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Health inequalities and income for people with spinal cord injury. A comparison between and within countries

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ABSTRACT

Income and health are related in a bi-directional manner, whereby level of income affects health and vice versa. People in poorer households tend to experience worse health status and higher mortality rates than people in wealthier households, and, at the same time, having poor health could restrict workability leading to less income. This gap exists in almost every country, and it is more pronounced in more unequal countries and in vulnerable populations, such as people experiencing disability. The goal of this paper is to estimate the health-income gap in people with a Spinal Cord Injury (SCI), which is a chronic health condition often associated with multiple comorbidities that leads to disability. As data on mortality is inexistent, to estimate the health-income gap for persons with SCI, this paper uses two health outcomes: the number of years a person has lived with the injury, and a comorbidity index. Data was obtained from the International Spinal Cord Injury survey (InSCI), which is the first worldwide survey on community-dwelling persons with SCI. To compare across countries, the health outcomes were adjusted through hierarchical models, accounting for country fixed-effects, individual characteristics such as age and gender, and injury characteristics (cause, type and degree). Our results suggest that for the years living with SCI, the gap varies from 1 to 6 years between the lowest and the highest income groups. The main driver of such a difference is the cause of injury, where injuries caused by work accidents showed the biggest gap. Similarly, for the comorbidity index, persons with SCI in poorer deciles reported significantly more comorbidities, forty times more, than people in richer deciles.

1. Introduction

People in richer income groups tend to enjoy a better health status that translates into lower mortality rates compared to people in poorer income groups. This association between income and health is defined as the health-income gap (Chetty et al., 2016; Deaton, 2003; Pickett and Wilkinson, 2015; Spinakis et al., 2011; Truesdale and Jencks, 2016; World Health Organization, 2013). Related studies have analyzed health inequalities in the general population, where the gap between the poorest and the richest quintiles is estimated to be between 7 and 9 years at the age of 50 (Zaninotto, 2020). The underlying differences are related to social stratification, in which exposure to health inequalities varies between populations (Riley, 2020; Wilkins et al., 2019). Nevertheless, this gap might be even larger for the most vulnerable population, such as people experiencing long-term disabilities, where evidence is still lacking (World Health Organization and International Spinal Cord Society, 2013, p. 231; World Health Organization and Social determinants of health, 2021).

Spinal Cord Injury (SCI) is a long-term health condition that is often accompanied by disability, not only because of the medical complexities and impairments in functioning, but because this group is prone to face stigmatization and discrimination (World Health Organization and

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International Spinal Cord Society, 2013, p. 231). People with SCI are frequent users of health services; thus, the way in which the health and social systems are organized have a direct impact on their health. Understanding how the income position of a person translates into health inequalities is of special importance in populations experiencing disability, as their survival is highly dependent on the response of the health and social systems (Fekete, 2020; World Health Organization and International Spinal Cord Society, 2013, p. 231).

Data on the life expectancy and mortality of persons with SCI is scarce, and existing estimates show a high variability (Brinkhof et al., 2016; Reinhardt et al., 2012; Solinsky and Kirshblum, 2018). Nevertheless, what is known is that persons with SCI have an elevated mortality risk, which is estimated to be 2 to 5 times greater than in the general population (Middleton et al., 2012; World Health Organization and International Spinal Cord Society, 2013, p. 231). Most of the existing studies on mortality and longevity after SCI have found substantial differences between regions and income levels in relation to the general population (Chamberlain et al., 2015). Nevertheless, the differences were computed across countries, and they did not include estimates within countries. In addition, as the causes of the injury may vary significantly between countries, comparison of the results is not always feasible. For example, in low-income countries, violence or work accidents are among the top causes for SCI, while in high-income countries, sports and leisure accidents can be more prevalent (Fekete, 2020; World Health Organization and International Spinal Cord Society, 2013, p. 231). In both cases, the socio-economic position of a person plays an important role.

This paper aims to estimate the health-income gap for people with SCI, and to understand the role of income between and within countries. Our hypothesis is that people in richer deciles tend to have a better health status (i.e. lower morbidity), and tend to live longer than people in lower-income deciles. We use data from the International Spinal Cord Injury Survey [InSCI], which provides for the first-time comparable data on the living situation of persons with SCI from all six WHO regions (Fekete et al., 2017). Due to the lack of mortality data, we use two alternative health measures: (a) the number of years a person has lived with the injury and (b) a co-morbidity index (Buzzell et al., 2020; DiPiro et al., 2019; Krause et al., 2011; Quan et al., 2011). To allow the comparison between countries, a relative personal income was estimated according to the socio-economic position in the country of residence of each respondent.

2. Methods

2.1. Data

2.1.1. Design

This study draws data from the InSCI community survey. The InSCI study is a cross-sectional, multi-country survey on the health, function, and social situation of people with SCI living in the community. The first wave of this survey was launched in 2017 and 22 countries participated. The questionnaire was validated in each national language and tested in sub-samples of the target population. One important strength of this survey is that it uses the International Classification of Functioning, Disability and Health (ICF) data frame, ensuring that the questions measure the same aspects in all the countries, which allows comparison between countries.

2.1.2. Data collection and measures

The first strategy to collect the data was a random sample from a national registry. Since some counties did not have such a registry, convenience sampling was used (Fekete, 2020; Gross-Hemmi et al., 2017). The questionnaire incorporated 11 sections that included personal information, lesion characteristics, energy and feelings, health problems, activity and participation, independence in activities of daily living, employment, environmental factors, health care services, personal factors and quality of life, and general health (Gross-Hemmi et al., 2017).

2.1.3. Participants

Eligible persons for the survey were adults aged 18 years and older with traumatic or non-traumatic SCI who were able to respond to the survey in one of the available language versions of the questionnaire, provided informed consent, and were residents in one of the participating countries (Gross-Hemmi et al., 2017). The present study only used data of participants with a traumatic etiology. We excluded data from participants with non-traumatic causes for two reasons. First, the majority of the participants (about 80%) had a traumatic etiology (Fekete, 2020), which left non-traumatic cases with few observations and big variance. Therefore, it would be difficult to compare the results across countries without generating biased estimates. Second, the causes of non-traumatic SCI are diverse, ranging from cancer, vascular accidents, or infections to degeneration of the spine, which makes it very challenging to link and explain the socio-economic situation of a person to the causes of non-traumatic SCI.

