

ORIGINAL RESEARCH

Working Conditions, Workplace Violence, and Psychological Distress in Andean Miners: A Cross-sectional Study Across Three Countries

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Abstract

BACKGROUND Psychosocial working conditions are well-known determinants of poor mental health. However, studies in mining populations where employment and working conditions are frequently precarious have, to our knowledge, only focused on occupational accidents and diseases.

OBJECTIVES The aim of this study was to assess psychosocial working conditions and psychological distress in Andean underground miners.

METHODS The study population consisted of 153 Bolivian miners working in a silver mining cooperative, 137 Chilean informal gold miners, and 200 formal Peruvian silver miners employed in a remote setting. High work demands, minimal work control, minimal social support at work, and workplace exposure to violence and bullying were assessed using the Spanish short form of the European Working Condition Survey. A general health questionnaire score >4 was used as cutoff for psychological distress. Associations between psychosocial work environment and psychological distress were tested using logistic regression models controlling for potential confounding and effect modification by country.

FINDINGS Prevalence of psychological distress was 82% in the Bolivian cooperative miners, 29% in the Peruvian formal miners, and 22% in the Chilean informal miners ($p_{\chi^2}^2 < 0.001$). 55% of the miners had suffered violence during the 12-months before the survey. Workplace demands were high (median 12.5 on a scale from 7-14), as was social support (median 5.5 on a scale from 3-6). After adjustment for country and other relevant exposure variables and considering interactions between country and job strain, miners in active (odds ratio [OR], 6.8; 95% confidence interval [CI] 2.1-22.7) and high strain jobs (OR, 7.2; 95% CI, 1.7-29.9) were at increased odds of distress compared with those in low strain jobs. Violence at work also contributed to increased odds of distress (OR, 1.86; 95% CI, 1.1-3.1).

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CONCLUSIONS Psychological distress is associated with the psychosocial work environment in Andean underground miners. Interventions in mining populations should take the psychosocial work environment into account.

KEY WORDS developing countries, epidemiology, Karasek, mental health, precarious employment

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INTRODUCTION

The work environment influences not only the physical but also the mental well-being of workers. Several models have been proposed to evaluate the effect of work on mental health. One of the most prominent models is the demand-control model.¹ The model assumes that negative health effects may result if workers do not have enough control over their work in relation to how demanding it is. This effect might be modified by social support.²

Most of the knowledge about the association between working conditions and psychosocial effects stems from industrialized countries. To our knowledge, only few studies have been carried out in developing countries.³ In these countries, changing working conditions in a globalized world are frequently combined with other challenges like poverty, precarious employment and informal work, lack of social security, malnutrition, and illiteracy.⁴

Mining is an important and rapidly growing industry in many developing countries. The mining process includes physically demanding jobs and exposes workers to various physical risks such as extreme temperatures, humidity, noise, and vibrations, as well as extended work hours and shift work.^{5,6} Additionally, the incidence of occupational accidents is known to be particularly high in traditional and small mines.⁷ Furthermore, the geographical location of many mines in Latin America requires working at high altitudes,⁸ frequently combined with internal migration to the mining zones where many miners live in camps far from their families.⁹ Informal mining with lack of knowledge about potential health risks, lack of safety equipment, and long working hours is also common and employs up to 13 million workers worldwide.¹⁰ These special employment and working conditions in the mining industry may cause psychological distress.^{11–15} Studies evaluating such working conditions and their associations with mental health—especially in developing countries—are sparse.¹⁶ Carrying out high-quality epidemiologic studies is particularly difficult in this occupational group in these countries due to

limited access and awareness, illiteracy among the miners, and lack of standardized and valid measures to assess psychosocial stressors in this profession.

Because of these gaps in the current evidence, this study aimed to evaluate the special working conditions in the mining industry and psychological distress in miners from Bolivia, Chile, and Perú, 3 Andean countries in which mining is among the most important economic activities.¹⁷

MATERIALS AND METHODS

Study Population and Settings. Cross-sectional interview studies were carried out in underground miners between 2010 and 2012. In each country, populations were chosen to present 1 of 3 typical employment conditions. The study included Bolivian miners working in a silver mining cooperative in a traditional mining town (~190,000 inhabitants); informal miners from northern Chile working and living in the gold mining sector in a traditional mining village (~10,000 inhabitants); and formal silver miners employed in a large international mining enterprise in a remote setting of Perú. Further characteristics of each mine are presented in [Table 1](#).

