash injury (92). Another explanation could be women’s responsibility for the home and family means that women do not prioritize their own health, even in the presence of symptoms (93). Finally, gender differences in health care seeking behavior may also be explained by that women and men are raised with

different gender-based expectations and structures within the family and labor market (94, 95). The cultural gender norms mean men seek healthcare at hospitals (96). The male gender role also means that men are not ashamed of having been involved in a car accident (97). According to Conell's economical gender dimension, another alternative explanation for men attending healthcare early after trauma might be that men have the responsibility for insurance documents at home more often than women (97). This might result in a greater understanding of the importance of early medical contact to gain adequate documentation and subsequent correct insurance compensation. Information from our study opens the way for future economic studies investigating the gender implications of late care seeking and its influence on possible compensation in case of chronic WAD. Study II showed gender differences with a clear disadvantage for women. Westergren *et al* studied 745 patients in 2018 and showed that a longer time between trauma and assessment tendency towards more widespread pain was observed among the women but did not affect pain distribution among the men (98). The importance of "female sex" as a risk factor for the development of persistent pain after neck trauma needs to be discussed in future guidelines addressing WAD, and these guidelines need to consider using information channels suitable to both women and men.

### *Level of care*

In study III we found that most patients, (96%) turned out to have a low risk for hospital admission. These patients were characterized by having no signs of commotio cerebri, fracture/luxation or serious injury. These patients should be referred to PHCC for the initial management. There is the potential to increase the proportion of patients directed to primary health care from 46% to 96%. Having the first assessment at the right level of care is important for optimal utilization of healthcare resources. The predictors identified in study IV are perhaps not surprising. However, to our knowledge this is the first time these variables have been weighted together to create a simple and clinically useful lookup table

### *Implementing a guideline for pre-hospital triage*

Study IV shows a consensus around scenario 1 with a mild injury contacting a health care provider later than the same day as the trauma. There is a consensus in scenario 3 with a potentially severe injury. The challenge is to implement an evidence-based pre-hospital triage for patients similar to

scenario 2 (44). The implementation of this algorithm for pre-hospital triage should have two phases. Firstly, gaining acceptance from various organizations where this algorithm for pre-hospital triage should be implemented, and medical practitioners, specifically medical doctors, will most likely be involved in this process. Secondly, implementing the algorithm as a guideline “on the floor”. Most pre-hospital triage is likely to be done by paramedic staff at the crash site or nurses taking a phone call from a worried person. Hence, the second phase is less likely to engage the same medical doctors as above. The next logical step is to identify key organizations, collaborative networks and key persons willing to rework this evidence-based algorithm into a guideline (99, 100). The algorithm is quite simple so it may be possible to do this as a national guideline with a minimal need for local adaptations. It may also be relevant to incorporate this algorithm in existing guidelines describing recommended management of patients exposed to a whiplash trauma, rather than creating a new guideline solely for pre-hospital triage. However, an external validation of the prediction model should take place before attempting a large scale implementation.

## 9.1 VISION ZERO ACADEMY (NOLLVISION)

Vision Zero has introduced a new approach to road safety. It started in Sweden, but its working methods have spread internationally. The virtual Vision Zero Academy contains a collection of the knowledge available on Vision Zero (101). The road transport system is the most extensive man-machine system in daily use in Sweden. It is based on people complying with current standards, laws, regulations and guidelines; having a degree of common sense, being cautious and always making the correct decisions when they are driving, making choices and generally being in traffic situations. These decisions are made on the assumption that all the information in the road transport system is clear and easy to understand, and that the correct decisions will inevitably be made. It is not entirely surprising that this kind of system does not always work. The most serious problem relating to the road transport system is that a single wrong decision or mistake may have life-or-death effects on a number of people (102). Vision Zero Academy contains articles and different types of information that illustrate Vision Zero. The Swedish Vision Zero is changing the approach to road safety work around the world. An example is New York, where Vision Zero was introduced in 2014, and where road safety has been improved and the effects of increased road safety have been achieved (fewer deaths) (101).

## 9.2 STRENGTHS

In Study I we followed up treatment of WAD patients using a Swedish classification to complement WAD QTF. The main strength in study II and III is that the data comes from clinical encounters in the healthcare system and is not limited to data from an insurance company. High data quality where all patients included were examined by the physician in charge and diagnosis according to ICD-10 after taking a history and doing a clinical examination. The quality of this database was closely monitored with regular checks. Being based on clinical encounters in the healthcare system with an inclusion rate of 80% it can be considered that the database reflects real life activities of managing acute trauma. The results in this study are perhaps not surprising. However, to our knowledge this is the first time these variables have been weighted together to create a simple and clinically useful look-up table. In study III the multivariable logistic regression was done robustly where independent variables were checked for multicollinearity. There were no missing cases in the final regression analysis. Four variables remained strongly statistically associated with the dependent variable hospital admission irrespective of keeping or removing outliers.

## 9.3 WEAKNESSES

One of the main weakness in study I is that the study is done retrospectively for example, when looking at the use of the questionnaire regarding life satisfaction. The patients were instructed to answer one questionnaire about their quality of life before the accident and one regarding their present situation. The vocational situation before and at the time of assessment refers to answers provided by the patient without data from the Swedish Social Insurance Office.

In study II and III data was from between 1998 and 2008 and no data regarding insurance claims or compensations were used in these studies. The level of WAD injury was not classified in the medical documentation, and it is not possible to do so retrospectively. Another limitation is that no follow-up was possible for individuals involved in a whiplash trauma. We can therefore not report the long-term fate or care of these patients.



One weakness in study III is that the study base, Skaraborg County, is not necessarily comparable with studies in cities with a population larger than 100,000 where traffic may be more intense.

The strong association between concomitant presence of commotio cerebri, fracture / luxation or other serious injuries and hospital admission is likely to eclipse any relationship that might exist between other independent variables and hospital admission, for example age. However, it makes sense to use the strongest predictors to build a prediction model.

In study IV medical practitioners were not randomly chosen. They were a convenience sample as they participated in a continuous professional education or other meeting in Västra Götaland Region, Sweden. Another potential weakness is that all three scenarios used female patients as examples. The algorithm in focus has not yet been externally validated.

## 10 FUTURE PERSPECTIVES

The incidence of WAD will likely change drastically within the course of a generation, or about 25 to 30 years. The most likely development is a decreased incidence due to the effects of self-driving and -braking vehicles (103), artificial intelligence (104), and national allocation of health care resources with the interaction of national guidelines (71).

### 10.1 HUMAN, TECHNOLOGY AND ORGANISATION

Knowledge is increasing in the field of Human, Technology and Organisation (Människa, Teknik och Organisation, MTO), for example on the increased interaction between human and technology like cars. *Internet of things* can contribute in reducing traffic casualties (105). Analysis and management of risk and safety in the work environment is being discussed (104). A car using modern technology, *internet of things* can be equipped with sensors registering for example needs for repairs, and what needs to be serviced or has broken. A vehicle that is hooked up to the system can have automatic contact with workshop and factory, where service can be scheduled, and spare parts ordered.