2.1.4. Additional data sources

The InSCI survey asked every participant to report their household income level. To compare the income across countries, we supplemented the data with external sources that allowed us to identify how rich or poor a person was in each country. More specifically, we translated the reported income to income deciles[1] at population level for each country reported by the Luxemburg Income Study Database [LIS] (Luxembourg Income Study Luxembourg income study LIS, 2020) the World Inequality Database [WID] (Word Inequality Database), the European Commission [Eurostat] database (Eurostat and in Information), and single country-specific surveys (National Bureau of Statis, 2019, p. 2020; Statistics Korea, 2019).

2.2. Data analysis

The health-income gap requires two components: (1) a comparable income measure and (2) health outcomes. For the first component, we estimated a new variable that allowed us to compare respondents within and between countries in terms of their relative income position. For the second component, we used the years a person has lived with SCI and a comorbidity index. To estimate the general gap, we implemented a hierarchical model considering the structure of the sample. The models were re-estimated using multiple imputations (see Appendix, table A4). As the results did not show substantial changes, we kept the original data (Gross-Hemmi et al., 2017; Outhwaite and Turner, 2007; Buuren and Groothuis-Oudshoorn, 2010). In addition, as a sensitivity analysis, we re-estimated the results using multiple regressions country by country. To visualize the results, we plotted the health-income gap by country and cause of the injury. All the statistical analyses were performed using R version 3.6.0 (The R Foundation for Statistical Computing) (R Core Team, 2019).

2.2.1. Income decile estimation

For comparison purposes, we matched the reported income in the survey to the income distribution, at the population level, in each country. The idea was to identify the income position of a person in their country. To do so, we used income deciles, a measure that divides the population, ranked by income, into 10 groups.

Participants of the survey reported income levels. Therefore, to obtain point estimates of the income, we implemented random draws (10.000) using the reported income as a cutoff. In this way, we guaranteed comparable distributions between the reported and estimated

[1] There is a difference in the health outcomes between countries and a difference in income within countries.

income. To compare our results across countries, the reported household income was standardized by the country currency, periodicity, and purchasing power parity (PPP). We also adjusted the income variable by household size. Depending on the external source of the income distribution, the estimation of the income decile might show small differences because of the weights to account for the household size and the ages of the family members. Nevertheless, we consider these differences do not affect our results, as, in our sample, we did not observe a high variation in the size of the households.

2.2.2. Health outcome variables

To estimate the health income gap, we constructed two health outcomes 1) the number of years a person with SCI has lived since the injury, and 2) a comorbidity index. In the first case, years living with injury were computed as the difference between the age at the time of the survey and the reported year of the injury. In the second case, the comorbidity index is a proxy for the health status of a person. The index was constructed using 14 self-reported health problems in the survey plus an indicator for depression, which is of high relevance to the SCI population (DeVivo et al., 1991; Gross-Hemmi et al., 2017; Savic et al., 2018). The indicator of depression comes from the question: Have you felt downhearted and depressed?

The index was computed as the sum of the 15-health problems (h), weighted by their estimated mortality risk (ω_h) (Buzzell et al., 2020; Cao et al., 2019; DiPiro et al., 2019; Frankel et al., 1998; Garshick et al., 2005; Lidal et al., 2007; Minaire et al., 1983; Neumann et al., 2009; Osterthun et al., 2014; Sabre et al., 2013; Savic et al., 2017; Soden et al., 2000; World Health Organization, 2016), times the reported severity (T_{ih}) (see appendix). The severity was ranked as "chronic" (value 2), mild or moderate (value 1), and no problem (value 0). In formal terms:

$$H_i = \sum_{h=1}^{15} \omega_h * T_{ih}$$

The index ranged from zero to 54. For interpretation purposes, we rescaled the predicted values between zero, for a person with a low-comorbidity index, and 1 for a person with a high comorbidity index.

Both outcomes, years living with SCI and the comorbidity index, were adjusted by age, gender, country of residence, personal characteristics, and lesion characteristics. The comorbidity index was also controlled for the age at the time of the injury (Brinkhof et al., 2016; Buzzell et al., 2019; Cao et al., 2019; Claxton et al., 1998; DiPiro et al., 2019; Frankel et al., 1998; Furlan et al., 2009; Krause et al., 2009; Varma et al., 2010; World Health Organization and International Spinal Cord Society, 2013, p. 231).

2.2.3. Hierarchical and individual models

To estimate the adjusted health outcome in the sample, we used multi-level models with random effects by country (intercept) and individual income (slope).[2] The general model at the individual level (i) in each country (j) is represented by the following equation (Gelman and Hill, 2006):

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + \varepsilon_{ij}$$

where Y_{ij} represents the health outcome for individual (i) in country (j).

β_{0j} random intercept for country (j).

β_{1j} regression coefficient associated with the independent variables for country (j).

X_{ij} is the vector of the independent variables by individual (i) and country level (j).

ε_{ij} the random error associated with individual (i) in country (j).

At the country level, the coefficients β_{0j} and β_{ij} are used with the following equations:

$$\beta_{0j} = \tau_{00} + \mu_{0j}$$

$$\beta_{1j} = \tau_{10} + \mu_{1j}$$

where τ_{10} is the common slope to all countries. This model can also be written:

$$Y_{ij} = \tau_{00} + \tau_{10} X_{ij} + \mu_{0j} + \mu_{1j} X_{ij} + \varepsilon_{ij}$$

The "fixed" part is: $\tau_{00} + \tau_{10} X_{ij}$ and the "random" part is: $\mu_{0j} + \mu_{1j} X_{ij} + \varepsilon_{ij}$. This model shows that the relationship between X and Y is not constant between countries.

When the dependent variable (Y_{ij}) is *years living with SCI*, the variables in X_{ij} included the income decile, the age at the time of the injury, gender, paraplegia/tetraplegia, extent (completeness) of the injury, and cause of the injury. When the dependent variable (Y_{ij}) is the *comorbidity index*, the equation was adjusted by gender, age, years lived with the injury, cause, extent and type of the injury, smoking status, and income at individual level (decile).

