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Education, job position, income or multidimensional indices? The influence of different indicators of socioeconomic status on low back pain in a German sample

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ABSTRACT:

Objectives: Comparison of the influence of most common socioeconomic status (SES) indicators (education, job position, income, multidimensional index) on intermitted low back pain in a single sample.

Design: Longitudinal observational study

Setting: Four medical clinic sides in Germany

Participants: 381 people. Inclusion criteria: 1) age 18 to 65, 2) able to understand the meaning of the study and to complete a questionnaire without help.

Exclusion criteria: 1) pregnancy, 2) serious pain syndromes in the last 3 month, 3) inability to stand upright, 4) inability to give sick leave information, 5) signs of serious spinal pathology, 6) not completed all relevant questions needed for the different SES operationalisations.

Outcome measures: Intensity of intermitted low back pain (LBP) and disability because of intermitted LBP.

Results: Hierarchical linear regression revealed that for LBP intensity the multidimensional index (*beta*=-0.12, *p*<0.01), job position (*beta*=0.11, *p*=0.01) and education (*beta*=-0.10, *p*<0.05) had equally high impacts. Income had no significant influence (*beta*=0.04, n.s.). For LBP disability the multidimensional index (*beta*=-0.21, *p*<0.01) and job position (*beta*=0.20, *p*<0.01) had the highest influence. Education (*beta*= -0.13, *p*<0.01) and income (*beta*=-0.13, *p*=0.01) had equal but less strong impacts.

Conclusion: The results reveal that different indicators have different strong influences on intermitted LBP and therefore should not be treated interchangeably. Job position is the most important single indicator. Prevention and intervention work therefore should focus on the areas influences by job position. In general more research on the relationship between SES and health outcomes is needed.

STRENGTHS AND LIMITATIONS OF THIS STUDY:

- The paper expands the analysis of the influence of different indicators of the SES on a subject not yet investigated under this aspect, namely intermitted low back pain.

- Various regression models with the identical sample are performed to highlight how much the predicted influence between SES and the health output may vary if only one SES indicator is taken into account.

- Furthermore the paper introduces a theoretical framework dedicated to support researchers in choosing the most suitable indicator for their research question.

- The results are limited by the fact that the chosen theoretical framework may be too simple.

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1   **BACKGROUND**

2   It is widely accepted in health sciences that the socioeconomic status (SES) is linked to many health

3   outcomes [1]. However, less is known about the causal pathways and mediating factors that lead

4   from SES to these outcomes. This gap in research seems to be at least partly caused by unresolved

5   methodological issues concerning the operationalization of SES. Since SES is a latent construct,

6   various indicators are used to measure a person's SES. The most commonly used indicators are

7   education, job position, income or combinations of these variables [2]. The decision for a specific SES

8   indicator is often not adequately justified in articles [3], and they are even used interchangeably [1].

9   This limits the interpretation of research results: Different operationalizations are based on different

10   theoretical explanatory models connecting the SES-indicators and health outcomes. Job position for

11   example is thought to be connected with the amount of stress someone has to face, which may

12   influence his health, whereas education influences the knowledge someone has about health [4]. As

13   a consequence, it is very likely that different operationalizations will influence the predicted strength

14   between SES and a specific health outcome. This indeed has been confirmed for several health

15   domains such as myocardial infarctions [5], overall mortality [5, 6], diabetes [5] or subjective health

16   status [7, 8]. From these studies two things are noteworthy: First of all, there is no single SES

17   indicator that always has the strongest influence on health outcomes. This means that instead of

18   advocating the use of one SES indicator over another, ideally, separate analyses in every health

19   domain would be needed to determine which indicators are the most relevant. Secondly, in studies

20   investigating the link between SES and health outcomes, these differences in influence are rarely

21   acknowledged [3]. However, if we want to fully understand the relationship between SES and

22   different health outcomes, we not only need to know whether different indicators differ in influence,

23   but also try to understand why this is so. Ultimately, this would enable prevention and interventions

24   efforts to more efficiently target the most relevant factors. In this article these questions will be

25   addressed in a health domain that has rarely been studied in this context, intermitted low back pain

26   (LBP).

27   LBP seems a suitable health outcome to take a closer look at it regarding its connection to

28   SES: It is a mayor public health burden with a worldwide lifetime prevalence of about 39 percent,

29   whereby about 20 percent of people suffer from chronic low back pain [9]. Moreover, it has a

30   multidimensional aetiology with interactions between health behaviour [10] and different social [11]

31   and psychological factors [12]. This makes it very plausible that different SES indicators would lead to

32   different degrees of influence. However, as with other health outcomes, researchers investigating

33   the influence of SES on back pain have used a variety of different SES indicators, often without

34   explaining their choice [3]. To date, one study by Latza and colleagues have compared different SES

35   indicators and their relative influence on self-reported back pain. They found that education had the

strongest impact on severe back pain, followed by job position and income [13]. Crucially however, the study did not use identical samples for all their SES predictors, making it difficult to determine whether the observed differences in influences were caused by the SES indicator or by differences in the sample. Therefore, a study that investigates the link between different SES indicators and LBP in a single sample is needed to understand the influence of different SES indicators on back pain.

For the evaluation of the most important indicator on LBP, a closer look at the factors that mediate the relationship between SES and health outcomes is needed [4]. According to the well-established model of social determinants of health by Brunner and Marmot [14], there are three groups of mediating factors between SES and health: Material factors (e.g. pollution), social and psychological factors (e.g. stress) and health behaviour (e.g. dietary habits). Translating this general model to the current example, prior research has revealed that chronic LBP is strongly associated with social and psychological factors such as depressive symptoms [15] stress [16] or working conditions [17]. Additionally, health behaviour plays an, albeit minor, role [18, 19]. The third group of factors, material factors, have not been found to be associated with chronic LBP in in previous studies. Based on these findings, it can be assumed that the SES indicators that are most closely associated with the two groups of mediating factors related to LBP, social and psychological factors and health behaviour, exert stronger influence on LBP. Hradil, examining the influence of SES indicators on cardiovascular diseases, has proposed such connections between SES indicators and the mediating factors in question [4]: He assumes job position to be strongly connected with social and psychological factors, education with health behaviour and income with material factors. Applying these insights to LBP we hypothesise that job position is most strongly connected with LBP, followed by education. Income should have the weakest influence. The multidimensional index, covering all possible pathways, should be most influential.

METHOD

Sample: Participants were recruited in four medical clinic sides in Germany as part of a large study on low back pain (Medicine in Spine Network, [20]). Inclusion criteria were: 1) age 18 to 65, 2) able to understand the meaning of the study and to complete a questionnaire without help. Exclusion criteria were 1) pregnancy, 2) inability to stand upright, 3) inability to give sick leave information, 4) signs of serious spinal pathology. To ensure homogeneity in the here presented research question, all participants who failed to complete all relevant questions needed for the different SES operationalisations were excluded. Additionally all people who did not have a job at the time of the study were excluded, as it would not be possible to create the indicator job position for them. Furthermore, since new onset of LBP was in the focus of this study, all people who already reported

70 serious chronic pain syndromes at baseline were excluded. This led to a final sample of *N*=381

71 participants.

72

73 **Testing procedure:** All measurements were performed at medical clinics. After baseline, people were

74 again questioned 6 month later. Written consent was granted by all participants. The survey was

75 approved by ethics committee of University of Potsdam (Ethics approval 36/2011) and is in

76 accordance with the principles of the Declaration of Helsinki.

77

78 **Instruments and data pre-processing:**

79 SES indicators: Socioeconomic status was evaluated at baseline using the following instruments:

80 *Education* was assessed using the International Standard Classification of Education (ISCED), which

81 combines school and vocational education [21], resulting in a score from 0 (less than primary

82 education) to 5 (tertiary education).

83 *Job position* was measured using the nine categories of the International Standard Classification of

84 Occupation (ISCO-08), combining jobs according to main tasks, skill level and specialisation [22].

85 *Monthly net income* was asked using 7 categories (less than 1 250€, 1 250€ to 1 749€, 1 750€ to 2

86 249€, 2 250€ to 2 999€, 3 000€ to 3 999€, 4 000€ to 4 999€, 5 000€ and more).

87 *Multidimensional SES index* was calculated using the Winkler-Scheuch-Index (WS-index). This index,

88 recommended by the German Working Group for Social Epidemiology [23], is based on the three

89 dimensions: education, job position and income. Each person gets a value between 1 and 7 for each

90 of the single indicators. The total of these three values then determines the person's score in the WS-

91 index, from 3 (lowest SES) to 21 [23].