It is possible that vehicles in the future be equipped with sensors in the passenger seats and in the head restraints that can indicate the impact of the collision on the seat and the driver, which, using an adequate algorithm can give advice on where to seek medical care, and in the case of more severe injuries can be put in contact directly with the hospital emergency rooms. The combined knowledge on injuries is collected to enable preventive measures.

### 10.2 FUTURE CHALLENGES – NATIONAL GUIDELINES

In Sweden there are efforts made toward creating national guidelines for medical care in cases of whiplash / WAD. In introducing guidelines, it is important to involve both those who help (medical health professionals) as well as those being helped (through patient organisations). Education and adequate implementation of medical care programs to achieve the sought after effects are also very important (99, 100, 106). Through international cooperation, pre-hospital triage and system of diagnostics are created, and an

updated uniform classification regarding WAD, we should be able to create the conditions and understanding of what constitutes an appropriate level of care after a whiplash injury (71). Implementation of existing research results on triage and rehabilitation to promote the quality optimal outcomes of rehabilitation (71). Active cooperation between PHCC and hospitals is important for the WAD patient group and through extended multi-professional teamwork and specialized WAD / pain rehabilitation we can strive for an even better experience.

Increased emphasis on quality of care with the individual in focus in rehabilitation, aiming toward increased CARF accreditation of rehabilitation programs in Sweden creates the conditions for high quality, well thought out rehabilitation for the individual. Multidisciplinary research based on the Swedish Quality Registry for Pain rehabilitation (SQPR) where methods can be compared between different clinics and improved according to best practice (91).

# 11 CONCLUSION

- The results of the work presented in this thesis support the hypothesis that for allocation of rehabilitation resources after a whiplash trauma the Swedish classification model from 1998 could be used as a complement to the Quebec Classification.
- Gender differences in care-seeking behavior immediately after whiplash trauma existed in Skaraborg between 1999-2008.
- A practical tool for medical personnel in prehospital triage, after a neck trauma that results in neck pain, was a risk stratification model for individuals exposed to a whiplash trauma.
- Patients with no signs of commotio cerebri, no fracture/luxation injury, no serious injury, comprise >90% of all patients exposed to a whiplash trauma and can initially be referred to PHCC for initial assessment. (However, those contacting health care the same day as the trauma should be referred to a hospital for evaluation if they can't get an appointment with a PHCC the same day).
- On the basis of the exciting literature which has been published between 2007 and 2019, the Swedish National Board of Health and Welfare guidelines (2007) about sick leave length and information about disability, activity limitation and rehabilitation after distortion in the cervical spine including specifically ICD10 diagnosis S.13.4, Whiplash injury (62) are in need of updating.

# ACKNOWLEDGEMENT

I would like to thank the Department of Public Health and Community Medicine Institute of Medicine, The Sahlgrenska Academy, University of Gothenburg, Sweden and Hälsan och Stressmedicin / Hälsan & Arbetslivet, Occupational Health Care Unit, Region Västra Götaland, Alingsås and Skövde, Sweden, where the work presented in this thesis was carried out.

Thank you to Professor Ronny Gunnarsson, my principal supervisor and mentor who believed in me, helped me and encouraged me to fulfil my research studies and this thesis. An outstanding scientist with a brilliant intellect, and a wise and humble person whose values I deeply respect.

To my associate supervisors Lena Nordeman PhD, and Professor Katharina Stibrandt Sunnerhage, thank you. Lena is a skilled and tenacious researcher who introduced me to the world of SPSS. She is a wise and considerate leader at the research and development unit for primary health care in Borås, Sweden. Katharina is one of the most knowledgeable persons, both nationally and internationally, in the field of rehabilitation medicine, and for more than 20 years she has skillfully encouraged me through our common quests.

Thank you to my former counsellors Annika Billhult, and Professor Åke Nygren a senior expert in the field of whiplash, and Professor Eva Vingård with her huge knowledge in the field of occupational medicine.

To Professor John-Gunnar Forsberg, who introduced me to the field of research when I was a young student of medicine, thank you. You gave me the opportunity to work as an assistant at the Institution of Anatomy in Lund where I got to try and learn about the difficult arts of pedagogy, teaching and research. You taught me and all other students to be on time! And you were right, I should have written my thesis 30 years ago.

Thank you to my mother, Helena (Florczyk) Tenenbaum, and Stefan Tenenbaum, who survived the horrors of the Second World War and who took part in courageously changing our country in 1969, from a communist dictatorship to Sweden and democracy. This opened up educational opportunities and gave me the opportunity to become a medical doctor and develop within the field of research.

Thank you to my wife, Rose-Marie Tenenbaum, who patiently and wisely has encouraged me through good, and, above all, through bad times and for all your love.

To my children Jon, Jerker, David, Julia, Rebecka and Sebastian with their loved ones, Pernilla, Hanna, Cecilia, Henrik, Carl Johan, and Anna, thank you. You are a new generation of wise, well educated, independent people who are skilled in crafts and music. From each of your individual areas of expertise, you have aided and encouraged me. Thank you for your time, patience and wisdom, and last but not least, for all your love.

Thank you to Magda Florczyk, artist and my niece who has created the cover of this book.

To Benny Wärnehall and Lars Arvidsson who created the opportunity for research resources in cooperation with my friend Dr. Sven Olof Krafft, thank you.

Thank you to associate professors Malin Lind and Olle Bunketorp for educational work with care programs in Västra Götaland. Thank you to researcher Mark Rosenfeldt PhD and Aris Seferiadis PhD, who through the years have widened my knowledge in the field.

To my current heads at work, Mirko Ivanovic and Ewa Book, and earlier bosses who have believed in me and made it possible for me to finish this work; Marie Louise Fasth, Tore Gustafsson, Karl-Georg Winberg, Bengt Pettersson, David Roos, Lars Johansson, Gunnel Lorentzon Karlsson and Stefan Håkansson, thank you.

Thank you to Professors Jerzy and Stefan Einhorn, who throughout the years always encouraged me to complete my research education.

Thank you to co-authors Dr. Carsten Tjell, PhD, associate professor Marcelo Rivano Fischer and Dr. Micael Edblom.

Thank you to Dr. Andrzej Matynów, Dr. Lars-Olof Svensson PhD and associate professor Kai Österberg from each of your individual areas of expertise, you have encouraged me.

Thank you for assistance in statistics in article I to statistician Göran Långström. Thank you for assistance in End-Note in article II to associate professor Agneta Lindegård Andersson.

To secretaries Anna-Karin Hållander and Anette Svensson for their patient work with studies I and IV

Thank you for patience and linguistic assistance to Dr. Kate Bramley-Moore and my coworkers Lennart Larsson, Dr. Karin Wilde and Dr. Stefan Magnusson PhD.

Thank you to Maj Ader, Dr. Jan Ejdebäck PhD, Stig Svensson and Madelaine Andersson for work with the Injury Register in Skaraborg, which was used in studies 2 and 3.