To account for the role that the country income plays to determine health, the statistical models included the GDP per capita (in constant terms at PPP prices). This variable, for comparison purposes across countries, is a relative indicator that is measured as a fixed effect, i.e., constant for every person within each country. The country income ranks the countries by how poor or rich they are in the sample. In addition, the models also include a country indicator for the intercept as a random effect, and the income decile as random effects for the slope.

Hierarchical models allowed the analysis of individual variables, as the personal income or specific characteristics of the participants and country variables, as GDP per capita. However, there might be some heterogeneity that was not captured by the model. Therefore, as a sensitivity test of our results, we re-analyzed our data country by country. Multiple regressions were used to estimate the relationship between income and health outcomes in each country. The variables were the same as in the hierarchical model, with the exception of the aggregate income.

Finally, using the predicted values of the models, we plotted the gap in the years living with SCI and the comorbidities by the cause of injury. We grouped the deciles 8, 9, and 10 to show the income gap at the highest income levels.

3. Results

3.1. Descriptive statistics

The InSCI survey included 12,591 participants in 22 countries; excluding missing values in the reported income, the sample counted with 11,530 observations. As we aimed to estimate and compare across countries the health-income gap, we included in the analysis only those countries with observations in almost all income levels. The excluded countries were those that presented clear self-selection in the sample related to the income distribution, yielding 9014 cases (72% of the original data). As we focused on traumatic SCI etiologies (81%), 7272 cases remained after the removal of non-traumatic cases. The final estimations used data for countries including Poland, Germany, France, Switzerland, Spain, Greece, Romania, South Korea, China, and Australia. The sample represented 51% of the original data, with a total of 6445 participants.

Four countries constituted 61% of the data: Australia (17%), Germany (16%), Switzerland (14%), and China (14%). The average age of included participants was 51.5 (median: 52) years, and 36 (median: 33) years was the average age at the time of the injury. Of those surveyed,

[2] The causes of the injury is a multiple question, so more of one cause could be choice.

Table 1
Sociodemographic, lesion characteristics and adjusted health outcomes by country.

		Country																					
Variables	Statistics	Australia		China		France		Germany		Greece		South Korea		Poland		Romania		Spain		Switzerland		Total	
Age	median (q1; q3)	57	(47; 66)	49	(40; 56)	52	(40; 60)	56	(45; 65)	46	(37; 54)	49	(40.5; 57)	45	(36; 55)	37	(30; 45)	49	(40; 58)	57	(48; 67)	52	(41; 62)
Age SCI		35	(23; 51)	45	(34; 52)	27	(20; 42)	39	(23; 54)	27	(20; 36)	31	(23; 40)	28	(21; 40)	28	(21; 37)	28	(20; 39)	30	(21; 45)	33	**(23;47)**
Years living with SCI		20.5	(15; 24.8)	5.8	(2.8; 9.5)	22.0	(16.4; 24.3)	17.1	(11.8; 22.4)	18.3	(15.2; 20.5)	18.7	(15.2; 21.1)	17.3	(13.3; 19.4)	10.8	(7.5; 12.8)	20.3	(16.2; 22.5)	25.9	(20.7; 29)	17.7	**(11.6;22.5)**
Comorbidity index		0.48	(0.42; 0.53)	0.24	(0.17; 0.29)	0.31	(0.25; 0.35)	0.51	(0.45; 0.55)	0.35	(0.29; 0.38)	0.83	(0.79; 0.86)	0.52	(0.48; 0.56)	0.38	(0.31; 0.41)	0.38	(0.32; 0.42)	0.3	(0.29; 0.4)	0.44	**(0.32;0.54)**
Males	n (%)	877	78%	689	77%	235	78%	808	76%	123	76%	571	77%	692	86%	141	80%	228	76%	653	74%	5′017	**78%**
Paraplegia		619	55%	625	70%	194	64%	520	49%	104	64%	425	58%	418	52%	119	67%	189	63%	601	69%	3′814	**59%**
Causes:																							
Traffic accidents		454	40%	269	30%	166	55%	405	38%	90	56%	380	51%	284	35%	60	34%	149	50%	315	36%	2′572	**40%**
Falls		233	21%	313	35%	66	22%	330	31%	29	18%	176	24%	255	32%	64	36%	56	19%	247	28%	1′769	**27%**
Sport		123	11%	41	5%	20	7%	253	24%	4	2%	35	5%	36	4%	6	3%	11	4%	157	18%	686	**11%**
Leisure		248	22%	96	11%	28	9%	255	24%	14	9%	57	8%	187	23%	31	18%	32	11%	170	19%	1′118	**17%**
Work accidents		176	16%	162	18%	40	13%	150	14%	23	14%	119	16%	151	19%	27	15%	56	19%	142	16%	1′046	**16%**
Violence		13	1%	25	3%	6	2%	9	1%	3	2%	6	1%	10	1%	1	1%	7	2%	22	3%	102	**2%**
Total		**1124**	**17%**	**898**	**14%**	**303**	**5%**	**1061**	**16%**	**162**	**3%**	**739**	**11%**	**805**	**12%**	**177**	**3%**	**299**	**5%**	**877**	**14%**	6′445	**100%**
SCI etiology (using the complete data)																							
Traumatic	n (%)	1′305	83%	869	66%	330	81%	1′234	79%	159	85%	815	92%	861	89%	180	84%	320	77%	1′199	79%	7′272	**81%**
Non traumatic		258	17%	438	34%	77	19%	327	21%	28	15%	69	8%	104	11%	35	16%	94	23%	312	21%	1′742	**19%**
Total		**1′563**	**100%**	**1′307**	**100%**	**407**	**100%**	**1′561**	**100%**	**187**	**100%**	**884**	**100%**	**965**	**100%**	**215**	**100%**	**414**	**100%**	**1′511**	**100%**	9′014	**100%**

Notes: Participants could choose more than one cause of the injury.
-Years living with SCI were adjusted by the age of the injury and gender.
-The comorbidity index was adjusted by years lived with the injury and gender.
-q1 is the first quartile and q3 is the third quartile.

Table 2
Hierarchical model results.