92 Pain indicators:

93 *Pain intensity* was evaluated using the Chronic Pain Grade questionnaire (CPG) created by von Korff

94 [24], asking about the current intensity of pain, the average intensity in the last three months and the

95 worst experienced pain in the last three months. Answering options ranged from 0 (no pain) to 10

96 (worst pain possible). The mean of these three questions was calculated and multiplied by 10,

97 resulting in a score of 0 to 100 for each participant. These variables were collected at baseline and

98 follow up. Internal consistency was good for both measurement points (baseline: *Cronbach's*

99 *Alpha*=0.76; follow up: *Cronbach's Alpha*=0.82).

100 *Pain disability* was also evaluated using three questions of the CPG questionnaire asking about how

101 much the pain interfered with daily activities, recreational and social activities and with work (again

102 rated on a scale from 0 to 10). The mean of these three questions was calculated and the result

103 multiplied by 10 resulting in a score from 0 to 100 [24]. Internal consistency was excellent (baseline:

104 *Cronbach's Alpha*: 0.87; follow up: *Cronbach's Alpha*=0.93).

105   *Pain Class:* To enable focussing on new onsets of back pain only, a pain classification index was used

106   at baseline (CPG pain classes). This scale grades pain intensity, pain disability and the number of days

107   with limitations because of pain into 5 categories: 0: no pain; 1 pain with low intensity and low

108   disability; 2 low disability but high intensity; 3 high disability with few days of limitation in everyday

109   life; 4 high disability with severe limitation in everyday life [24]. For the present study, only

110   participants with pain class 0 or 1 at baseline were included.

111

112   <u>Statistical analysis:</u> After descriptives, four hierarchical regression analyses were conducted for each

113   pain outcome using either education, job position, monthly net income or the multidimensional

114   index as the respective predictors while controlling for age, sex and pain at baseline. Requirements of

115   the regression analysis were tested with collinearity diagnosis, Durbin-Watson test and Kolmogorov

116   Smirnoff test for normality of residuals. All analyses were performed with IBM SPSS Statistics 21.

117

118   **RESULTS**

119   **Descriptives:** Looking at the characteristics of the sample Table 1 reveals that respondents (55.1

120   percent women) were on average middle-aged, covering the whole spectrum of the age range. On

121   average participants were highly educated and held high job positions. The average income in the

122   sample was between 1750 and 2249 Euros and the WS-index was on average 14.9 on the scale from

123   3 to 21. Pain intensity and disability was low at t0 and t1.

124

125   Table 1: Characteristics of study sample (*N*=381):

Variable (range)	M	SD	MIN.	MAX.
Age (18 to 65)	41.0	11.8	19	65
Education (1 to 5)	4.1	0.9	1	5
Jobposition (1 to 9)	3.3	2.0	1	9
Income (1 to 7)	3.3	1.8	1	7
Winkler-Scheuch Index (3 to 21)	14.9	2.9	8.2	20.4
CPG pain intensity baseline (0 to 100)	21.0	13.8	0	47
CPG pain intensity follow up (0 to 100)	19.4	16.7	0	67
CPG disability baseline 0 to 100)	9.9	12.7	0	63
CPG disability follow up (0 to 100)	9.7	15.6	0	90
CPG pain class baseline	0.9	0.3	0	1

126

127   **Regression models:**

128   Starting with the models for the prediction of pain intensity (Table 2), three SES indicators (namely

129   education, job position and the WS-index) were able to explain significant variance. Comparing the

130 strength of these respective SES indicators, the ranking is as follows: WS-index (beta=-0.12), job

131 position (beta=0.11) and education (beta=-0.10). People with higher overall SES, higher job positions

132 and higher education experience on average less intense pain. Change in R^2 due to these variables

133 vary between 0.012 (job position and WS-index) and 0.009 (education). Income showed no

134 significant influence. The high absolute R^2 is partly caused by the strong impact of the control

135 variable pain intensity at first measurement point (highly significant beta of 0.53, not indicated in the

136 table).

137

138 Table 2: Hierarchical regression models predicting influence of different operationalisations of SES on CPG pain intensity

139 score (higher values more pain), controlled for age, sex and baseline pain intensity (*N*=381):

MODEL	SES INDICATOR	R^2	ΔR^2	BETA	T-VALUE	P
1	Education	0.32	0.009*	-0.10	-2.29	0.02*
2	Job position	0.32	0.012*	0.11	2.57	0.01*
3	Income	0.31	0.002	-0.04	-0.91	0.36
4	WS-index	0.32	0.012*	-0.12	-2.63	<0.01**

140 * = p<0.05; ** = p<0.01

141

142 The situation is different for the models for pain disability (Table 3). All four predictor variables exert

143 significant influence on disability. Moreover, they all had a higher impact in comparison to their

144 impact on pain intensity. The strongest predictor was the WS-index (beta=0.21), followed by job

145 position (beta=0.20), education (beta=-0.13) and income (beta=-0.13): People with higher combined

146 socioeconomic status, higher job position, higher education and higher income report on average

147 less disability because of pain. Change in R^2 varies between 0.039 (WS-index) and 0.014 (income).

148

149 Table 3: Hierarchical regression models predicting influence of different operationalisations of SES on CPG disability (higher

150 values, more disability), controlled for age, sex and baseline pain intensity (*N*=381):

MODEL	SES INDICATOR	R^2	ΔR^2	BETA	T-VALUE	P
1	Education	0.14	0.017*	-0.13	-2.77	<0.01**
2	Job	0.16	0.038*	0.20	4.14	<0.01**
3	Income	0.14	0.014*	-0.13	-2.48	0.01*
4	WS-index	0.16	0.039*	-0.21	-4.20	<0.01**

151 * = p<0.05; ** = p<0.01

152

153 **DISCUSSION**

154 The purpose of this study was to evaluate whether the influence of SES on intermitted LBP changes

155 as a function of the used SES indicator.

156   It was found that there are indeed differences in the predictive power of commonly used SES

157   indicators. Although it is unlikely to overlook the connection between SES and back pain completely

158   (since all indicators except for income on pain intensity exert significant influence), there were

159   differences in the predictive strength of the SES indicators for pain disability, which could mean that

160   the SES predictor should be selected carefully in order to not underestimate the influence of SES on

161   back pain. Based on the results of this study, it appears that job position would be the most

162   appropriate SES indicators to use in studies on intermitted low back pain. In general however, only

163   income could be clearly identified as suboptimal predictor. In this respect the current findings differ

164   from studies in other health domains that compared the relative impact of SES predictors. For

165   example Geyer and colleagues [5] found education to be a much stronger predictor for diabetes than

166   job position and income to predict better overall mortality than education and job position, whereas

167   Miech and colleagues [7] revealed education as stronger predictors for subjective health than

168   education. This was not confirmed by Geyer [8], who found income and job position to influence

169   subjective health stronger than education. This emphasizes the importance of rethinking possible

170   pathways between SES indicators and health for every health outcome in question.

171   With regard to predicting the relative influence of the various SES predictors, the findings only

172   partially support the predicted associations. Starting with pain intensity, it was hypothesized that the

173   multidimensional index and job position, followed by education should be the most influential

174   predictor, whereas income should play no or just a small role. As predicted, income shows no

175   significant influence and is not able to predict pain intensity. But other than assumed, the

176   multidimensional index (*beta*=-0.12,), job position (*beta*=0.11) and education (*beta*=-0.09), are

177   (nearly) equally strong predictors for pain intensity. The reason for this may be that the model was

178   oversimplifying when assigning the SES indicators to separate mediating pathways (e.g. job position

179   exclusively to psychosocial, and education exclusively to health behaviour). Education also influences

180   psychosocial conditions and job position also affects health behaviour as prior research has shown

181   [25, 26] . Finally, a priori it was assumed that the WS-index, combining the influences of the single

182   indicators should have significantly more impact. This was not the case in the present study. It

183   appears that the impact of the single dimensions do not necessarily add up in such a way that people

184   scoring high in more than one dimension have a remarkably lower risk of developing back pain and

185   people scoring low a higher risk, something Geyer [8] already showed in a different health domain.

186   The reason for this may be the inter-relatedness of the indicators and the mediating factors, leading

187   to a shared influence on back pain for all indicators.