Thank you to statistician Mikael Kjerfve for data from the Vega Register in the Västra Götaland region.

Thank you to associate professors Hans Westergren, Eva-Maj Malmström and Marcelo Rivano Fischer for sharing your knowledge on pain rehabilitation and The Swedish Quality Registry for Pain.

Thank you to Gabriel Bake, Eva-Sjögren-Nilsson and Eva Deutsch who patiently helped me, and to Mats Kamperin and Anette Nilsson for book production.

Thank you to all unit heads and doctors who have enabled study IV to be conducted. There are many more colleagues, researchers and friends who have stood by me, thank you for being there!

Finally, a big thank you to Dr. Piotr Czech and Dr. Kissmat Mirkhan, without whose medical expertise, swift decisions and skill, along with all the skilled staff cooperating at Centralsjukhuset in Kristianstad this past summer, this book never would have come to be.

## REFERENCES

1. Tenenbaum A, Terstappen N, Angesjö P, Blom L, Börsbo T, Fransson C. När framtiden kommer bakifrån. Mariestad, Sweden: Vårdprogram Landstinget Skaraborg. 1997. [cited 2019-10-11]. Swedish. Available from: [http://www.whiplashinfo.se/Vard/vardprogram/vpskovde\\_whiplash.htm#inledning](http://www.whiplashinfo.se/Vard/vardprogram/vpskovde_whiplash.htm#inledning)
2. Stiftelsen Unga Forskare. [cited 2019-10-11]. Swedish. Available from: <https://ungaforskare.se/historia/>
3. Unga Forskare: Wikipedia; [cited 2019-10-11]. Swedish. Available from: [https://sv.wikipedia.org/wiki/Unga\\_Forskare](https://sv.wikipedia.org/wiki/Unga_Forskare)
4. Tenenbaum A, Forsberg JG. Structural and functional changes in ovaries from adult mice treated with diethylstilboestrol in the neonatal period. *J Reprod Fertil.* 1985;73(2):465-77
5. Tenenbaum A, Sernvi C, Forsberg JG. Ovarian progesterone synthesis and content and plasma progesterone levels in adult mice treated with diethylstilbestrol neonatally. *Biol Res Pregnancy Perinatol.* 1985;6(3):143-9
6. Rozga J, Flati G, Tenenbaum A, Andersson L, Jeppsson B, Bengmark S. Beneficial effect of hepatic arterialization on hypogonadism in male rats with portacaval shunt. *Eur Surg Res.* 1990;22(1):34-40
7. Tenenbaum A, Rivano-Fischer M, Tjell C, Edblom M, Sunnerhagen KS. The Quebec classification and a new Swedish classification for whiplash-associated disorders in relation to life satisfaction in patients at high risk of chronic functional impairment and disability. *J Rehabil Med.* 2002;34(3):114-8
8. Tjell C, Tenenbaum A, Rosenhall U. Auditory function in whiplash-associated disorders. *Scand Audiol.* 1999;28(4):203-9
9. Lindh M, Bunketorp O, Rosenfeld M, Tenenbaum A, Jansson A, Persson G. Omhändertagande av patienter med whiplashrelaterade besvär. Göteborg, Sweden. 2003.[cited 2019-10-11]. Swedish. Available from: <http://www1.vgregion.se/whiplash/Startsida/pif/Omh%C3%A4ndertagande%20av%20patienter%20hela%20v%C3%A5rdsprogrammet.pdf>



10. Sanden H, Edblom M, Ekman A, Tenenbaum A, Wallin BG, Hagberg M. Normal nerve conduction velocity and vibrotactile perception thresholds in computer users. *Int Arch Occup Environ Health*. 2005;78(3):239-42
11. Johnsson A, Tenenbaum A, Westerlund H. Improvements in physical and mental health following a rehabilitation programme for breast cancer patients. *Eur J Oncol Nurs*. 2011;15(1):12-5
12. Fredriksson S, Hammar O, Toren K, Tenenbaum A, Waye KP. The effect of occupational noise exposure on tinnitus and sound-induced auditory fatigue among obstetrics personnel: a cross-sectional study. *BMJ open*. Institution NVS.2015;5(3):e005793
13. Sahlin E, Ahlborg G, Tenenbaum A, Grahn P. Correction: Sahlin, E., et al. Using Nature-Based Rehabilitation to Restart a Stalled Process of Rehabilitation in Individuals with Stress-Related Mental Illness. *Int. J. Environ. Res. Public Health* 2015, 12, 1928-1951. *Int J Environ Res Public Health*. 2015;12(6):6946-7
14. Persson R, Osterberg K, Viborg N, Jonsson P, Tenenbaum A. The Lund University Checklist for Incipient Exhaustion-a cross-sectional comparison of a new instrument with similar contemporary tools. *BMC Public Health*. 2016;16:350
15. Osterberg K, Persson R, Viborg N, Jonsson P, Tenenbaum A. The Lund University Checklist for Incipient Exhaustion: a prospective validation of the onset of sustained stress and exhaustion warnings. *BMC Public Health*. 2016;16(1):1025
16. Persson R, Osterberg K, Viborg N, Jonsson P, Tenenbaum A. Two Swedish screening instruments for exhaustion disorder: cross-sectional associations with burnout, work stress, private life stress, and personality traits. *Scandinavian journal of public health*. 2017;45(4):381-8
17. Tenenbaum A, Österberg K. *Klinisk handbok för LUQSUS-K*. En praktisk guide för användning av LUQSUS-K i samband med utredning, sjukskrivning och rehabilitering av misstänkt stressrelaterad utmattning. Vänersborg: Hälsan & Arbetslivet, Region Västra Götaland och Arbets- och miljömedicin, Lunds universitetArbetslivet2019. [cited 2019-10-11]. Swedish. Available from: [http://www.trialrand.lu.se/luqsus/Klinisk\\_handbok\\_v.1.1\\_för\\_LUQSUS-K.pdf](http://www.trialrand.lu.se/luqsus/Klinisk_handbok_v.1.1_för_LUQSUS-K.pdf)