Predictors	Years living with the injury			Comorbidity index		
	Estimates	CI	p	Estimates	CI	p
(Intercept)	16.97	15.49–18.46	< **0.001**	0.34	0.30–0.39	< **0.001**
Age injury	−6.12	−6.38–−5.86	< **0.001**			
Gender: Female	−0.29	−0.88 – 0.29	0.324	0.02	0.01–0.03	0.004
Injury level: Tetraplegia	−0.25	−0.76 – 0.26	0.343	0.05	0.04–0.06	< **0.001**
Injury Extent: Incomplete	−0.88	−1.39–−0.37	**0.001**	−0.05	−0.06–−0.04	< **0.001**
Cause: Work accidents	1.16	0.42–1.91	**0.002**	0.02	0.00–0.03	**0.028**
Cause: Traffic accidents	0.23	−0.48 – 0.93	0.527	0.01	−0.01 – 0.02	0.456
Cause: Falls	−0.51	−1.18 – 0.15	0.132	0.01	−0.00 – 0.02	0.103
Cause: Violence	0.41	−1.56 – 2.37	0.685	0	−0.04 – 0.04	0.988
Cause: Leisure activities	−0.16	−0.90 – 0.58	0.67	−0.01	−0.02 – 0.01	0.471
Cause: Sport accidents	−2.34	−3.21–−1.47	< **0.001**	−0.01	−0.03 – 0.01	0.268
Personal income	0.5	−0.13 – 1.12	0.121	−0.02	−0.04–−0.01	< **0.001**
GDP_pc in USD	5.45	3.81–7.08	< **0.001**	0.03	−0.01 – 0.06	0.11
Age				0.01	0.01–0.02	< **0.001**
Years since the injury				0	−0.01 – 0.00	0.697
Smoking status: Former smoker				0.03	0.02–0.04	< **0.001**
Smoking status: Current smoker				0.03	0.02–0.04	< **0.001**
Random Effects						
σ^2	90.49			0.03		
τ_{00}	4.26	country code		0.00	country code	
τ_{11}	0.77	country code × individual income		0	country code × individual income	
ρ_{01}	0.12	country code		−0.81	country code	
ICC	0.05			0.12		
N	10	country code		10	country code	
Observations	6272			6202		
Marginal R^2/Conditional R^2	0.406/0.437			0.067/0.178		

Notes: The reference variables are gender-male, injury level-paraplegia, injury extend-complete, cause-others, smoking status-no smoker.
-For the years living with SCI the significant variables are the intercept, age of injury, incomplete injury, work accidents, and GDP per capita. The random slope (a different slope for the income variable in each country) has a variance of 0.77; this is sizeable and reflects the heterogeneity in the relationship between income and years living with injury across countries. The proportion of the total variance in the years living with SCI within the country-level is low (interclass correlation coefficient –ICC).
-For the comorbidity index, the random slope has a zero variance. This means that there is no variation, and the random slope could be drop without losing anything. However, using models with only interactions between income decile and country do not allow the country-specific covariates as GPD pp. In this model, the significant variables are intercept, gender, type of injury, degree, work accidents, personal income, smoker conditions, and age. The ICC index is 0.12, showing more correlation among observations within the same cluster.

78% were males. The most common causes of SCI were traffic accidents (40%), falls (27%), leisure (17%), and work-related injuries (16%),[3] with 59% of the persons with SCI having paraplegia, although in Germany and Poland, paraplegia affected 49%, and 52% of SCI cases, respectively. Using a hierarchical model, people with SCI had lived an average of 17.7 years lived with the injury (Q1:11.6; Q3:22.5) .[4] In Switzerland, people had lived the longest with an average of 26 years (Q1: 20.7; Q3:29) and China had the shortest average with 6 years[5] (Q1: 2.8; Q3: 9.5). The median value for comorbidity index in the sample was 0.44 (Q1: 0.32; Q3:0.54), China and France showed values less than 0.31, whereas South Korea showed a value of around 0.83 (Table 1).

3.2. The health-income gap

Years living with SCI

The results showed that the income designation affects the health outcomes in different ways. For the years living with SCI, the country income measure through the aggregate country income (GDP per capita) better predicted this variable. An increase of one standard deviation in the GDP was associated with an increase of 5.45 years living with the injury, while one more standard deviation of income individual-level (income decile) was associated with an additional 0.5 year, which was not significant (Table 2).

The results varied considerably across countries, where the average estimated difference was of about 2 years. Greece reported the steepest health-income gap with 6.8 years difference between the richest and the poorest deciles, followed by Germany (5.1 years), France (4.5 years), and Switzerland (4.3 years). Australia and Spain showed similar results with almost 1.5 years. Interestingly, South Korea and China showed a different pattern than other countries, in which people in higher income deciles reported fewer years living with SCI (Fig. 1).

Comorbidity index

For the comorbidity index, the individual income (deciles) better predicted the results. People with SCI in higher income deciles reported a lower comorbidity index by 0.02 or 2%. The results at the country level showed that the steepest gap was reported in Germany with a 35.7% gap, Romania with a 35.4% gap, followed by South Korea with a 32.3% gap. Interestingly, France showed a deviating pattern, where higher income groups reported also a higher comorbidity index; however, the difference was not significantly different from zero (Fig. 2).

3.2.1. The health-income gap by cause of the injury

Years living with SCI. Disaggregating the results by the cause of injury gives a picture of the roots of the estimated inequality. In the case of the years lived with SCI, the results showed the biggest difference when the injury was caused by a work-related injury. People in richer deciles lived, on average, 2 years longer with the injury than people in the lowest decile. Injuries caused by traffic, sports, and leisure accidents reported differences of less than a year. No big differences were seen in the results of violence and falls (Fig. 3).

[3] The left value is the first quartile and the right value the third quartile.
[4] China has a lower average of years since SCI because they do not have electronic health records in many cases for people who have been injured earlier than 10 years before the survey.