188   For the outcome pain disability, the results are again only partly in line with the hypothesis:

189   First of all, job position (*beta*=0.20) is, as expected, the strongest predictor out of the single

190   indicators, but the multidimensional index (*beta*=-0.21) is as strong. Again it appears to be wrong to

191 assume that the impact of the single dimensions simply will add up. With regard to education (*beta*=-
192 0.13), the results are in line with the assumptions: Education predicts pain disability, but not as well
193 as job position or the WS-index. Income (*beta*=-0.13) has, other than expected, also a significant
194 influence on pain disability. Here the assumption that material factors play no role for pain disability
195 seems to be wrong: a possible explanation may be that a higher income enables people to acquire
196 material resources which reduce their disability in everyday life.

197 To our knowledge this is the first study that has compared the predictive strength of various
198 SES indicators on intermitted LBP in a single sample, thereby adding to the literature that advocates a
199 critical and careful selection of SES indicators. While the results of this and other studies suggest that
200 the SES indicator should be carefully selected and should not be used interchangeably, it has proven
201 to be difficult to predict beforehand which SES indicator will be the most appropriate. In this study
202 the pathways described in the model by Brunner and Marmot [14] was used to predict the influence
203 of the various SES indicators, however the findings were not fully in line with these predictions. A
204 reason for this may be that the predictions were based on a simplified reflection of reality, assuming
205 no intercorrelations between the different variables.

206 Nonetheless, since the article stresses the importance of careful SES indicator selection,
207 further research should aim to develop frameworks to aid researchers in selecting the appropriate
208 SES indicator for their research question. Ultimately such frameworks will help to improve the
209 understanding of the link between SES and health.

210

211 **AUTHOR CONTRIBUTION**

212 All authors substantially contributed to the conception and realization of this article. MF conceived

213 and wrote the first draft of this manuscript and provided the statistical analysis. JW and PW revised

214 the manuscript. PW was responsible for the psychometric design, analysis plan and conceived the

215 social methods of the study. All authors read and approved the final manuscript.

216

217 **COMPETING INTERESTS:**

218 The authors declare that they have no competing interests.

219

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224 collection or the content of this manuscript.

225

226 **ETHICAL APPROVAL**

227 The study was approved by the Independent ethics committee of University of Potsdam (Ethics

228 approval 36/2011).

229

230 **DATA SHARING:**

231 No additional data available

232

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239

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Education, job position, income or multidimensional indices? Associations between different socioeconomic status indicators and intermitted low back pain in a German sample: a longitudinal field study

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ABSTRACT:

Objective: Investigation of associations between common socioeconomic status (SES) indicators (education, job position, income, multidimensional index) on intermitted low back pain (LBP) in a single sample.

Design: Longitudinal field study

Setting: Four medical clinics across Germany

Participants: 352 people. Inclusion criteria: 1) age 18 to 65, 2) able to understand the meaning of the study and to complete a questionnaire without help.

Exclusion criteria: 1) pregnancy, 2) inability to stand upright, 3) inability to give sick leave information, 4) signs of serious spinal pathology, 5) not completed all relevant questions needed for the different SES operationalisations and 6) serious pain syndromes in the last 3 months.

Outcome measures: Intensity of intermitted LBP and disability due to intermitted LBP.

Results: Hierarchical linear regression of four different models for each dependent variable revealed job position to be the best predictor for LBP intensity followed by the multidimensional index, whereas education and income had no impact. For LBP disability, again job position proved the best predictor followed by the multidimensional index and education, while income had no significant association.

Conclusion: The results revealed that several SES indicators have strong, but different associations with intermitted LBP and are therefore not interchangeable. Job position was found to be the single most important indicator. Prevention and interventions should thus focus on areas influenced by job position. In general, more research on the relationship between SES and health outcomes is needed.

STRENGTHS AND LIMITATIONS OF THIS STUDY:

- The extension of SES indicator analysis to a new patient pathology, namely intermitted low back pain (LBP).

- The comparison of various regression models performed on the identical sample to highlight exact variations in the predicted associations between SES and LBP.

- Results could be limited due to the relatively small group sizes and because only four SES indicators were taken into account.

- Transferability of results to other health settings and countries still has to be proven.

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1 **BACKGROUND**

2 It is widely accepted in health sciences that socioeconomic status (SES) is linked to many health

3 outcomes [1]. However, less is known about the causal pathways and mediating factors that lead

4 from SES to these outcomes. This gap in research seems to be at least partly caused by unresolved

5 methodological issues concerning the operationalization of SES. Because SES is a latent construct,

6 various indicators are used to measure a person's SES. The most commonly used indicators are

7 education, job position, income or combinations of these variables [2]. The justification for using a

8 specific SES indicator is often not adequately justified in articles [3], and they are even used

9 interchangeably [4]. This limits the interpretation of research results: Different operationalizations

10 are based on different theoretical explanatory models connecting SES-indicators and health

11 outcomes. Job position, for example, is thought to be connected with stress, which may influence

12 health, whereas education influences knowledge about health [5]. As a consequence, it is very likely

13 that different operationalizations will influence the predicted association between SES and a specific

14 health outcome. This has indeed been confirmed for several health domains such as myocardial

15 infarctions [6], overall mortality [6, 7], diabetes [6] and subjective health status [8, 9]. From these

16 studies, two things are noteworthy. First, there is no single SES indicator that always has the

17 strongest influence on health outcomes. This means that instead of advocating the use of one SES

18 indicator over another, ideally, separate analyses in every health domain would be needed to

19 determine which indicators are the most relevant. Secondly, in studies investigating the link between

20 SES and health outcomes, these differences in influence are rarely acknowledged [3]. However, if we

21 want to fully understand the relationship between SES and different health outcomes, we not only

22 need to know whether different indicators differ in their association, but also to try and understand

23 why this is so. Ultimately, this would enable prevention and intervention efforts to more efficiently

24 target the most relevant factors. In this article, these questions will be addressed in a health domain

25 that has rarely been studied in this context, intermitted low back pain (LBP).

26 LBP seems a suitable health outcome to investigate regarding its connection to SES. LBP is a

27 major public health burden with a worldwide lifetime prevalence of about 39 %, whereby about 20 %

28 of people suffer from chronic LBP [10]. Moreover, it has a multidimensional aetiology with

29 interactions between health behaviour [11] and different social [12] and psychological factors [13].

30 This makes it very plausible that different SES indicators would lead to different degrees of

31 association. However, as with other health outcomes, researchers investigating the influence of SES

32 on back pain have used a variety of different SES indicators, often without explaining their choice [3].

33 To date, one study by Latza and colleagues compared different SES indicators and their relative

34 influence on self-reported back pain. They found that education had the strongest impact on severe

35 back pain, followed by job position and income [14]. However, and this is crucial, the study did not

36 use identical samples for all SES predictions, making it difficult to determine whether the observed

37 differences were caused by the SES indicators or by differences in the samples. Therefore, a study

38 investigating the link between different SES indicators and LBP in a single sample is needed to best

39 understand possible associations.

40 For evaluation of the most important indicators in LBP, a closer look at the factors mediating

41 the relationship between SES and health outcomes is needed [5]. According to the well-established

42 model of social determinants of health by Brunner and Marmot [15], there are three groups of

43 mediating factors between SES and health: material factors (e.g. pollution), social and psychological

44 factors (e.g. stress) and health behaviour (e.g. dietary habits). Translating this general model to the

45 current example, prior research revealed that chronic LBP is strongly associated with social and

46 psychological factors such as depressive symptoms [16], stress [17] and dissatisfaction with work

47 organisation [18]. Additionally, health behaviour plays a role, albeit minor [19, 20]. The third group of

48 factors, material factors, have not been found to be associated with chronic LBP in previous studies.

49 Based on these findings, it can be assumed that SES indicators most closely associated with social and

50 psychological factors and health behaviour exert stronger influence on LBP. Hradil et al., examining

51 the influence of SES indicators on cardiovascular diseases, assumed job position to be most strongly

52 connected with social and psychological factors, education with health behaviour and income with

53 material factors [5]. Using these assumptions, we hypothesise that from the single indicators job

54 position will be strongly associated with LBP, followed by education. Income, we believe, will have

55 the weakest, if any, association. The multidimensional index, covering all possible pathways, should

56 however yield the greatest predictive power.

57

58 **METHOD**

59 **Sample:** Participants were recruited in four medical clinics across Germany as part of a national study

60 on LBP (Medicine in Spine Network, [21]). Inclusion criteria consisted of: 1) age 18 to 65 years, and 2)

61 able to understand the meaning of the study and to complete a questionnaire without help.