18. Trafikutskott. Nollvisionen och det trafiksäkra samhället. Trafikutskottets betänkande 1997/98:TU4. [cited 2019-10-11]. Swedish. Available from: [https://www.riksdagen.se/sv/dokument-lagar/arende/betankande/nollvisionen-och-det-trafiksakra-samhallet\\_GL01TU4](https://www.riksdagen.se/sv/dokument-lagar/arende/betankande/nollvisionen-och-det-trafiksakra-samhallet_GL01TU4)
19. Swedish Transport Administration. Trafikverket. Nollvision. [cited 2019-10-11]. Swedish. Available from: <https://www.trafikverket.se/en/startpage/>
20. Rydevik B, Brodda Jansen G, Edlund C, Grane P, Hildingsson C, Karlberg M, et al. The Whiplash Commission Final Report. [cited 2019-10-11]. Available from: [http://whiplashkommissionen.se/www.whiplashkommissionen.se/pdf/WAD\\_Diagnosis.pdf](http://whiplashkommissionen.se/www.whiplashkommissionen.se/pdf/WAD_Diagnosis.pdf)
21. Erichsen JE. On railway and other injuries of the Nervous System. 1866. [cited 2019-10-11]. Available from: <https://archive.org/details/b21289451/page/n1>
22. Crowe H. Injuries to the cervical spine. Annual meeting of the western orthopedic association; San Fransisco, USA.1928
23. Gay J, Abbott K. Common whiplash injuries of the neck. JAMA. 1953;152:1698-704
24. Spitzer WO, Skovron ML, Salmi LR, Cassidy JD, Duranceau J, Suissa S, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. Spine (Phila Pa 1976). 1995;20(8 Suppl):1s-73s
25. Herrström P, Lannerbro-Geijer G, Högstedt B. Whiplash injuries from car accidents in a Swedish middle-sized town during 1993-95. Scand J Prim Health Care. 2000;18(3):154-8
26. Sterner Y, Toolanen G, Gerdle B, Hildingsson C. The incidence of whiplash trauma and the effects of different factors on recovery. Journal Of Spinal Disorders & Techniques. 2003;16(2):195-9
27. Socialstyrelsen. Vården vid trafikskador med långvariga smärttillstånd. Expertutlåtande. Stockholm, Sweden: The National Board of Health and Welfare in Sweden. 2017. [cited 2019-10-11]. Swedish. Available from: <https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2017-12-3-bilaga3-expertutlatande.pdf>

28. Galasko CS, Murray PM, Pitcher M, Chambers H, Mansfield S, Madden M, et al. Neck sprains after road traffic accidents: a modern epidemic. *Injury*. 1993;24(3):155-7
29. Pastakia K, Kumar S. Acute whiplash associated disorders (WAD). *Open Access Emerg Med*. 2011;3:29-32
30. Holm LW, Carroll LJ, Cassidy JD, Hogg-Johnson S, Cote P, Guzman J, et al. The burden and determinants of neck pain in whiplash-associated disorders after traffic collisions: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976)*. 2008;33(4 Suppl):S52-9
31. Gustafsson M, Stigson H, Krafft M, Kullgren A. Risk of permanent medical impairment (RPMI) in car crashes correlated to age and gender. *Traffic Injury Prevention*. 2015;16(4):353-61
32. Sterling M, Kenardy Y. Whiplash evidence base for clinical practice. Chatswood: Elsevier Australia; 2011. 197 p
33. Bunketorp L, Nordholm L, Carlsson J. A descriptive analysis of disorders in patients 17 years following motor vehicle accidents. *Eur Spine J*. 2002;11(3):227-34
34. Jansen GB, Edlund C, Grane P, Hildingsson C, Karlberg M, Link H, et al. Whiplash injuries: diagnosis and early management. The Swedish Society of Medicine and the Whiplash Commission Medical Task Force. *European Spine Journal: Official Publication Of The European Spine Society, The European Spinal Deformity Society, And The European Section Of The Cervical Spine Research Society*. *Eur Spine J*. 2008;17 Suppl 3:355-358
35. Landzberg G, El-Rabbany M, Klasser GD, Epstein JB. Temporomandibular disorders and whiplash injury: a narrative review. *Oral surgery, oral medicine, oral pathology and oral radiology*. 2017;124(2):e37-e46
36. Sarrami P, Armstrong E, Naylor JM, Harris IA. Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors. *J Orthop Traumatol*. 2017;18(1):9-16
37. Bussieres AE, Stewart G, Al-Zoubi F, Decina P, Descarreaux M, Hayden J, et al. The Treatment of Neck Pain-Associated Disorders and Whiplash-Associated Disorders: A Clinical Practice Guideline. *J Manipulative Physiol Ther*. 2016;39(8):523-64.e27

38. Côté P, Boyle E, Shearer HM, Stupar M, Jacobs C, Cassidy JD, et al. Is a government-regulated rehabilitation guideline more effective than general practitioner education or preferred-provider rehabilitation in promoting recovery from acute whiplash-associated disorders? A pragmatic randomised controlled trial. *BMJ open*. 2019;9(1):e021283
39. Côté P, Wong JJ, Sutton D, Shearer HM, Mior S, Randhawa K, et al. Management of neck pain and associated disorders: A clinical practice guideline from the Ontario Protocol for Traffic Injury Management (OPTiMa) Collaboration. *European Spine Journal: Official Publication Of The European Spine Society, The European Spinal Deformity Society, And The European Section Of The Cervical Spine Research Society*. 2016;25(7):2000-22
40. Ferrara SD, Ananian V, Baccino E, Banczerowski P, Bordignon D, Boscolo-Berto R, et al. Whiplash-Associated Disorders : Clinical and medico-legal guidelines on the methods of ascertainment. *Int J Legal Med*. 2016;130(1):13-22
41. Westergren H ME, Rivano Fischer M,. Vårdprogram för nacksmärta och funktionsnedsättning efter olycka: Region Skåne. 2015. [cited 2019-10-11]. Swedish. Available from:[https://vardgivare.skane.se/siteassets/1.-vardriktlinjer/regionala-varldprogram---fillistning/varldprogram\\_nacksmarta\\_slutversion-giltig-tom-2019-12-31.pdf](https://vardgivare.skane.se/siteassets/1.-vardriktlinjer/regionala-varldprogram---fillistning/varldprogram_nacksmarta_slutversion-giltig-tom-2019-12-31.pdf)
42. Westergren H, Freeman MD, Malmstrom EM. The whiplash enigma: Still searching for answers. *Scandinavian journal of pain*. 2014;5(4):226-8
43. Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. Gender differences in care-seeking behavior and healthcare consumption immediately after whiplash trauma. *PLoS One*. 2017;12(4):e0176328-e
44. Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. A risk stratification tool for prehospital triage of patients exposed to a whiplash trauma. *PLoS One*. 2019;14(5):e0216694
45. Gerdle B, Bring G, Fredin Y, Johansson B, Levander B, Smedmark V. Vårdprogram för Whiplashrelaterade besvär. University Hospital of Linköping, Sweden: Pain & Rehabilitation Centre. 1998. [cited 2019-10-11]. Swedish. Available from: <https://www.imh.liu.se/samhallsmedicin/rehabiliteringsmedicin/filarkiv/1.59720/varldprogrammetswad.pdf>