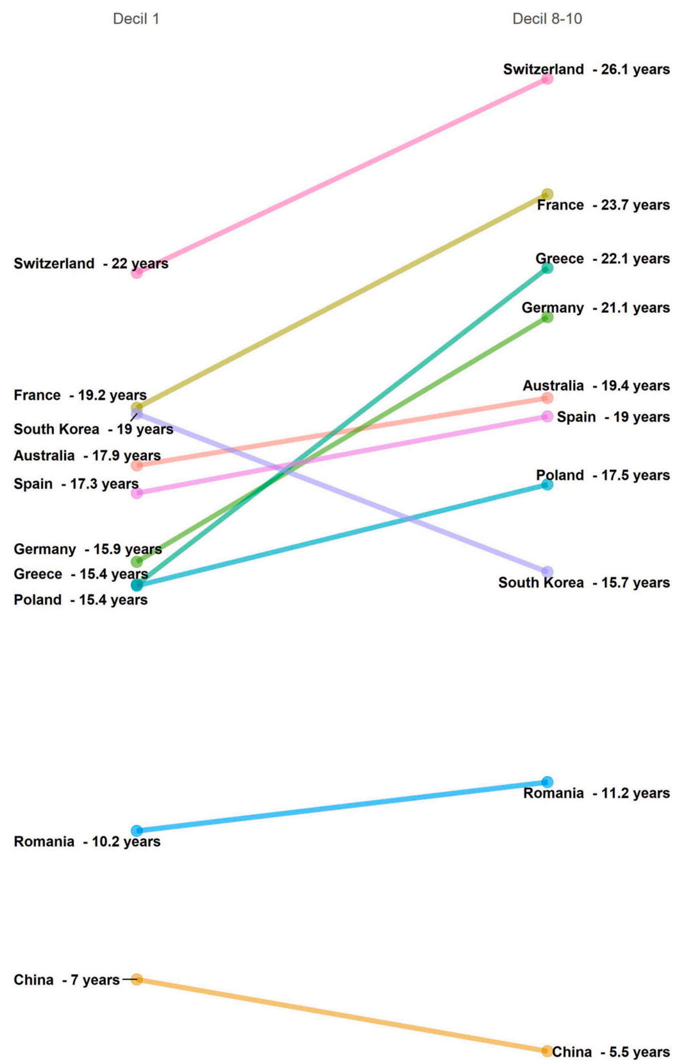

Fig. 1. The gap in the years living with SCI by income and country.

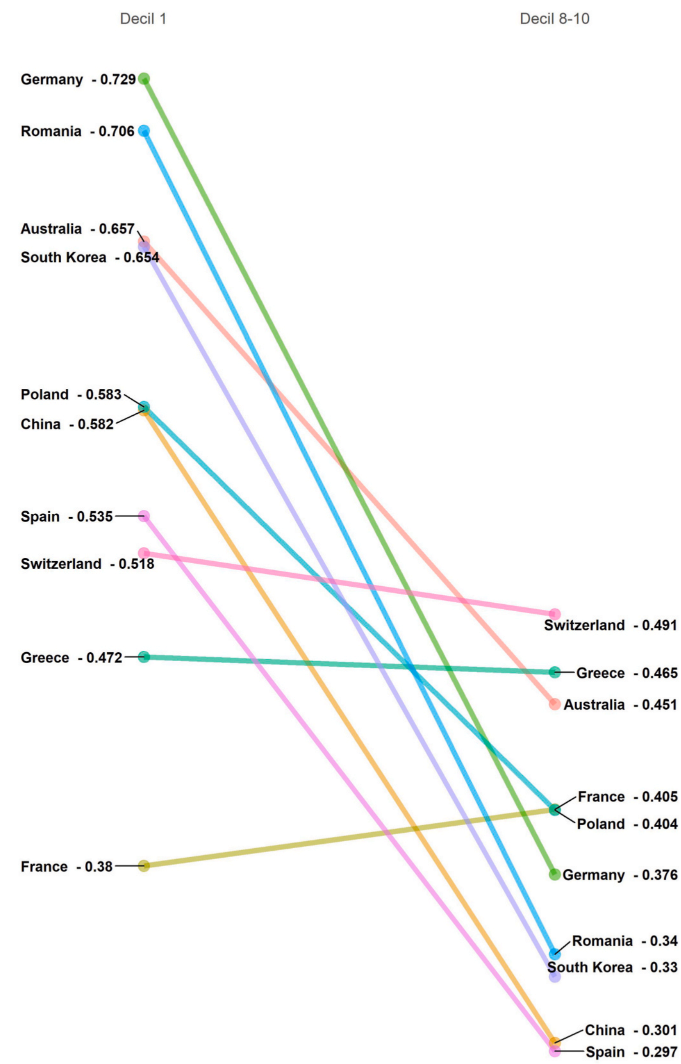

Fig. 2. The gap in the morbidity index by income and country.

Comorbidity index. For the comorbidity index, the results showed the biggest difference when the injury was caused by traffic crashes (18.7%), falls (16.6%), sports (16.4%), and leisure accidents (15.3%). Work-related injuries and violence showed differences of around 8% (Fig. 4).

3. Discussion

This study uses newly available data on the living situations of people with SCI to measure the health-income gap in 10 countries. Due to the lack of information on mortality data for persons with SCI, we use two health outcomes to estimate the gap: years living with SCI, and a comorbidity index. The results show that, on average, persons in the richest income groups live longer with the injury and have fewer comorbidities. In the case of years living with SCI, the results show that work-related injuries explain most of the gap, showing that the type of job before the accident are the key determinants of the disparities (Bae et al., 2019; Wu et al., 2018). As for the comorbidity index, the steepest gap is displayed by injuries caused by falls, traffic accidents, sports accidents, and leisure injuries. When comparing the results between the two health outcomes, it is possible to see that the curves display similar results (see Figs. 1–4).

Our models include a measure of GDP per capita to account for the relative development of a country compared to others in the sample, and an individual income variable to account for the financial situation of the person with SCI. The idea to include both measures is to get a better estimate of the relationship between personal income and health. In fact, in some countries access to timely and high-quality services is less dependent on the financial situation of a person because the access is universal. The results show that in the case of the first outcome “years living with SCI”, the GDP per capita is a better predictor of the disparities, whereas, for the comorbidity index, personal income is more important. This means that the “years living with SCI” is highly dependent on the response and quality of the health system, but it also depends on other measures of a country’s development like comprehensive social support to persons with disabilities, environment, and violence, among others (Bae et al., 2019). In contrast, for the comorbidity index, personal income played a more important role as it is a better measure of access to health services a person has. Nevertheless, it is important to highlight that regardless of how much each of these two definitions affects the health outcomes, they show a substantial variation by the cause of injury and across countries.

Some countries show a reverse relationship, in which people in poorer deciles reported better health outcomes. More specifically, for the “years living with SCI”, people in the poorest groups in China and Korea are observed more years living with their injury than the people in richer deciles. This result, even when counterintuitive, has two potential explanations: One, related to differences in the collected sample, where people in poorer groups were more likely to be observed in the sample due to the insurance coverage that is mostly public. Two, by

Fig. 3. The gap in the years living with SCI by income and cause of the injury.