62 Exclusion criteria were 1) pregnancy, 2) inability to stand upright, 3) inability to give sick leave

63 information, or 4) signs of serious spinal pathology. This led to a primary sample size of N = 1071

64 participants. To ensure homogeneity and avoid bias, only participants were included, who at the time

65 of study had an actual job position and answered all relevant questions needed for SES

66 operationalisation. This reduced the sample size to N=654. Furthermore, because prediction of LBP

67 was the focus of this study, participants already reporting serious chronic pain syndromes at baseline

68 were excluded. This led to a sample of N = 367 participants. Finally, since numbers in the groups of

69 primary educated and lower secondary educated people, agricultural workers, machine operators

70 and elementary occupations was very small (under 10 people in each group), these groups were

71 excluded from further analysis, leading to a final sample size of *N*=352.

72

73 **Testing procedure:** All measurements were performed in four Medicine in Spine Network medical

74 clinics. Participants completed questionnaires regarding SES and LBP at baseline and again 6 months

75 later. Written consent was granted by all participants. The study was approved by the University of

76 Potsdam ethics committee (Ethics approval 36/2011) and is in accordance with the principles of the

77 Declaration of Helsinki.

78

79 **Instruments and data pre-processing:**

80 <u>SES indicators</u>: Socioeconomic status was evaluated at baseline using the following instruments:

81 *Education* was assessed using the International Standard Classification of Education (ISCED), which

82 combines school and vocational education [22], resulting in a score from 0 (less than primary

83 education) to 5 (tertiary education).

84 *Job position* was measured using the ten major categories from the International Standard

85 Classification of Occupation (ISCO-08), combining jobs according to main tasks, skill level and

86 specialisation [23].

87 Monthly net personal income was surveyed using 7 categories (less than 1,250€, 1,250€ to 1,749€,

88 1,750€ to 2,249€, 2,250€ to 2,999€, 3,000€ to 3,999€, 4,000€ to 4,999€, 5,000€ and more) based on

89 the recommendations of the German Federal Statistical Institute and grouped at the extremes [24].

90 *Multidimensional SES index* was calculated using the Winkler-Scheuch-Index (WS-index). This index, a

91 revised version of the German Working Group for Social Epidemiology recommendations [25], is

92 based on three dimensions: education (generated as combination of general and job specific

93 educational level), job position and income. The composition is similar to those of international

94 additive indices. For example Hollighead's "Index of Social Status" [26]. Participants are scored

95 between 1 and 7 for each of the single indicators. The total of these three values then determines

96 the participant's WS-index score [25].

97 <u>Pain indicators:</u>

98 *Pain intensity* was evaluated using the Chronic Pain Grade questionnaire (CPG) created by von Korff

99 [27], which asks about the current intensity of pain, the average intensity of pain in the last three

100 months and the worst experienced pain in the last three months. Possible answers range from 0 (no

101 pain) to 10 (worst pain possible). The mean of these three questions was calculated and multiplied by

102 10, resulting in a score of 0 to 100 for each participant. These variables were collected at baseline

103 and follow-up 6 months later. Internal consistency was good for both measurement points (baseline:

104 *Cronbach's α* = 0.76; follow-up: *Cronbach's α* = 0.82).

105 *Pain disability* was evaluated using three questions from the CPG questionnaire concerning how

106 much pain interfered with daily activities, recreational and social activities and with work (again

107 rated on a scale from 0 to 10). The mean of these three questions was calculated and the result

108 multiplied by 10, resulting in a score from 0 to 100 [27]. Internal consistency was excellent (baseline:

109 *Cronbach's α* = 0.87; follow-up: *Cronbach's α* = 0.93).

110 *Pain Class:* To exclude participants with current strong or disabling LBP, a pain classification index

111 was used at baseline (CPG pain classes). This scale grades pain intensity, pain disability and the

112 number of days with limitations due to of pain into 5 classes: 0: no pain; 1: pain with low intensity

113 and low disability; 2: low disability, but high intensity; 3: high disability with few days of limitation in

114 everyday life; 4: high disability with severe limitation in everyday life [27]. For the present study, only

115 participants from pain classes 0 and 1 at baseline were included.

116

117 <u>Statistical analysis:</u> After descriptive statistics, four separate hierarchical regression analyses were

118 conducted for each pain outcome using either education, job position, monthly personal net income

119 or the multidimensional index as the respective predictors, while controlling for age and sex, two

120 variables known for their high predictive value in the development of back pain [28]. Education, job

121 position and income thereby were treated as dummy variables to reflect the categorical character of

122 these variables. As most studies only use single indicators to represent SES, a separate model for

123 each indicator was used here as this allowed for demonstration of how much the association

124 between the different indicators and LBP may vary if the other indicators were not taken into

125 account. Requirements of the regression analysis were tested with collinearity diagnosis, Durbin-

126 Watson test and Kolmogorov Smirnoff test for normality of residuals. All analyses were performed

127 with IBM SPSS Statistics 21.

128

129 **RESULTS**

130 **Descriptive statistics:** Sample characteristics (Tables 1 and 2) revealed that 55% of respondents were

131 women and on average middle-aged, but ranged from 19 to 65 years. Generally, participants were

132 highly educated, with few people with primary or lower secondary education and held high job

133 positions. The mean monthly net personal income of the sample was between 1,750 and 2,249€ and

134 the average WS-index was 14.9, on the scale from 3 to 21. Pain intensity and disability were both low

135 at baseline and 6-month follow-up. People with primary or lower secondary education, agricultural

136 workers, machine operators and elementary job positions are excluded for further analysis because

137 of the small sample size in the groups.

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141 Table 1: Characteristics of study sample, categorical variables, *N* = 367:

Variable	N	%		N	%
EDUCATION			**JOB POSITION**		
Primary education	4	1.1	Managers	34	9.2
Lower secondary education	4	1.1	Professionals	97	26.4
Upper secondary education	105	28.5	Technicians	124	34.0
Post-secondary-non tertiary education	80	21.7	Clerical Support Workers	37	10.1
Tertiary education	174	47.6	Service and Sales Workers	50	13.6
INCOME			Agricultural Workers	1	0.3
Under 1250	60	16.3	Craft Workers	16	4.3
1250-1749	74	20.4	Machine Operators	3	0.8
1750-2249	59	16.0	Elementary Occupations	5	1.4
2250-2999	56	15.2			
3000-3999	65	17.7			
4000-4999	28	7.6			
More than 5000	25	6.8			

142

143 Table 2: Characteristics of study sample, continuous variables, *N* = 367:

Variable (Range)	M	SD	Min.	Max.
Age (18 to 65)	41.0	11.8	19	65
Winkler-Scheuch Index (3 to 21)	14.9	2.9	8.2	20.4
CPG pain intensity baseline (0 to 100)	21.0	13.8	0	47
CPG pain intensity follow up (0 to 100)	19.4	16.7	0	67
CPG disability baseline 0 to 100)	9.9	12.7	0	63
CPG disability follow up (0 to 100)	9.7	15.6	0	90
CPG pain class baseline	0.9	0.3	0	1

144

145 **Regression models:**

146 Regarding the prediction models for pain intensity (Table 3), only 'job position' and 'WS-index'

147 significantly improved variance explanation. Comparing variance explanation of the respective SES

148 indicators, the ranking was as follows: job position (change in R^2 = 0.04, $p < 0.01$), WS-index (change

149 in R^2 = 0.02, $p < 0.05$), education (change in R^2 = 0.02, n.s.) and income (change in R^2 = 0.01, n.s.). In

150 detail, the analysis revealed that people with upper secondary education experience, on average,

151 greater pain intensity compared to people with tertiary education. Considering job position,

152   technicians had significantly lower pain intensity scores compared to managers. Again, no other

153   significant differences were observed. Income did not contribute to variance explanation, nor were

154   there any significant differences between income groups. The multidimensional WS-index (included

155   as a continuous variable) improved the model significantly: People with higher overall SES

156   experienced less back pain.