The same core protocol was used in all settings. However, because of cultural and organizational differences, sampling strategies were adapted to each location ([Table 1](#)). Because no complete lists of miners existed in Bolivia and Chile, convenience sampling was carried out. In Bolivia, contact was established through the board of the miners' cooperative and miners were informed about the study during a meeting organized by the board. During the following days, all those interested could answer the questionnaire in an office of the board located near the main pithead. As relatively few miners followed the invitation, miners were also actively invited to participate in the study by direct contact before their work around the pithead. In Chile, the interviews were carried out after explaining the study to the miners in 1 of 3 meetings organized by the local union, at the mines' entrances and in

Table 1. Characteristics of the Mines, Sampling Strategy, and Response by Country

	Bolivia	Chile	Perú
Employment condition	Mining cooperation	Informal	Formal, employed for ≥12 mo
Scale	Small	Artisanal	Medium
Mineral exploited	Silver	Gold	Silver
Underground mining	Yes	Yes	Yes
Altitude	~ 4000 m	~ 1000 m	4600 m
Setting	Mining town ~ 190,000 inhabitants	Mining village ~ 10,000 inhabitants	Remote area
Sampling strategy	Convenience sample <ul style="list-style-type: none"> ● Invitation to take part in study presented during meetings organized by local board ● Active recruitment 	Total target population	Random sample
Contact points	<ul style="list-style-type: none"> ● Office close to main pithead ● Miners storage room 	<ul style="list-style-type: none"> ● Meetings of the miners' union ● Mine entrance ● Home visits 	Medical unit
Target population	~ 2000	~ 200	507
Study population	<ul style="list-style-type: none"> ● 62 ● 90 	137	200
Response	<ul style="list-style-type: none"> ● – ● 65% 	~ 68.5%	~ 95%

home visits. In Perú, a simple random sample was taken from the complete list of miners directly employed in the mine. Medical staff carried out the interviews at the mine's medical unit. Subcontractors and those working <12 months were excluded.

Study Instruments and Variable Definition. The Spanish short version of the European Working Condition Survey using the recommended minimum set of questions was applied in all study locations.¹⁸ Due to the high level of illiteracy in the study population, interviews were conducted. Before participation, miners were informed about the voluntary nature of the study and gave informed consent. The interviews were conducted anonymously by 1 or 2 trained interviewers per location.

Ethical approval was obtained by the ethics committee of the University Hospital Munich, the Universidad Católica del Norte (Chile), the Regional Health Department (Bolivia), and the Universidad Católica Santa María de Arequipa (Perú).

Following the approach used by the European Working Condition Survey,¹⁹ 3 dimensions of the demand-control model were formed:

1. Psychological work demands (4 items: working at high speed; working to tight deadlines; not having enough time to get the job done; pace of work dependent on the work of colleagues)

2. Decision latitude (7 items: applying own ideas in work; freedom to decide; being able to choose or change order of tasks, methods of work, speed or rate of work; being able to take a break when one wishes; being free to decide when to take holidays/days off)
3. Social support (3 items: getting assistance from colleagues or superiors/boss when needed; having good relationships at work)

For each dimension, an overall score was calculated as previously suggested.¹⁹ The Likert scale-based responses ranging from 1 (*never*) to 5 (*always*) were transformed based on the formula:

$$x = 1 + \frac{\text{reponse on Likert scale} - 1}{\text{Numer of response categories} - 1}$$

The resulting values (ranging between 1 and 2) of each dimension were summed. Using the median as cutoff point, those with resulting scores above the median were defined as being exposed to the respective dimension (high demand, high control, or high social support).^{1,19}

Based on Karasek's demand-control model, 4 categories of job strain were defined:

1. Low strain: low demand, high control
2. Passive: low demand, low control

3. Active: high demand, high control
4. High strain: high demand, low control.

Exposure to physical violence (2 items), sexual harassment (1 item), or bullying (3 items) was considered present if at least 1 of the situations was reported to have occurred during the 12 months before the survey.