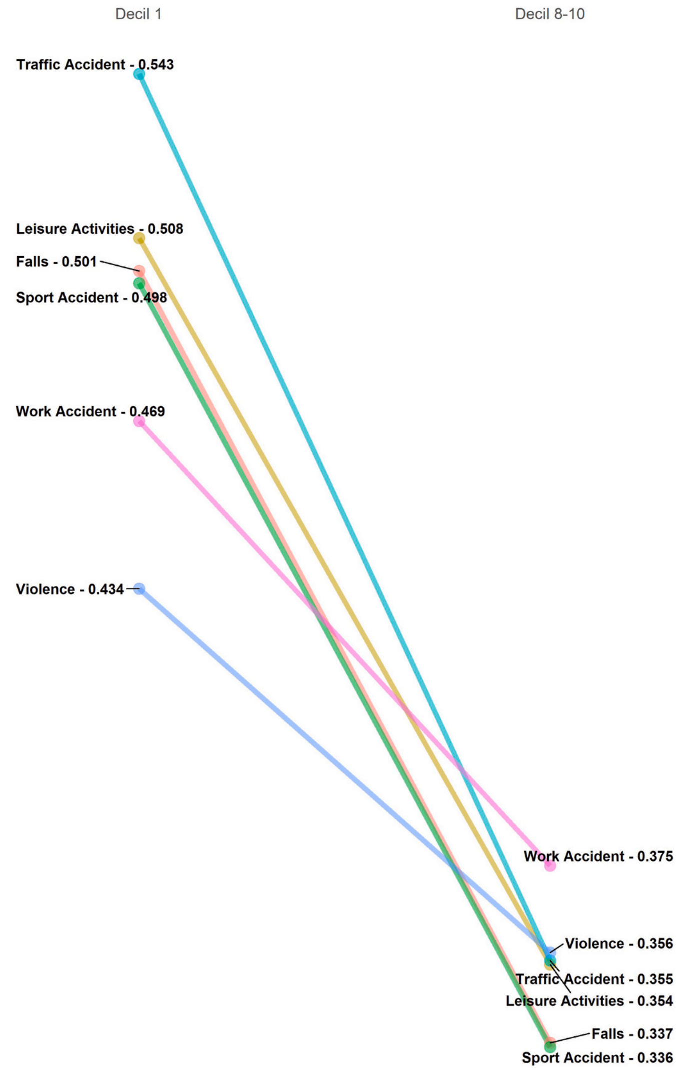

Fig. 4. The gap in the morbidity index by income and cause of the injury.

improvements of the public health system in the mentioned countries, which have shown a better health care response and an expansion of the health care coverage in recent years where people in poorer groups may be the most benefited (Lee et al., 2018; Meng et al., 2019; World Health Organization, 2015a, 2015b, p. 365; Yip et al., 2020). Nevertheless, it is important to mention that these results might reflect the situation in urban areas in China, and the results in rural China may be different. Similarly, France, Switzerland, and Greece show an inverse relationship in the comorbidity index. Nevertheless, the differences are not significantly different from zero, which means that the situation seems to be similar for people in poor and richer deciles, i.e., the income position does not play a role.

Our findings have implications on how the health and social systems support people living with long-term disabilities. In the case of the “time with the injury”, where inequality seems to arise from the cause of injury, suggest that interventions should be designed beyond the health system and might involve other public measures like occupational safety codes that prevent work injuries, or more comprehensive and specialized vocational rehabilitation services that guarantee labor market reintegration after the injury especially for low-income groups. The marked differences in the comorbidities by income level suggest that the health system should put greater attention to people in lower-income groups to guarantee access to health services and timely treatment. Nevertheless, these measures should be thought of analyzed in the context of each country.

Although we estimated the health income gap using proxy variables for mortality, the indicators show the expected behavior in the total estimates, and across countries. With this paper, we claim that both measures, years living with the injury and the comorbidity index, are a good proxy for mortality, as the health status of persons with SCI is highly dependent on the performance of the health system and the quality of its services (Pacheco Barzallo et al., 2020; World Health Organization and International Spinal Cord Society, 2013, p. 231). If the response of the social and health systems were appropriate, inequalities due to income should be ineligible, where people with SCI should have a similar health outcome across income groups. In countries with fewer resources, where the response of the health systems is delayed, and its access depends on the financial situation of a person, people with paraplegia show a significantly reduced life expectancy, and people with tetraplegia is almost inexistent as they die soon after the injury (World Health Organization and International Spinal Cord Society, 2013, p. 231). Similarly for the comorbidity index, which is a good indicator of the general health status of a person, where a very high index is a good indicator for the proximity to death (Howdon and Rice, 2018).

The estimated health-income gap suggests that income is a crucial variable to explain health disparities. However, health inequalities have complex interrelationships with other personal and environmental factors that contribute to this persistence. Therefore, the results of this paper should be taken as descriptive evidence of the relationship between health and income, avoiding any causal interpretation. In fact, any intervention intended to reduce health inequalities should first consider individuals with the same conditions to obtain more accurate estimates of the health income gap (Langellier, 2016). In addition, since this relationship changes substantially across areas and over time, even in high-income countries (Chetty et al., 2016), the fundamental causes of health inequalities should be assessed by collecting better data over time and between and within populations.

Finally, this study has several strengths worth mentioning. First, this research discusses the correlation between income and health for people with SCI in ten countries around the world. Second, we formulated a standard income definition to correct for self-selection in the sample. Each participant was located according to their socio-economic position in their country, and thus it was possible to compare their health conditions to other citizens in the same country, and across countries. Third, the computed comorbidity index was validated against the probability to visit SCI specialists, a variable that is a good proven indicator of mortality risk (DiPiro et al., 2019). Finally, we built a specific measurement of income inequalities in health for InSCI survey, which could be used for monitoring purposes.

4. Limitations

There are some limitations that have to be mentioned when considering our results:

First, data concerning reported income levels was not collected with our research objective in mind, which resulted in several countries to be excluded. In fact, in some countries, people in specific income deciles were not observed, especially for the highest income groups, which means the income-gap does not include those at the top. This implies that our results are likely to be an underestimation of the health-income gap of persons with SCI. As the survey provided one question related to the household income, the accuracy of the income measurement was difficult to test.