157

158   Table 3: Four different hierarchical regression models predicting influence of different operationalisations of SES on CPG

159   pain intensity score (higher values more pain), controlled for age and sex (*N*=352) *ΔR²* indicates model improvement after

160   application of SES indicator:

Model	ΔR²	Variable	B	SE B	Beta	p
Model 1: **Education** **Reference group: Tertiary Education**	0.01	Upper Secondary Education	4.3	2.0	0.12	0.03*
		Post-secondary non-tertiary education	0.76	2.2	0.02	0.73
Model 2 job position reference group: Manager	0.04**	Professionals	-3.6	2.0	-0.1	0.13
		Technicians	-4.5	2.2	-0.14	0.05*
		Clerical Support Workers	-0.36	3.2	-0.01	0.91
		Service and Sales Workers	2.8	2.7	0.06	0.30
		Craft Workers	8.5	4.5	0.11	0.06
Model 3: Income Reference group: more than 5000€	0.02	Under 1250	5.2	4.2	0.12	0.22
		1250-1749	1.9	3.9	0.05	0.63
		1750-2249	2.1	4.0	0.05	0.61
		2250-2999	5.9	3.9	0.14	0.14
		3000-3999	0.8	3.9	0.02	0.83
		4000-4999	5.0	4.5	0.09	0.27
Model 4: WS-Index	0.02*		-0.9	0.3	-0.15	<0.01*

161   *$p < 0.05$; **$p < 0.01$

162

163   The pain disability models yielded different results (Table 4). Education, job position and WS-index

164   explained a significant amount of variance. Moreover, they had a greater impact in comparison to

165   their impact on pain intensity. The strongest predictor was job position (change in R^2=0.07, $p<0.01$),

166   followed by WS-index (change in R^2=0.05, $p<0.01$) then education (change in R^2=0.02, $p<0.05$).

167   Income had no significant influence. Further, people with professional, secondary education were

168 significantly more disabled because of back pain compared to people with tertiary education.

169 Professionals experienced, in comparison with managers, significant lower impairment, while craft

170 workers experienced significantly more. Although the income model did not improve variance

171 explanation, people with an income of less than 1,250€ experienced significantly more impairment

172 than people with an income over 5000€. In general, people with a higher SES experienced fewer

173 limitations due to their back pain.

174

175 Table 4: Four hierarchical regression models predicting influence of different operationalisations of SES on CPG pain

176 disability score (higher values more pain), controlled for age and sex (N = 352). ΔR^2 indicates model improvement after

177 application of SES indicator:

Model	ΔR^2	Variable	B	SE B	Beta	p
Model 1: Education Reference group: Tertiary Education	0.02*	Upper Secondary Education	5.8	2.0	0.17	<0.01**
		Post-secondary non-tertiary education	2.6	2.2	0.07	0.22
Model 2 job position reference group: Manager	0.07**	Professionals	-5.2	2.0	-0.16	<0.01**
		Technicians	-1.9	2.2	-0.06	0.38
		Clerical Support Workers	0.8	3.1	0.02	0.80
		Service and Sales Workers	2,4	2.7	0.05	0.36
		Craft Workers	13.1	4.4	0.17	<0.01**
Model 3: Income Reference group: more than 5000€	0.02	Under 1250	8.8	4.1	0.20	0.03*
		1250-1749	4.9	3.9	0.13	0.21
		1750-2249	4.9	4.0	0.12	0.21
		2250-2999	4.5	3.9	0.10	0.25
		3000-3999	1.3	3.9	0.03	0.73
		4000-4999	2.5	4.4	0.04	0.57
Model 4: WS-Index	0.05**		-1.3	0.3	-0.23	<0.01**

178 *p < 0.05; **p < 0.01

179

180 **DISCUSSION**

181 The purpose of this study was to investigate the associations between common SES indicators and

182 intermitted LBP in a single sample and observe changes in association as a function of SES indicator.

183 Differences were indeed found in the predictive power of commonly used SES indicators, which

184 means SES predictors should be carefully selected in order not to underestimate the SES influence on

185 LBP. Based on these results, it appears that job position is the most appropriate SES indicator for

186 studies regarding intermitted LBP. In general however, only income and education for pain intensity

187 could be identified as suboptimal predictor. In this respect, the current findings differ from studies in

188 other health domains comparing the relative impact of SES predictors. For example, Geyer and

189 colleagues [6] found education to be a much stronger predictor for diabetes than job position and

190 income to predict better overall mortality compared to education and job position. Whereas, Miech

191 and colleagues [8] determined education to more strongly predict subjective health than occupation.

192 This was not confirmed by Geyer [9], who found income and job position to have a greater influence

193 on subjective health than education. This emphasizes the importance of rethinking the possible

194 pathways connecting SES indicators and each distinct health outcome in question.

195 With regard to the hypothesized associations the findings are only partly in line. We hypothesized

196 that the multidimensional index and job position, followed by education would be the most

197 influential predictors of pain intensity, whereas income we believed would play little or no role. As

198 predicted, job position was found to be the strongest indicator: In detail, technicians (and

199 tendentially professionals) showed significantly less pain intensity. One reason for this may include

200 that technicians have better awareness and opportunities to adjust or tend to their LBP by reducing

201 work stress, for example. Income, as suggested, showed no significant influence and was not able to

202 predict pain intensity. Education in general did not contribute to variance explanation, although

203 people with upper secondary education did experience significantly more pain than people with

204 tertiary education. We believe, because educated people should have better knowledge, thus

205 judgement to choose adequate (health) behaviours when confronted with pain [5], their pain is

206 reduced.

207   Finally, *a priori,* it was assumed the WS-index, combining the influences of the single

208 indicators would have significantly more predictive power. This was not the case in the present study

209 though. It appears the addition of single SES dimensions do not necessarily yield a cumulative

210 increase in predictive power, something Geyer [9] previously showed in a different health domain.

211 The overlapping of indicators and mediating factors could be the problem here, leading to a shared

212 influence on back pain for all indicators, or the effect of one indicator being counterbalanced by

213 another.

214   Reviewing SES and pain disability associations, results are again only partially in line with our

215 hypotheses. First, job position was, as expected, the most influential single predictor. Professionals

216 experienced significantly less impairment due to their LBP, while craft workers experienced more. As

217 with pain intensity, we believe professionals have better possibilities to adjust in their work places

218 when experiencing LBP, so that they are not as hampered compared to managers or craft workers.

219   The multidimensional index explained the second most variance. Again, it seems wrong to

220 assume that the impact of single dimensions will simply add up, making multidimensional indices

221 more influential than single indicators. With regard to education, the results agreed with our

222 assumptions. Education predicted pain disability, but not as well as job position or WS-index. Again,

223 upper secondary educated people experienced stronger impairment than tertiary educated people.

224 Reasons for this may lie in the educated people knowing better how to adjust their everyday life as

225 not avoid their pain.

226 Income in general explained no significant part of pain disability variance, although people in

227 the lowest income class reported greater impairment in comparison with those from the highest.

228 Better incomes may enable these people to acquire material resources, which reduce their disability

229 in everyday life.

230 To our knowledge this is the first study to compare the predictive strength of various SES

231 indicators on intermitted LBP in a single sample, thereby adding to the literature that advocates a

232 critical and careful selection of SES indicators. While the results of this and other studies suggest SES

233 indicators should be selected carefully and should not be used interchangeably, it has proven difficult

234 to predict *a priori*, which SES indicator will be most appropriate. In this study, the pathways

235 described in the model of Brunner and Marmot [15] was used to predict the association between

236 various SES indicators and intermitted LBP, though findings were not fully in line with these

237 predictions.

238 The results presented in this paper are afflicted by some limitations, namely the small group sizes of

239 primary and lower secondary educated people, agricultural workers, machine operators and

240 elementary occupations, leading to the exclusion of these groups. A repetition of the research design

241 with a larger sample would make the results more reliable. Furthermore, the study was conducted in

242 four study centres in different federal states of Germany. Although Germany has comparable

243 numbers to other European countries regarding prevalence and severity rates of pain [29], country

244 specific differences may lead to other results in other countries. Additionally, not all approaches of

245 gauging SES were taken into account. Newer approaches, for example self-assessed socioeconomic

246 status [30, 31] or neighbourhood indicators [3], could improve future studies, but as of yet, no

247 statement can be made as to whether these approaches would have influenced results.

248 Nonetheless, this study showed especially job position as an important dimension concerning

249 SES influence on intermittent LBP. Further research aiming to prevent and reduce intermittent LBP

250 should therefore focus on conditions that may be influenced by job positions.

251

252 **AUTHOR CONTRIBUTION**

253 All authors substantially contributed to the conception and realization of this article. MF conceived

254 and wrote the first draft of this manuscript and provided statistical analysis. JW and PW revised the

255 manuscript. PW was responsible for the psychometric design, analysis plan and conceived the social

256 methods of the multicentre study. All authors read and approved the final manuscript.

257

258 **COMPETING INTERESTS:**

259 The authors declare that they have no competing interests.

260

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266

267 **ETHICAL APPROVAL**

268 The study was approved by the independent ethics committee of University of Potsdam (Ethics

269 approval 36/2011).