46. Carlsson IH, M. Brorsson, J-Å. Gårdestig, S. Lundgren. M-L. Rehnqvist, N. Danielsson, H. Lundius, A. The Whiplash Commission Final Report. Sandvikens tryckeri, Sandviken, Sweden. 2005. [cited 2019-10-11]. Swedish. Available from:  
[http://whiplashkommissionen.se/www.whiplashkommissionen.se/pdf/Wk\\_slutrappport2005.pdf](http://whiplashkommissionen.se/www.whiplashkommissionen.se/pdf/Wk_slutrappport2005.pdf)
47. Hartling L, Brison RJ, Ardern C, Pickett W. Prognostic value of the Quebec Classification of Whiplash-Associated Disorders. *Spine (Phila Pa 1976)*. 2001;26(1):36-41
48. Sterling M. A proposed new classification system for whiplash associated disorders--implications for assessment and management. *Man Ther*. 2004;9(2):60-70
49. Lesko MM, Woodford M, White L, O'Brien SJ, Childs C, Lecky FE. Using Abbreviated Injury Scale (AIS) codes to classify Computed Tomography (CT) features in the Marshall System. *BMC Med Res Methodol*. 2010;10:72
50. Norin H, Krafft M, Korner J, Nygren A, Tingvall C. Injury severity assessment for car occupants in frontal impacts, using disability scaling. *J Clin Epidemiol*. 1997;50(1):95-103
51. Bunketorp O, Lindh M, Rivano-Fisher M, Rydevik B. Handläggning av patienter med whiplash besvär: Riksförbundet för trafik- och polioskadade; 2008 [cited 2019-10-11]. Swedish. Available from:  
<https://rtp.se/kunskap/nackskada/>
52. Regionala cancercentrum i samverkan. Nationellt vårdprogram Bröstcancer 2019 [updated 2019-01-30; cited 2019 2019-10-11]. Swedish. Available from:  
<https://www.cancercentrum.se/samverkan/cancerdiagnoser/brost/vardprogram/>
53. Westergren H, Malmström E-M. Nacksmärta efter olycka Lund, Sweden: Region Skåne. 2019. [cited 2019-10-11]. Swedish. Available from:  
<https://vardgivare.skane.se/vardriktlinjer/rorelseorgan/ako/nacksmarta-efter-olycka/>
54. Weyrich P, Christ M, Celebi N, Riessen R. [Triage systems in the emergency department]. *Medizinische Klinik, Intensivmedizin und Notfallmedizin*. 2012;107(1):67-78; quiz 79

55. Swedish Council on Health Technology Assessment (SBU). Triage Methods and Patient Flow Processes in Emergency Departments: A Systematic Review. Stockholm, Sweden. 2010. [cited 2019-10-11]. Swedish. Available from:  
[https://www.sbu.se/contentassets/79b7a8f6aaad46dc988cffed33339f/triage\\_fulltext2.pdf](https://www.sbu.se/contentassets/79b7a8f6aaad46dc988cffed33339f/triage_fulltext2.pdf)
56. Farrokhnia N, Goransson KE. Swedish emergency department triage and interventions for improved patient flows: a national update. *Scand J Trauma Resusc Emerg Med.* 2011;19:72
57. Goransson KE, von Rosen A. Interrater agreement: a comparison between two emergency department triage scales. *Eur J Emerg Med.* 2011;18(2):68-72
58. World Health Organization (WHO). International Statistical Classification of Diseases and Related Health (ICF).2001. [cited 2019-10-11]. Available from: <https://www.who.int/classifications/icf/en/>
59. Socialstyrelsen. Klassifikation av funktionstillstånd, funktionshinder och hälsa (ICF). Stockholm, Sweden: The National Board of Health and Welfare in Sweden. 2019 [cited 2019-10-11]. Swedish. Available from:  
<https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/klassifikationer-och-koder/2003-4-1.pdf>
60. Walton D. A review of the definitions of 'recovery' used in prognostic studies on whiplash using an ICF framework. *Disabil Rehabil.* 2009;31(12):943-57
61. Fresk M, Brodin N, Grooten WJ, Joseph C, Kiessling A. Mapping a measure of physical ability for persons with long-term musculoskeletal pain to the ICF and ICF Core Sets. *Eur J Public Health.* 2019;29(2):286-91
62. Socialstyrelsen. Guidelines on sick leave after distortion in the cervical spine including Whiplash injury Stockholm, Sweden: The National Board of Health and Welfare in Sweden. 2019 [updated 2007-10-01; cited 2019-10-11]. Swedish. Available from: <https://roi.socialstyrelsen.se/fmb/distorsion-i-halskotpelaren-inklusive-whiplash-skada/204>
63. Socialstyrelsen. Guidelines on sick leave. The National Board of Health and Welfare. (Försäkringsmedicinskt beslutsstöd) Stockholm, Sweden: The National Board of Health and Welfare in Sweden. 2019 [updated 2019-05-27; cited 2019-10-11]. Swedish. Available from:  
<https://www.socialstyrelsen.se/regler-och-riktlinjer/forsakringsmedicinskt-beslutsstod/>

64. Rosenfeld M, Seferiadis A, Carlsson J, Gunnarsson R. Active intervention in patients with whiplash-associated disorders improves long-term prognosis: a randomized controlled clinical trial. *Spine (Phila Pa 1976)*. 2003;28(22):2491-8
65. Sterner Y, Gerdle B. Acute and chronic whiplash disorders--a review. *J Rehabil Med*. 2004;36(5):193-209
66. Vendrig AA, van Akkerveeken PF, McWhorter KR. Results of a multimodal treatment program for patients with chronic symptoms after a whiplash injury of the neck. *Spine (Phila Pa 1976)*. 2000;25(2):238-44
67. Verhagen AP, Peeters GG, de Bie RA, Oostendorp RA. Conservative treatment for whiplash. *The Cochrane Database Of Systematic Reviews*. 2001(4):CD003338
68. Agnew L, Johnston V, Landen Ludvigsson M, Peterson G, Overmeer T, Johansson G, et al. Factors associated with work ability in patients with chronic whiplash-associated disorder grade II-III: A cross-sectional analysis. *J Rehabil Med*. 2015;47(6):546-51
69. Rosenfeld M, Gunnarsson R, Borenstein P. Early intervention in whiplash-associated disorders: a comparison of two treatment protocols. *Spine (Phila Pa 1976)*. 2000;25(14):1782-7
70. Borenstein P, Rosenfeld M, Gunnarsson R. Cognitive symptoms, cervical range of motion and pain as prognostic factors after whiplash trauma. *Acta Neurol Scand*. 2010;122(4):278-85
71. Socialstyrelsen. Publikationer. The National Board of Health and Welfare in Sweden. 2017. [cited 2019-10-11]. Swedish. Available from: <https://www.socialstyrelsen.se/publikationer/>
72. The Organisation for Economic Co-operation and Development (OECD). Road accidents. 2019. [cited 2019-10-11]. Available from: <https://data.oecd.org/transport/road-accidents.htm>
73. Socialstyrelsen. Statistik om skador och förgiftningar behandlade i slutenvård 2017. The National Board of Health and Welfare in Sweden. 2017. [updated 2018-01-01; cited 2019-10-11]. Swedish. Available from: <https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/statistik/2018-9-15.pdf>