Second, as country registries of persons with SCI are almost inexistent, our results cannot be extrapolated to the population level, but they can be used as a reference point to identify factors that determine the gap. Even though our sample included some countries that displayed a convenience sampling, 73% of our data came from countries that applied random samples (Gross-Hemmi et al., 2017).

Finally, due to the sample limitations, our study used data on traumatic SCI and excluded non-traumatic causes. As the health-income gap for non-traumatic causes could be more important, as inequalities play a more important role for this group, we think future versions of the survey should make an extra effort to gather data of this group. Excluding non-traumatic causes make our results rather conservative.

5. Conclusion

This article provides evidence of the health-income gap for people with SCI, in which people in higher-income groups have lived more years living with the injury and experienced fewer comorbidities than people in poorer income groups. The estimated gap varies significantly across countries, where the main driver of such inequality is the cause of injury: work-related injuries, sports accidents, and traffic crashes displayed the highest gap. As the survival of people with SCI is highly dependent on the response and quality of the health system, our results suggest the importance to eliminate barriers that keep people in poorer groups from getting timely and adequate care.

Ethical statement

Ethical approval is not required, the study used anonymized data from the International Spinal Cord Injury Survey (InSCI). The InSCI Study Group approves all studies bases on data from this community survey, including the present study.

CRediT authorship contribution statement

Ana Oña: Conceptualization, Formal analysis, Methodology, Writing – original draft. **Vegard Strøm:** Investigation, Conceptualization, Writing – review & editing. **Bum-Suk Lee:** Investigation, Writing – review & editing. **Marc Le Fort:** Investigation, Writing – review & editing. **James Middleton:** Investigation, Writing – review & editing. **Christoph Gutenbrunner:** Investigation, Writing – review & editing. **Diana Pacheco Barzallo:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare to have no conflicts of interest.

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The members of the InSCI Steering Committee are: Julia Patrick Engkasan (ISPRM representative), James Middleton (ISCoS representative; Member Scientific Committee; Australia), Gerold Stucki (Chair Scientific Committee), Mirjam Brach (Representative Coordinating Institute), Jerome Bickenbach (Member Scientific Committee), Christine Fekete (Member Scientific Committee), Christine Thyrian (Representative Study Center), Linamara Battistella (Brazil), Jianan Li (China), Brigitte Perrouin-Verbe (France), Christoph Gutenbrunner (Member Scientific Committee; Germany), Christina-Anastasia Rapidi (Greece), Luh Karunia Wahyuni (Indonesia), Mauro Zampolini (Italy), Eiichi Saitoh (Japan), Bum Suk Lee (Korea), Alvydas Juocevicius (Lithuania), Nazirah Hasnan (Malaysia), Abderrazak Hajjioui (Morocco), Marcel W. M. Post (Member Scientific Committee; The Netherlands), Johan K. Stanghelle (Norway), Piotr Tederko (Poland), Daiana Popa (Romania), Conran Joseph (South Africa), Mercè Avellanet (Spain), Michael Baumberger (Switzerland), Apichana Kovindha (Thailand), Reuben Escorpizo (Member Scientific Committee, USA).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100854.

References

Bae, S. W., et al. (2019). Changes in income after an industrial accident according to industry and return-to-work status. *International Journal of Environmental Research and Public Health, 16*(14), 2603.
Brinkhof, M. W., et al. (2016). Health conditions in people with spinal cord injury: Contemporary evidence from a population-based community survey in Switzerland. *Journal of Rehabilitation Medicine, 48*(2), 197–209.
Buuren, S.v., & Groothuis-Oudshoorn, K. (2010). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, 1–68.
Buzzell, A., et al. (2019). Survival after non-traumatic spinal cord injury: Evidence from a population-based rehabilitation cohort in Switzerland. *Spinal Cord, 57*(4), 267–275.
Buzzell, A., et al. (2020). All-cause and cause-specific mortality following non-traumatic spinal cord injury: Evidence from a population-based cohort study in Switzerland. *Spinal Cord, 58*(2), 157–164.
Cao, Y., DiPiro, N., & Krause, J. S. (2019). Health factors and spinal cord injury: A prospective study of risk of cause-specific mortality. *Spinal Cord, 57*(7), 594–602.