270

271 **DATA SHARING:**

272 No additional data available

273

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract Check Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Check Page 2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Check Pages 3 and 4
Objectives	3	State specific objectives, including any prespecified hypotheses Check Page 4
Methods		
Study design	4	Present key elements of study design early in the paper Check Title and Pages 4, 5, 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Check Pages 4 and 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants Check Pages 4 and 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Check Pages 5 and 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Check Pages 5 and 6
Bias	9	Describe any efforts to address potential sources of bias Check Page 6
Study size	10	Explain how the study size was arrived at Check Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Check Page 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Check Page 6
		(*b*) Describe any methods used to examine subgroups and interactions Not applicable
		(*c*) Explain how missing data were addressed Check Page 4
		(*d*) If applicable, describe analytical methods taking account of sampling strategy Not applicable
		(*e*) Describe any sensitivity analyses Not applicable
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Check Pages 4 and 5
		(b) Give reasons for non-participation at each stage Check Pages 4 and 5
		(c) Consider use of a flow diagram Not used
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Check Pages 6 and 7
		(b) Indicate number of participants with missing data for each variable of interest Not applicable (all participants with missing data were excluded)
Outcome data	15*	Report numbers of outcome events or summary measures Check Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Check Tables 3 and 4

		(*b*) Report category boundaries when continuous variables were categorized Check Table1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Not applicable

Discussion

Key results	18	Summarise key results with reference to study objectives Check Page 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Check Page 11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Check Page 12
Generalisability	21	Discuss the generalisability (external validity) of the study results Check Page 11

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Check Page 13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Education, job position, income or multidimensional indices? Associations between different socioeconomic status indicators and chronic low back pain in a German sample: a longitudinal field study

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Education, job position, income or multidimensional indices? Associations between different socioeconomic status indicators and chronic low back pain in a German sample: a longitudinal field study

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ABSTRACT:

Objective: To investigate associations between socioeconomic status indicators (education, job position, income, multidimensional index) and the genesis of chronic low back pain (CLBP).

Design: Longitudinal field study (baseline and 6-month follow-up)

Setting: Four medical clinics across Germany

Participants: 352 people were included according to the following criteria: 1) between 18 and 65 years of age, 2) intermittent pain, and 3) an understanding of the study and the ability to answer a questionnaire without help. Exclusion criteria were: 1) pregnancy, 2) inability to stand upright, 3) inability to give sick leave information, 4) signs of serious spinal pathology, 5) acute pain in the past 7 days, or 6) an incomplete SES indicators questionnaire.

Outcome measures: subjective intensity and disability of CLBP

Results: Analysis showed that job position was the best single predictor of CLBP intensity, followed by a multidimensional index. Education and income had no significant association with intensity. Subjective disability was best predicted by job position, succeeded by the multidimensional index and education, while income again had no significant association.

Conclusion: The results showed that SES indicators have different strong associations with the genesis of CLBP and should therefore not be used interchangeably. Job position was found to be the single most important indicator. These results could be helpful in the planning of back pain care programs, but in general, more research on the relationship between SES and health outcomes is needed.

STRENGTHS AND LIMITATIONS OF THIS STUDY:

- Analysis of different SES indicators and their influence on the genesis of chronic low back pain.
- This comparison was driven by various regression models within the same sample to highlight variations in CLBP prediction when using different SES indicators.
- Limitations include a small and homogeneous sample of above average SES status and the use of only the most common SES indicators, the setting in one country and the focus on one health domain.
- Transferability has to be proven in other health settings and countries.

1 **BACKGROUND**

2 In the health sciences, it is widely accepted that socioeconomic status (SES) is linked to many health

3 outcomes [1]. However, less is known about the causal pathways and mediating factors that lead to

4 these outcomes. This gap in research is partially caused by unresolved methodological issues

5 concerning the operationalization of SES. Because SES is a latent construct, various indicators can be

6 used to measure a person's SES. The most commonly used indicators are education, job position and

7 income, or combinations of these variables [2]. The justification for specific SES indicator use is often

8 not adequately described in articles [3], and some SES indicators are even used interchangeably [4].

9 This limits the interpretation of results because different indicators are based on different theoretical

10 models connecting SES-indicators to health outcomes. For example, job position is strongly

11 connected with stress, which then detrimentally influences health. Whereas, education is strongly

12 associated with knowledge about health and treatments [5]. It thus becomes obvious that the

13 chosen indicator will indeed influence the association with specific health outcomes. This has already

14 been confirmed for several health outcomes, including myocardial infarction [6], overall mortality [6,

15 7], diabetes [6] and subjective health status [8, 9]. After reviewing these studies, two things become

16 noteworthy. First, each SES indicator differs in its connection with specific health outcomes, which

17 leads to the notion that SES indicators should initially be analysed separately for each health domain

18 of interest. Secondly, in the studies investigating links between SES and health outcomes, it was

19 rarely acknowledged that different indicators led to different results, nor discussed why [3]. For a

20 better understanding of the relationship between SES and health improved methodology yielding

21 more information concerning indicator associations and underlying mechanisms, is needed.

22 Therefore, the objective of this study was to compare and report the association of common SES

23 indicators with the genesis of one common global health problem, chronic low back pain (CLBP).

24   CLBP seems a suitable health outcome to investigate regarding its connection to SES It is a

25 major public health burden with an international lifetime prevalence of approximately 39 %, whereby

26 about 20% of people suffer from CLBP [10]. Moreover, the development of chronic pain has a

27 multidimensional aetiology and is moderated by health behaviour [11], as well as social [12] and

28 psychological factors [13]. For these reasons, we hypothesize that different SES indicators will lead to

29 different degrees of association in the genesis of CBLP. However, past studies analysing CLBP and SES

30 have used a variety of different SES indicators, often without explanation [3]. To date, only one study

31 from Latza et al. has compared different SES indicators and their relative influence on self-reported

32 back pain. They found education to have the strongest association with chronic back pain, followed

33 by job position and income [14]. However, and this is crucial, they did not use identical samples for

34 all SES prediction calculations. So it is not clear whether the observed differences were caused by the

SES indicators or by differences in the samples. Hence, a study investigating the link between different SES indicators and CLBP in a single sample is needed.

Before evaluating, it is important to have a differentiated perspective on factors mediating the relationship between SES and health [5]. According to the well-established model of social determinants of health by Brunner and Marmot [15], there are three groups of factors mediating SES and health: material factors (e.g. pollution), social and psychological factors (e.g. stress) and health behaviour (e.g. dietary habits). Translating this general model to the current example, prior research has revealed that CLBP is most strongly associated with social and psychological factors, such as depressive symptoms [16], stress [17] and dissatisfaction with work organisation [18]. Health behaviour has also been associated with CLBP [19, 20], however, material factors have not. Based on these findings, it could be assumed that SES indicators more closely associated with social/psychological factors and health behaviour will have stronger associations with CLBP. Hradil et al., examining the influence of SES indicators on cardiovascular diseases, assumed job position to be most strongly connected with social and psychological factors, education with health behaviour and income with material factors [5]. Using these assumptions, we hypothesise that the single indicator, job position will be strongly associated with the genesis of CLBP, followed by education. Income, we believe, will have the weakest association. The multidimensional index, covering all possible pathways, should however yield the strongest association.

METHOD

Sample: Participants were recruited from four medical clinics across Germany as part of a national study on LBP (National Research Network for Medicine in Spine Exercise, MiSpEx, [21]). Inclusion criteria consisted of: 1) 18 to 65 years of age, 2) intermittent pain, 3) an understanding of the study and the ability to answer a questionnaire without help. Exclusion criteria were 1) pregnancy, 2) inability to stand upright, 3) inability to give sick leave information, or 4) signs of serious spinal pathology. This led to a primary sample size of N = 1071 participants. To ensure homogeneity and to avoid bias, only participants, who at the time of assessment were actually employed and answered all relevant SES indicator questions, were included. This reduced the sample size to N = 654. Furthermore, as SES association with the genesis of CLBP is the focus, participants already reporting serious chronic pain syndromes at baseline were excluded, reducing the sample to N = 367 participants. After final screening, an insufficient number of some SES groups (primary and lower-secondary educational level, agricultural workers, machine operators and elementary occupations) was observed (under 10 people in each group), therefore these groups were excluded from further analysis, leading to a final sample size of N = 352.

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70 **Testing procedure:** All measurements were performed in the four medical clinics of the MiSpEx

71 Network. Participants completed questionnaires regarding SES and CLBP at baseline and again six

72 months later. Written consent was obtained from all participants. The study was approved by the

73 University of Potsdam ethics committee (Ethics approval 36/2011) and is in accordance with the

74 principles of the Declaration of Helsinki.