74. Krook A. Smärtrehabilitering på Rehabiliteringsmedicinska kliniken, Jönköping. Rehabiliteringsmedicinska kliniken Länssjukhuset Ryhov, Psykiatri rehab o diagnostik: Regionen Jönköpings län. 2019. [updated 2019-03-27; cited 2019-10-11]. Swedish. Available from: <https://folkhalsaochsjukvard.rjl.se/sidor/rehabilitering/smartrehabilitering-pa-rehabiliteringsmedicinska-kliniken-jonkoping/>
75. The Commission on Accreditation of Rehabilitation Facilities (CARF). CARF International. [cited 2019-10-11]. Available from: <http://carf.org/home/>
76. Swedish Council on Health Technology Assessment (SBU). Rehabilitation in chronic pain – a systematic review. Stockholm, Sweden. 2010. Swedish. [cited 2019-10-11]. Swedish. Available from: <https://www.sbu.se/sv/publikationer/SBU-utvarderar/rehabilitering-vid-langvarig-smarta/>
77. Jensen IB, Bergstrom G, Ljungquist T, Bodin L. A 3-year follow-up of a multidisciplinary rehabilitation programme for back and neck pain. *Pain*. 2005;115(3):273-83
78. Rivano Fischer M, Persson EB, Stalnacke BM, Schult ML, Lofgren M. Return to work after interdisciplinary pain rehabilitation: One- and two-year follow-up based on the Swedish Quality Registry for Pain rehabilitation. *J Rehabil Med*. 2019;51(4):281-9
79. Swedish Council on Health Technology Assessment (SBU). Metoder för behandling av långvarig smärta: Statens beredning för medicinsk utvärdering. 2006. [cited 2019-10-11]. Swedish. Available from: <https://www.sbu.se/sv/publikationer/SBU-utvarderar/rehabilitering-vid-langvarig-smarta/>
80. Swedish Medical Products Agency. Läkemedelsverket. Behandlingsrekommendationer. 2017. [cited 2019-10-11]. Swedish. Available from: <https://lakemedelsverket.se/malgrupp/Halso---sjukvard/Behandlings--rekommendationer/>
81. Swedish Council on Health Technology Assessment (SBU). Arbetsplatsrelaterade åtgärder för att minska nacksmärta. 2006. [cited 2019-10-11]. Swedish. Available from: [https://www.sbu.se/contentassets/76b832b9393e4231983cf7a3ed28ace3/arbeitsplatsrelaterade\\_interventioner\\_for\\_att\\_minska\\_nacksmarta.pdf](https://www.sbu.se/contentassets/76b832b9393e4231983cf7a3ed28ace3/arbeitsplatsrelaterade_interventioner_for_att_minska_nacksmarta.pdf)



82. Swedish Council on Health Technology Assessment (SBU). Rehabilitering vid långvarig smärta. Stockholm: Statens beredning för medicinsk utvärdering. 2010. [cited 2019-10-11]. Swedish. Available from: [https://www.sbu.se/contentassets/f0f1e57fb7b14f1fbdd18382eeda7ab0/rehab\\_smarta\\_2010\\_fulltext.pdf](https://www.sbu.se/contentassets/f0f1e57fb7b14f1fbdd18382eeda7ab0/rehab_smarta_2010_fulltext.pdf)
83. Socialstyrelsen. Smärta och störd käkmotorik associerad med pisksnärtskada (WAD). The National Board of Health and Welfare in Sweden. 2011. [cited 2019-10-11]. Swedish. Available from: <https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/nationella-riktlinjer/2011-5-1.pdf>
84. Grooten W. Fysisk aktivitet vid långvariga utbredda smärttillstånd 2015. [cited 2019-10-11]. Swedish. Available from: <http://www.fysss.se/wp-content/uploads/2018/01/Långvariga-rygg-och-nackbesvär-1.pdf>
85. Swedish Medical Products Agency. Läkemedelsverket. Läkemedelsbehandling av lång-varig smärta hos barn och vuxna – behandlingsrekommendation. 2017. [cited 2019-10-11]. Swedish. Available from: [https://lakemedelsverket.se/upload/halso-och-sjukvard/behandlingsrekommendationer/Information\\_fran\\_lakemedelsverket\\_nr\\_3\\_2017\\_behandlingsrekommendation.pdf](https://lakemedelsverket.se/upload/halso-och-sjukvard/behandlingsrekommendationer/Information_fran_lakemedelsverket_nr_3_2017_behandlingsrekommendation.pdf)
86. Socialstyrelsen. Vården vid trafikskador med långvariga smärttillstånd. Report No: 2017-12-3. The National Board of Health and Welfare in Sweden. 2017. [cited 2019-10-11]. Swedish. Available from: <https://www.socialstyrelsen.se/sok/?q=V%C3%A5rden+vid+trafikskador+med+l%C3%A5ngvariga+sm%C3%A4rttillst%C3%A5nd>
87. Vårdguiden. 1177 Vårdguiden; Pisksnärtsskada – whiplashskada; 2016-06-22. [updated 2019; cited 2019-10-11]. Swedish. Available from: <https://www.1177.se/Vastra-Gotaland/sjukdomar--besvar/skelett-leder-och-muskler/rygg-och-nacke/pisksnartsskada--whiplashskada/>
88. Dale RA. Nonfatal injuries in a local context: analyzing social structures and perceptions in young people. Göteborg: Department of Public Health and Community Medicine, Social Medicine Unit, Institute of Medicine at Sahlgrenska Academy, University of Gothenburg, Sweden. 2012. ISBN: 9789162884352
89. Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. Medical practitioners' recommendation for pre-hospital triage of patients exposed to a traffic accident resulting in neck pain. May 2019. Manuscript

90. Fugl-Meyer AR, Eklund M, Fugl-Meyer KS. Vocational rehabilitation in northern Sweden. III. Aspects of life satisfaction. *Scand J Rehabil Med.* 1991;23(2):83-7
91. Nationella Registret över Smärtrehabilitering (NRS) i samarbete med UCR. 2019. Swedish Quality Registry for Pain rehabilitation (SQPR). [cited 2019-10-11]. Swedish. Available from: <https://www.ucr.uu.se/nrs/nrs-specialistvard/arsrapporter-specialistvard>
92. Osika Friberg I, Krantz G, Maatta S, Jarbrink K. Sex differences in health care consumption in Sweden: A register-based cross-sectional study. *Scandinavian journal of public health.* 2016;44(3):264-73
93. Dobson A, Brown W, Ball J, Powers J, McFadden M. Women drivers' behaviour, socio-demographic characteristics and accidents. *Accid Anal Prev.* 1999;31(5):525-35
94. Schenck-Gustafsson. K PD. Handbook of clinical gender medicine. Karger. 2012
95. Mellner C, Krantz G, Lundberg U. Symptom reporting and self-rated health among women in mid-life: the role of work characteristics and family responsibilities. *Int J Behav Med.* 2006;13(1):1-7
96. Galdas PM, Cheater F, Marshall P. Men and health help-seeking behaviour: literature review. *J Adv Nurs.* 2005;49(6):616-23
97. Connell. R. Gender Short Introductions: Polity Press in association with Blackwell Publishers Ltd. 2002
98. Westergren H, Larsson J, Freeman M, Carlsson A, Joud A, Malmstrom EM. Sex-based differences in pain distribution in a cohort of patients with persistent post-traumatic neck pain. *Disabil Rehabil.* 2018;40(9):1085-91
99. Livesey EA, Noon JM. Implementing guidelines: what works. *Arch Dis Child Educ Pract Ed.* 2007;92(5):ep129-34
100. Gagliardi AR, Marshall C, Huckson S, James R, Moore V. Developing a checklist for guideline implementation planning: review and synthesis of guideline development and implementation advice. *Implementation science: IS.* 2015;10:19
101. Swedish Transport Administration. Trafikverket. Vision Zero Academy. 2019. [cited 2019-10-11]. Available from: <https://www.trafikverket.se/en/startpage/operations/Operations-road/vision-zero-academy/>