Chamberlain, J. D., et al. (2015). Mortality and longevity after a spinal cord injury: Systematic review and meta-analysis. *Neuroepidemiology, 44*(3), 182–198.
Chetty, R., et al. (2016). The association between income and life expectancy in the United States, 2001-2014. *Journal of the American Medical Association, 315*(16), 1750–1766.
Claxton, A. R., et al. (1998). Predictors of hospital mortality and mechanical ventilation in patients with cervical spinal cord injury. *Canadian Journal of Anaesthesia, 45*(2), 144.
Deaton, A. (2003). Health, inequality, and economic development. *Journal of Economic Literature, 41*(1), 113–158.
DeVivo, M. J., et al. (1991). Suicide following spinal cord injury. *Spinal Cord, 29*(9), 620–627.
DiPiro, N. D., Cao, Y., & Krause, J. S. (2019). A prospective study of health behaviors and risk of all-cause and cause-specific mortality after spinal cord injury. *Spinal Cord, 57*(11), 933–941.
Zaninotto, P., et al. (2020). Socioeconomic inequalities in disability-free life expectancy in older people from england and the United States: A cross-national population-based study. *Journal of Gerontology: Series A, 75*(5), 906–913.
Eurostat, in information society Statistics database.
Fekete, C., et al. (2017). A structured approach to capture the lived experience of spinal cord injury: Data model and questionnaire of the international spinal cord injury community survey. *American Journal of Physical Medicine and Rehabilitation, 96*(2), S5–S16.
Fekete, C., et al. (2020). Cohort profile of the international spinal cord injury (InSCI) community survey implemented in 22 countries. *Archives of Physical Medicine and Rehabilitation, 96*(2).
Frankel, H., et al. (1998). Long-term survival in spinal cord injury: A fifty year investigation. *Spinal Cord, 36*(4).
Furlan, J. C., Kattail, D., & Fehlings, M. G. (2009). The impact of co-morbidities on age-related differences in mortality after acute traumatic spinal cord injury. *Journal of Neurotrauma, 26*(8), 1361–1367.
Garshick, E., et al. (2005). A prospective assessment of mortality in chronic spinal cord injury. *Spinal Cord, 43*(7), 408–416.
Gelman, A., & Hill, J. (2006). *Data analysis using regression and multilevel/hierarchical models*. Cambridge university press.
Gross-Hemmi, M. H., et al. (2017). Study protocol of the international spinal cord injury (InSCI) community survey. *American Journal of Physical Medicine & Rehabilitation, 96*(2 Suppl 1), S23–S34.
Howdon, D., & Rice, N. (2018). Health care expenditures, age, proximity to death and morbidity: Implications for an ageing population. *Journal of Health Economics, 57*, 60–74.
Krause, J. S., Carter, R. E., & Pickelsimer, E. (2009). Behavioral risk factors of mortality after spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 90*(1), 95–101.
Krause, J. S., Saunders, L. L., & DeVivo, M. J. (2011). Income and risk of mortality after spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 92*(3), 339–345.
Langellier, B. A. (2016). An agent-based simulation of persistent inequalities in health behavior: Understanding the interdependent roles of segregation, clustering, and social influence. *SSM-Population Health, 2*, 757–769.
Lee, G., Yang, S.-J., & Woo, E. (2018). Past, present, and future of home visiting healthcare services based on public health centers in Korea. *Journal of Korean Public Health Nursing, 32*(1), 5–18.
Lidal, I. B., et al. (2007). Mortality after spinal cord injury in Norway. *Journal of Rehabilitation Medicine, 39*(2), 145–151.
Meng, Q., et al. (2019). *What can we learn from China's health system reform? Bmj*.
Middleton, J., et al. (2012). Life expectancy after spinal cord injury: A 50-year study. *Spinal Cord, 50*(11), 803–811.
Minaire, P., et al. (1983). Life expectancy following spinal cord injury: A ten-years survey in the rhone-alpes region, France, 1969-1980. *Spinal Cord, 21*(1), 11–15.
National Bureau of Statistics of China. (2019). *China Statistical yearbook*.
Neumann, C. R., Brasil, A. V., & Albers, F. (2009). Risk factors for mortality in traumatic cervical spinal cord injury: Brazilian data. *Journal of Trauma and Acute Care Surgery, 67*(1), 67–70.
Osterthun, R., et al. (2014). Causes of death following spinal cord injury during inpatient rehabilitation and the first five years after discharge. A Dutch cohort study. *Spinal Cord, 52*(6), 483–488.
Outhwaite, W., & Turner, S. (2007). *The SAGE handbook of social science methodology*. Sage.
Pacheco Barzallo, D., et al. (2020). Quality of life and the health system: A 22-country comparison of the situation of people with spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 101*(12), 2167–2176.
Pickett, K. E., & Wilkinson, R. G. (2015). Income inequality and health: A causal review. *Social Science & Medicine, 128*, 316–326.
Quan, H., et al. (2011). Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *American Journal of Epidemiology, 173*(6), 676–682.
R Core Team, R. (2019). *A language and environment for statistical computing*. R Foundation for Statistical Computing.
Reinhardt, J. D., et al. (2012). Social inequalities of functioning and perceived health in Switzerland–a representative cross-sectional analysis. *PloS One, 7*(6), Article e38782.
Riley, A. R. (2020). Advancing the study of health inequality: Fundamental causes as systems of exposure. *SSM-Population Health, 10*, 100555.
Sabre, L., et al. (2013). Mortality and causes of death after traumatic spinal cord injury in Estonia. *The Journal of Spinal Cord Medicine, 36*(6), 687–694.
Savic, G., et al. (2017). Causes of death after traumatic spinal cord injury—a 70-year British study. *Spinal Cord, 55*(10), 891–897.
Savic, G., et al. (2018). Suicide and traumatic spinal cord injury—a cohort study. *Spinal Cord, 56*(1), 2–6.
Soden, R., et al. (2000). Causes of death after spinal cord injury. *Spinal Cord, 38*(10), 604–610.
Solinsky, R., & Kirshblum, S. C. (2018). Challenging questions regarding the international standards. *J Spinal Cord Med, 41*(6), 684–690.
Spinakis, A., et al. (2011). *Expert review and proposals for measurement of health inequalities in the European Union–full report*. Luxembourg: European Commission Directorate General for Health and Consumers.
Statistics Korea. (2019). *Household trend survey*.
Truesdale, B. C., & Jencks, C. (2016). The health effects of income inequality: Averages and disparities. *Annual Review of Public Health, 37*, 413–430.
Varma, A., et al. (2010). Predictors of early mortality after traumatic spinal cord injury: A population-based study. *Spine, 35*(7), 778–783.
Wilkins, N. J., et al. (2019). Societal determinants of violent death: The extent to which social, economic, and structural characteristics explain differences in violence across Australia, Canada, and the United States. *SSM-Population Health, 8*, 100431.
Luxembourg income study (LIS) (2020) Database, http://www.lisdatacenter.org, in (multiple countries; may 2020-sep 2020). Luxembourg: LIS.
Word inequality database (WID) in *(multiple countries)*. WID.word.
World Health Organization. (2013). *Handbook on health inequality monitoring: With a special focus on low-and middle-income countries*. World Health Organization.
World Health Organization. (2015a). *People's Republic of China health system review*. Manila: WHO Regional Office for the Western Pacific.
World Health Organization. (2015b). *Republic of Korea health system review*. Manila: WHO Regional Office for the Western Pacific.
World Health Organization, *Global Health Estimates*. (2016). *Disease burden by cause, age, sex, by country and by region, 2000-2016. . 2018:*. Geneva.
World Health Organization, Social determinants of health. (2021). *Excecutive board 148th session. Provisional agenda item 16*.
World Health Organization and International Spinal Cord Society. (2013). *International perspectives on spinal cord injury*. xiii.
Wu, Y., Schwebel, D. C., & Hu, G. (2018). Disparities in unintentional occupational injury mortality between high-income countries and low-and middle-income countries: 1990–2016. *International Journal of Environmental Research and Public Health, 15*(10), 2296.
Yip, W. C.-M., et al. (2020). *Realignment of incentives for health care providers in China.* Health care policy in east asia: A world scientific reference. *Health Care System Reform and Policy Research in China, 1*, 25–50.