75 **Patient and Public Involvement:** Participants were informed, that the study is about LBP. They were

76 not involved in the development of the design, recruitment, or study conduction. Each participant

77 got an individual feedback of his or her results shortly after the study was finished**.**

78 **Instruments and data pre-processing:**

79 SES indicators: Socioeconomic status was evaluated at baseline using the following instruments:

80 *Education* was assessed using the International Standard Classification of Education (ISCED), which

81 combines school and vocational education [22], resulting in a score from 0 (less than primary

82 education) to 5 (tertiary education).

83 *Job position* was measured using the ten major categories from the International Standard

84 Classification of Occupation (ISCO-08), combining jobs according to main tasks, skill level and

85 specialisation [23].

86 Monthly net personal income was separated into 7 brackets (less than 1,250€, 1,250€ to 1,749€,

87 1,750€ to 2,249€, 2,250€ to 2,999€, 3,000€ to 3,999€, 4,000€ to 4,999€, 5,000€ and more) based on

88 the recommendations of the German Federal Statistical Institute and grouped at the extremes [24].

89 *Multidimensional SES index* was calculated using the Winkler-Scheuch-Index (WS-index). This index, a

90 revised version of the German Working Group for Social Epidemiology recommendations [25], is

91 based on three dimensions: education (a combination of general and job specific educational level

92 obtained together with ISCED), job position (a combination of position and qualification) and income.

93 The composition is similar to those of international additive indices, for example, Hollighead's "Index

94 of Social Status" [26]. Participants were scored between 1 and 7 for each of the single indicators. The

95 total of these three values then determined the participant's WS-index score [25].

96 Pain indicators:

97 *Pain intensity* was evaluated using the Chronic Pain Grade questionnaire (CPG) created by von Korff

98 [27], which inquires the current intensity of pain, the average intensity of pain in the last three

99 months and the worst experienced pain in the last three months. Possible answers range from 0 (no

100 pain) to 10 (worst pain possible). The mean of these three questions was calculated and multiplied by

101 10, resulting in a score of 0 to 100 for each participant. These variables were collected at baseline

102 and follow-up 6 months later. Internal consistency was good at both measurement points (baseline:

103 *Cronbach's α* = 0.76; follow-up: *Cronbach's α* = 0.82).

104 *Pain disability* was evaluated using three questions from the CPG questionnaire concerning how

105 much pain interfered with daily, recreational, social and work activities (again rated on a scale from 0

106 to 10). The mean of these three questions was calculated and the result multiplied by 10, resulting in

107 a score from 0 to 100 [27]. Internal consistency was excellent at both measurement points (baseline:

108 *Cronbach's α* = 0.87; follow-up: *Cronbach's α* = 0.93).

109 *Pain Class:* To exclude participants with current strong or disabling CLBP, a pain classification index

110 was used at baseline (CPG pain classes). This scale grades pain intensity, pain disability and the

111 number of days with limitations due to pain into 5 classes: 0) no pain, 1) pain with low intensity and

112 low disability, 2) pain with low disability, but high intensity, 3) pain with high disability with few days

113 of limitation in everyday life, 4) pain with high disability with severe limitation in everyday life [27].

114 For the present study, only participants from pain classes 0 and 1 at baseline were included.

115

116 <u>Statistical analysis:</u> After descriptive statistics calculation, four separate hierarchical regression

117 analyses were conducted for each pain outcome using either education, job position, monthly

118 personal net income or the multidimensional index as the respective predictors, while controlling for

119 age and sex. These two variables are known for their high predictive value in the development of

120 back pain [28]. Education, job position and income thereby were treated as dummy variables to

121 reflect the categorical character of these variables. As most studies only use one indicator to

122 represent SES, a separate model for each indicator was used here as this allowed for comparisons in

123 variability if the other indicators had not been taken into account. Requirements of the regression

124 analysis were tested with collinearity diagnosis, Durbin-Watson test and Kolmogorov Smirnoff test

125 for normality of residuals. All analyses were performed with IBM SPSS Statistics 21.

126

127 **RESULTS**

128 **Descriptive statistics:** Sample characteristics (Tables 1 and 2) revealed 55% of respondents were

129 women and on average the sample was middle-aged, but ranging from 19 to 65 years. Generally,

130 participants were highly educated and held high job positions. Mean monthly net personal income

131 was between 1,750 and 2,249€, while the average WS-index score was 14.9 on the scale from 3 to

132 21. CLBP intensity and disability were low at both baseline and 6-month follow-up.

133 People with primary or lower secondary education, agricultural workers, machine operators and

134 elementary job positions are excluded for further analysis because of the small sample size in the

135 groups.

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139   Table 1: Sample characteristics. (Categorical variables, *N* = 367)

Variable	N	%		N	%
EDUCATION			**JOB POSITION**		
Primary education	4	1.1	**Managers**	34	9.2
Lower secondary education	4	1.1	**Professionals**	97	26.4
Upper secondary education	105	28.5	**Technicians**	124	34.0
Post-secondary-non tertiary education	80	21.7	**Clerical Support Workers**	37	10.1
Tertiary education	174	47.6	**Service and Sales Workers**	50	13.6
INCOME			**Agricultural Workers**	1	0.3
Under 1250€	60	16.3	**Craft Workers**	16	4.3
1250-1749€	74	20.4	**Machine Operators**	3	0.8
1750-2249€	59	16.0	**Elementary Occupations**	5	1.4
2250-2999€	56	15.2			
3000-3999€	65	17.7			
4000-4999€	28	7.6			
More than 5000€	25	6.8			

140

141   Table 2: Sample characteristics. (Continuous variables, *N* = 367)

Variable (Range)	M	SD	Min.	Max.
Age (18 to 65)	41.0	11.8	19	65
Winkler-Scheuch Index (3 to 21)	14.9	2.9	8.2	20.4
CPG pain intensity baseline (0 to 100)	21.0	13.8	0	47
CPG pain intensity follow up (0 to 100)	19.4	16.7	0	67
CPG disability baseline 0 to 100)	9.9	12.7	0	63
CPG disability follow up (0 to 100)	9.7	15.6	0	90
CPG pain class baseline	0.9	0.3	0	1

142 **Regression models:**

143 Regarding pain intensity (Table 3), only 'job position' and 'WS-index' significantly improved variance

144 explanation. Comparing variance explanation of respective SES indicators, the ranking was as follows:

145 job position (change in R^2 = 0.04, $p < 0.01$), WS-index (change in R^2 = 0.02, $p < 0.05$), education

146 (change in R^2 = 0.02, n.s.) and income (change in R^2 = 0.01, n.s.). Further, analysis revealed that

147 people with upper secondary education reported, on average, greater pain intensity compared to

148 people with tertiary education. Considering job position, technicians had significantly lower pain

149 intensity scores compared to managers. Income did not contribute to variance explanation, nor were

150 there any significant differences between income brackets. The multidimensional WS-index (included

151 as a continuous variable) improved the model significantly to confirm people with higher overall SES

152 reported less back pain.

153

154 Table 3: Four hierarchical regression models of different operationalisations predicting influence of SES on CPG

155 pain intensity score (higher values more pain). Controlled for age and sex (N = 352). ΔR^2 indicates model

156 improvement after application of SES indicator.

Model	ΔR^2	Variable	B	SE B	p
Model 1: **Education**	0.01	Upper Secondary Education (Reference: tertiary education)	4.3	2.0	0.03*
		Post-secondary non-tertiary education (Reference: tertiary education)	0.76	2.2	0.73
Model 2: **Job position**	0.04**	Professionals (Reference: managers)	-3.6	2.0	0.13
		Technicians (Reference: managers)	-4.5	2.2	0.05*
		Clerical Support Workers (Reference: managers)	-0.36	3.2	0.91
		Service and Sales Workers (Reference: managers)	2.8	2.7	0.30
		Craft Workers (Reference: managers)	8.5	4.5	0.06
Model 3: **Income**	0.02	Under 1250€ (Reference: more than 5000€)	5.2	4.2	0.22
		1250-1749€ (Reference: more than 5000€)	1.9	3.9	0.63
		1750-2249€ (Reference: more than 5000€)	2.1	4.0	0.61

		2250-2999€ (Reference: more than 5000€)	5.9	3.9	0.14
		3000-3999€ (Reference: more than 5000€)	0.8	3.9	0.83
		4000-4999€ (Reference: more than 5000€)	5.0	4.5	0.27
Model 4: **WS-Index**	0.02*		-0.9	0.3	<0.01*

157   *$p < 0.05$; **$p < 0.01$

158

159   Pain disability models yielded different results (Table 4). Education, job position and WS-index

160   explained a significant amount of variance, even sharing a stronger association in comparison to pain

161   intensity. The strongest predictor was job position (change in $R^2 = 0.07$, $p < 0.01$), followed by WS-

162   index (change in $R^2 = 0.05$, $p < 0.01$), then education (change in $R^2 = 0.02$, $p < 0.05$). Income had no

163   significant association with disability. People with professional, secondary education were

164   significantly more disabled due to back pain than people with tertiary education. Professionals

165   reported, in comparison with managers, significantly less impairment, while craft workers reported

166   significantly more. Although the income model did not improve variance explanation, people with an

167   income of less than 1,250€ reported significantly more impairment than people earning over 5000€.