102. Tingvall. C, von Holst. H, Nygren. Å, Thord. R. The Zero Vision. Springer, Berlin, Heidelberg ed. Berlin: Transportation, Traffic Safety and Health. 1997
103. Rovira E, McLaughlin AC, Pak R, High L. Looking for Age Differences in Self-Driving Vehicles: Examining the Effects of Automation Reliability, Driving Risk, and Physical Impairment on Trust. *Front Psychol.* 2019;10:800
104. How It Works: Internet of Things. IBM Think Academy.2015. [cited 2019-10-11]. Available from:  
<https://www.youtube.com/watch?v=QSIPNhOiMoE>
105. Newman SM, Keefe RF, Brooks RH, Ahonen EQ, Wempe AM. Human Factors Affecting Logging Injury Incidents in Idaho and the Potential for Real-Time Location-Sharing Technology to Improve Safety. *Safety (Basel, Switzerland).* 2018;4(4):43
106. Gagliardi AR, Brouwers MC, Bhattacharyya OK. The development of guideline implementation tools: a qualitative study. *CMAJ open.* 2015;3(1):E127-33

# APPENDIX - SUPPLEMENTAL MATERIAL STUDY III

## Supplemental material 1

*S1 Table. Potential risk factors for hospital admission-outliers >2.5 SD removed*

<i>Multivariable logistic regression (n = 1,031)</i>		<i>(n = 3,103)</i>		
	<b>P</b>	<b>Odds ratio</b>	<b>P</b>	<b>Odds ratio</b>
<b><i>Demographic factors</i></b>				
Increased age (one decade)	0.0083	1.4(1.1–1.9)	<0.001	1.3 (1.1-1.6)
Female gender	0.90	1.0 (0.45–2.4)		
<b><i>Circumstances of first contact</i></b>				
Attending at Night	0.062	2.2 (0.96–5.2)		
Attending at Weekend	0.029	3.0 (1.1–7.9)	0.0071	2.2 (1.2-4.0)
Attending in Summer	0.17	1.6 (0.80–3.3)		
Attending same day as trauma	0.0033	31 (3.1–300)	<0.001	11(4.2–30)
<b><i>Circumstances</i></b>				
Work related	0.050	2.9 (1.0–8.5)	0.95	1.0 (0.55-1.9)
Trauma not in the same direction of travel	0.43	1.5 (0.53–4.5)		
Car accident	0.94	0.95 (0.27–3.3)		
Being passenger in front seat	0.54	1.4 (0.45–4.6)		
Not using seat belt	0.028	3.9 (1.2–13)	<0.001	2.6 (1.5-4.7)
<b><i>Clinical diagnosis</i></b>				
Only whiplash injury (WAD)	0.62	0.57 (0.064–5.1)		
WAD + Contusion	0.082	6.1 (0.79–48)		
WAD + Commotio cerebri	<0.001	140 (13–1500)	<0.001	44 (19–100)
WAD + Wound	0.038	4.1 (1.1–16)	0.88	2.4 (0.88-6.9)
WAD + Fracture or luxation	0.016	8.1 (1.5–44)	<0.001	11 (4.2–29)
WAD + Other serious injury	0.0048	49 (3.3–730)	<0.001	36 (3.9–330)

## Supplemental material 2

**S2 Table.** Potential risk factors for hospital admission-outliers >2.0 SD removed

<i>Multivariable logistic regression (n = 1,006)</i>			<i>(n = 3,088)</i>	
	<b>P</b>	<b>Odds ratio</b>	<b>P</b>	<b>Odds ratio</b>
<b><i>Demographic factors</i></b>				
Increased age (one decade)	0.33	1.2(0.81–1.9)		
Female gender	0.46	0.59 (0.15–2.4)		
<b><i>Circumstances of first contact</i></b>				
Attending at Night	0.14	2.8 (0.72–11)		
Attending at Weekend	0.0072	15 (2.1–110)	0.012	2.3 (1.2–4.5)
Attending in Summer	0.072	4.2 (0.88–21)		
Attending same day as trauma	0.0048	150 (4.6–4700)	<0.001	8.4 (3.1–23)
<b><i>Circumstances</i></b>				
Work related	0.024	13 (1.4–110)	0.98	0.99 (0.48–2.0)
Trauma not in the same direction of travel	0.23	4.1 (0.40–42)		
Car accident	0.37	2.2 (0.38–13)		
Being passenger in front seat	0.86	1.2 (0.13–11)		
Not using seat belt	0.016	11 (1.6–81)	0.0026	2.6 (1.4–4.9)
<b><i>Clinical diagnosis</i></b>				
Only whiplash injury (WAD)	0.52	0.34 (0.013–9.1)		
WAD + Contusion	0.086	10 (0.72–150)		
WAD + Commotio cerebri	<0.001	2200 (50–99000)	<0.001	44 (19–102)
WAD + Wound	0.37	10 (1.2–96)		
WAD + Fracture or luxation	0.0021	94 (5.2–1700)	<0.001	19(7.4–50)
WAD + Other serious injury	<0.001	615 (19–20000)	0.0020	30 (3.5–260)

# **APPENDIX - SUPPLEMENTAL MATERIAL STUDY IV**

## **Supplemental material 1. Information for Medical practitioners about the study.**

We would like to invite you to participate in a research project with the aim of investigating your perception of the need for a level of care in the acute phase after a traffic accident that results in neck pain. If you choose to participate, this means that you will respond to a short questionnaire about where an imaginary patient with acute neck pain should initially be examined (care level).

We are carrying out this study to get a clearer picture of doctors' perceptions of the optimal level of care after an accident that occurs in traffic with subsequent neck pain. The study will be included in Dr Artur Tenenbaum's thesis. Professor Ronny Gunnarsson is the head supervisor.

If you agree to participate, we ask you to fill out a short questionnaire that takes about 5 minutes. We present three different scenarios with a total of nine questions and we are grateful if you answer all of the questions.

You give your consent to participate and agree that the answers can be used in the study by answering the questionnaire and returning it. We do not expect any significant advantages or disadvantages for you personally if you participate.

Participation is voluntary. Your answers are completely anonymous and cannot be linked to you. Data from the study will be used in research publications and reports. You will not be able to be identified in any way in these publications.

## CONTACT

If you have any questions or questions about the research now or during the study you can contact:

Artur Tenenbaum

PhD student, Department of Community Medicine and Public Health.  
Sahlgrenska Academy, University of Gothenburg.

[artur.tenenbaum@vgregion.se](mailto:artur.tenenbaum@vgregion.se)

## Survey traffic accident

Your age: \_\_\_\_\_ Your gender:  Female  Male  Other

Year of Graduation from Medicine: \_\_\_\_\_

Check the boxes below that are relevant to you and leave the rest empty:

I am a junior doctor (not yet qualified/registered)

I'm an intern

I am a licensed doctor and have been since (year): \_\_\_\_\_

I am a registered junior doctor

I am a resident doctor training to specialise in:  
\_\_\_\_\_

I am a specialist in general medicine have been since (year):  
\_\_\_\_\_

I have a specialty other than general medicine, which?:  
\_\_\_\_\_ years: \_\_\_\_\_

I am currently working at a primary care facility

I am currently working in hospitals

Below are three short stories about imagined events and emerging symptoms. We assume that the patient calls the health care information line.



**Supplemental material 2. Three different scenarios taken from a previous study establishing risk factors for having a sinister injury (44) \*. Represented cases with low, moderate or high risk for sinister injury. With nine questions regarding three different scenarios.**

*Scenario 1.* Karin is 40 years old and is a driver in a 2016 Volvo V70, gets hit by another passenger car from behind when she is stationary at a red light at a crossing. The accident happens at 2pm. The collision takes place at about 20 km / h and Karin was wearing a seat belt. After the accident, Karin goes out of the car, talks to the driver of the car that hit hers and together they write the insurance claim. Two hours after the accident when Karin gets home, she starts getting more neck pain and feels some neck stiffness. Karin manages to work as a supermarket cashier despite annoying neck problems, but she calls the health care information three days after the accident and wonders what to do. She has no other symptoms.

It is a 30 minute drive (on a paved, good quality road) to both the primary care centre and the hospital from where the patient is currently.

**Which first level of care do you think the health care information should refer the patient to?**

Answer **all** questions by checking the box for the option you are proposing in questions 1a, 1b and 1c, respectively.

Question 1a

- Primary care facility (open right now and has available appointments) ↔  Hospital emergency room

Question 1b

- Primary care facility (currently closed, but open the next morning) ↔  Hospital emergency room

Question 1c

- Primary care facility (currently closed, but open after the weekend, in two days) ↔  Hospital emergency room

**Scenario 2.** Eva is 37 years old and is a passenger in a 2016 Volvo V 70. It is 5am in January. The car is hit in the side by another passenger car as the car Eva is in crosses an intersection. The collision takes place at about 40 km / h and Eva had her seat belt on. After the accident, Eva has moderate neck pain and some neck stiffness. She has not lost consciousness and has no other symptoms. Eva goes home first, but calls the health care information three hours after the accident and wonders what to do.

It is a 30 minute drive (on a paved, good quality road) to both the primary care centre and the hospital from where the patient is currently.

**Which first level of care do you think the health care information should refer the patient to?**

Answer all questions by checking the box for the option that you suggest in question 2a, 2b and 2c, respectively.

**Question 2a**

- |  |   |  |
|--|---|--|
| <input type="checkbox"/> Primary care facility (open right now and has available appointments) | ↔ | <input type="checkbox"/> Hospital emergency room |
|--|---|--|

**Question 2b**

- |  |   |  |
|--|---|--|
| <input type="checkbox"/> Primary care facility (currently closed, but open the next morning) | ↔ | <input type="checkbox"/> Hospital emergency room |
|--|---|--|

**Question 2c**

- |  |   |  |
|--|---|--|
| <input type="checkbox"/> Primary care facility (currently closed, but open after the weekend, in two days) | ↔ | <input type="checkbox"/> Hospital emergency room |
|--|---|--|

**Scenario 3.** It is a sunny May morning at 08.30am. Elisabeth, 39 years old, is sitting in the back seat of a 2016 Volvo V 70. She is wearing a seat belt. In a curve on a smaller road, a frontal collision occurs with a 2017 AUDI A3 passenger car. Both cars are driving at about 50 km / h. Elisabeth hits her head on the back of the seat in front of her. After the collision, she feels that she has lost consciousness for a short while. It is unclear how long she has been unconscious but according to the driver probably less than 2 minutes. She has moderate neck pain and feels slight dizziness but has no other symptoms. An ambulance had attended the scene and retrieved the driver in the other car who seemed to be seriously injured. Elisabeth is now home and calls the health care information about two hours after the accident. She wonders what to do.

It is a 30 minute drive (on a paved, good quality road) to both the primary care centre and the hospital from where the patient is currently.

**Which first level of care do you think the health care information should refer the patient to?**

Answer all questions by checking the box for the option that you suggest in question 3a, 3b and 3c, respectively.

**Question 3a**

- |  |   |  |
|--|---|--|
| <input type="checkbox"/> Primary care facility (open right now and has available appointments) | ↔ | <input type="checkbox"/> Hospital emergency room |
|--|---|--|

**Question 3b**

- |  |   |  |
|--|---|--|
| <input type="checkbox"/> Primary care facility (currently closed, but open the next morning) | ↔ | <input type="checkbox"/> Hospital emergency room |
|--|---|--|

**Question 3c**

- |  |   |  |
|--|---|--|
| <input type="checkbox"/> Primary care facility (currently closed, but open after the weekend, in two days) | ↔ | <input type="checkbox"/> Hospital emergency room |
|--|---|--|

\*Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R: A risk stratification tool for prehospital triage of patients exposed to a whiplash trauma. *PLoS One* 2019, 14(5):e0216694

# APPENDIX - ORIGINAL PUBLICATIONS

## ORIGINAL PUBLICATIONS AND MANUSCRIPT

Tenenbaum A, Rivano-Fischer M, Tjell C, Edblom M, Sunnerhagen KS. **The Quebec classification and a new Swedish classification for whiplash-associated disorders in relation to life satisfaction in patients at high risk of chronic functional impairment and disability.** J Rehabil Med. 2002 May;34(3):114-8.

Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. **Gender differences in care-seeking behavior and healthcare consumption immediately after whiplash trauma.** PLoS One. 2017 Apr 25; 12(4):e0176328. doi: 10.1371/journal.pone.0176328. eCollection 2017.

Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R: **A risk stratification tool for prehospital triage of patients exposed to a whiplash trauma.** PLoS One. 2019 May 14; 14(5):e0216694. doi: 10.1371/journal.pone.0216694. eCollection 2019.

Tenenbaum A, Nordeman L, Sunnerhagen KS, Gunnarsson R. **Medical practitioners' recommendation for pre-hospital triage of patients exposed to a traffic accident resulting in neck pain.** 2019 May. Manuscript.

The papers have been reprinted with permission of the journals.