168   People with a higher general SES (indicated by the multidimensional index) reported fewer

169   limitations due to back pain.

170

171   Table 4: Four hierarchical regression models of different operationalisations predicting influence of SES on CPG

172   pain disability score. Controlled for age and sex ($N = 352$). ΔR^2 indicates model improvement after application

173   of SES indicator.

Model	ΔR²	Variable	B	SE B	p
Model 1: **Education**	0.02*	Upper Secondary Education (Reference: tertiary education)	5.8	2.0	<0.01**
		Post-secondary non-tertiary education (Reference: tertiary education)	2.6	2.2	0.22
Model 2: **Job position**	0.07**	Professionals (Reference: managers)	-5.2	2.0	<0.01**
		Technicians (Reference: managers)	-1.9	2.2	0.38
		Clerical Support Workers	0.8	3.1	0.80

	(Reference: managers)			
	Service and Sales Workers (Reference: managers)	2,4	2.7	0.36
	Craft Workers (Reference: managers)	13.1	4.4	<0.01**
Model 3: **Income**	0.02	Under 1250€ (Reference: more than 5000€)	8.8	4.1	0.03*
		1250-1749€ (Reference: more than 5000€)	4.9	3.9	0.21
		1750-2249€ (Reference: more than 5000€)	4.9	4.0	0.21
		2250-2999€ (Reference: more than 5000€)	4.5	3.9	0.25
		3000-3999€ (Reference: more than 5000€)	1.3	3.9	0.73
		4000-4999€ (Reference: more than 5000€)	2.5	4.4	0.57
Model 4: **WS-Index**	0.05**		-1.3	0.3	<0.01**

*$p < 0.05$; **$p < 0.01$

DISCUSSION

The purpose of this study was to report and compare the association of common SES indicators with the genesis of CLBP. Differences between these indicators were found, suggesting that SES indicators should be selected very carefully to avoid underestimation of SES's influence on CLBP. Our results show job position is the strongest predictor and should always be appraised in further research regarding CLBP. In contrast, income and education were determined to be suboptimal predictors of CLBP. In this respect, the current findings differ from studies in other health domains. For example, Geyer et al. [6] found education to be a much stronger predictor of diabetes than job position, and income was a better predictor of overall mortality compared to education and job position. Miech et al. [8] determined education to better predict subjective health than occupation, which was not corroborated by Geyer [9], who found income and job position to be superior. Again, this just illustrates the consequences of SES operationalization and the importance of considering all possible pathways connecting SES indicators and distinct health outcomes.

In line with our hypothesis, we confirmed the single indicator, job position, and the multidimensional index to be the most influential predictors of CLBP intensity. In detail, technicians reported significantly less CLBP intensity compared to managers. We believe this could be due to technicians' greater coping opportunities, but further research should be designed to answer such questions.

193   Income showed no significant associations and was not a reliable predictor for CLBP intensity.

194   Education, as well, did not explain variance, although people with upper secondary education did

195   experience significantly more pain than people with tertiary education. Previous studies have

196   explained such findings to be influenced by better knowledge concerning healthy and preventative

197   behaviour [5]. We reasonable assumed that the WS-index would yield a significantly stronger

198   association than the single indicators; yet, this was not the case. Clearly, the addition of single SES

199   dimensions does not necessarily deliver a cumulative increase in the association, which was also

200   found to be the case by Geyer et al. [9], albeit in a different health domain. The overlapping of

201   indicators and mediating factors is potentially the problem here, leading to a shared influence on

202   CLBP for all indicators or effects of one indicator being counterbalanced by another.

203   Focusing on associations between SES and CLBP disability, our results were again partly in

204   agreement with our hypotheses. Job position was, as expected, the most influential single predictor.

205   Professionals reported significantly less impairment due to CLBP compared to managers, while craft

206   workers reported more. In similar vein as the intensity results, we believe professionals have better

207   possibilities to adjust their work environments when experiencing CLBP, something neither managers

208   nor craft workers are afforded. The multidimensional index explained the second most variance in

209   CLBP disability. Again, we found it is wrong to assume the associations of single dimensions will sum

210   up. Education was also a significant predictor of CLBP disability, but not to the degree of job position

211   or WS-index. Similarly, to intensity, upper secondary educated people reported greater impairment

212   compared to tertiary educated people. Income could not significantly explain any variance, although

213   people in the lowest income bracket reported greater impairment in comparison with those from the

214   highest. Higher incomes may enable these people to acquire certain material resources, which could

215   reduce their disability in everyday life.

216   To our knowledge this is the first study to compare the association of various SES indicators

217   with CLBP in a single sample. Our results confirm SES indicators should be selected carefully and not

218   used interchangeably. In our study, the pathways described in the model of Brunner and Marmot

219   [15] were used to predict associations between various SES indicators and CLBP. Our findings did

220   however contradict some of these predictions emphasizing just how difficult it is to predict *a priori*,

221   the most appropriate SES indicators.

222   The results presented in this paper are afflicted by some limitations, namely the small group

223   sizes of primary and lower secondary educated people, agricultural workers, machine operators and

224   elementary occupations, which led to the exclusion of these groups. This reduces the explanatory

225   power of the results and may produce an underestimation in the predicted association of education

226   and job position. A replication study including more people from lower education and job groups

227   would assure more conclusive and generalizable results. Furthermore, the lowest income bracket

228   was relatively broad. We speculate income may have had a stronger association, had this category

229   been split up. The study was also conducted in four study centres in Germany. Although Germany has

230   comparable numbers to other European countries regarding pain prevalence and severity rates [29],

231   country specific differences may lead to conflicting results in other countries. Additionally, not all

232   approaches to gauge SES were taken into account. Newer approaches, for example self-assessed

233   socioeconomic status [30, 31] or neighbourhood indicators [3], could improve future studies, but as

234   of yet, no statement can be made as to whether these approaches would have influenced our

235   results. In this study, income was evaluated as personal net income, but perhaps the material

236   situation of some would be better reflected by household income, which may hide some

237   heterogeneity.

238   In conclusion, this study highlighted job position as an all-important dimension concerning

239   SES's association with CLBP. Further research aiming to prevent and reduce CLBP should therefore

240   focus on conditions that may be influenced by job positions.

241

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract Check Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Check Page 2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Check Pages 3 and 4
Objectives	3	State specific objectives, including any prespecified hypotheses Check Page 4
Methods		
Study design	4	Present key elements of study design early in the paper Check Title and Pages 4, 5, 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Check Pages 4 and 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants Check Pages 4 and 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Check Pages 5 and 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Check Pages 5 and 6
Bias	9	Describe any efforts to address potential sources of bias Check Page 6
Study size	10	Explain how the study size was arrived at Check Page 4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Check Page 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Check Page 6
		(*b*) Describe any methods used to examine subgroups and interactions Not applicable
		(*c*) Explain how missing data were addressed Check Page 4
		(*d*) If applicable, describe analytical methods taking account of sampling strategy Not applicable
		(*e*) Describe any sensitivity analyses Not applicable
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Check Pages 4 and 5
		(b) Give reasons for non-participation at each stage Check Pages 4 and 5
		(c) Consider use of a flow diagram Not used
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Check Pages 6 and 7
		(b) Indicate number of participants with missing data for each variable of interest Not applicable (all participants with missing data were excluded)
Outcome data	15*	Report numbers of outcome events or summary measures Check Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Check Tables 3 and 4

		(*b*) Report category boundaries when continuous variables were categorized Check Table1
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Not relevant
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Not applicable

Discussion

Key results	18	Summarise key results with reference to study objectives Check Page 9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Check Page 11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Check Page 12
Generalisability	21	Discuss the generalisability (external validity) of the study results Check Page 11

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Check Page 13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.