The participants reported type of job as open text answer. The respective local experts (A.B. for Bolivia, T.F.L. for Chile, and S.Q. for Peru) afterward grouped these jobs into the following 5 categories:

1. Supervisor (mainly supervisory tasks, no heavy manual work)
2. Technician (maintenance work)
3. Driver (eg, truck driver or transport of persons)
4. Equipment/machine operator (operating heavy machines)
5. Field operator (all other tasks directly related to mining; heavy physical work)

Additionally, 1 independent expert in the field of Latin American mining grouped all jobs (José Ignacio Mendez Campos). In case of discrepancy between the groupings, consensus was reached via e-mail discussion.

General mental health was assessed using the 12-item version of the General Health Questionnaire (GHQ-12).²⁰ This questionnaire evaluates the likelihood of common mental disorders.²¹ The general mental health score was formed using the 0-0-1-1 scaling method. As suggested by a Chilean validation study, miners with a GHQ-12 score >4 were defined as suffering from psychological distress (23). Additionally, to evaluate the stability of our results, we performed sensitivity analyses using 5 and 6 to define distress. Because the prevalence of distress might depend on culture,²² we also considered the use of country-specific cutoff values (4-5 for Chile and Perú, 6-7 for Bolivia).

Statistical Analyses. Overall and country-stratified absolute frequencies were calculated. To assess independence of the results by country, the Monte-Carlo exact method was used to estimate the p^2_χ -value. This was necessary due to low numbers of observations in some cells. Because item non-responses were low, bivariate and multivariate modeling was done using a complete case approach. Bivariate associations between psychosocial working conditions and distress at work were assessed also using the Monte-Carlo exact methods.

In the final step, logistic regression models of psychosocial exposure scores as predictors and

psychological distress as outcome variables were developed to calculate odds ratios (ORs) with corresponding 95% confidence intervals (CIs). First, crude results were estimated for all countries combined. In the next step, we adjusted for country to check potential confounding. After that, mutual adjustment for all factors with a $P < .05$ in the bivariate analyses was done. Finally, an interaction term for job strain and country was included to assess effect modification. Additionally, effect modification of job strain by social support was tested including an interaction term for the 4 job-strain categories multiplied by social support in the model. The final model contained all statistically significant predictors and interaction terms.

Additional sensitivity analyses were performed adjusting for age, duration of employment, and job insecurity. Furthermore, analyses were repeated using different cutoff points to define distress (see previously). A final sensitivity analyses tested the robustness of the findings when data were restricted to equipment and field operators. SPSS 22.0 (IBM) was used for all calculations.

RESULTS

Descriptive Results. Of 489 participating male miners, 63% were <40 years. Age differed statistically significantly by country with miners from Chile being older than miners from Bolivia or Perú (Table 2). Duration of employment was lowest in Perú ($p^2_\chi < 0.001$). All Bolivian miners worked as operators, whereas in Chile and Perú some miners also worked in jobs requiring higher skills or as drivers (12.9%; $p^2_\chi < 0.001$).

The psychosocial work environment differed greatly among the 3 populations in the study. Overall, job security was considered high by only one-third of the population, with highest levels in Bolivia (47%) and lowest in Chile (26%; $p^2_\chi < 0.001$). Fifty-five percent of the miners faced some kind of workplace violence over the previous 12 months. Prevalence was especially high in Bolivia (78%) and Perú (64%) compared with Chile (18%; $p^2_\chi < 0.001$). More than half of the Chilean miners considered their job to be of low strain (53%), whereas 54% of the Peruvian miners classified their jobs as passive. In contrast, Bolivian miners most frequently described their job as being active (42%; $p^2_\chi < 0.001$).

Using a cutoff of 4 to 5, the overall prevalence of psychological distress was 43% with substantial differences between countries: Whereas only 22% of

Table 2. Descriptive Data, Psychological Distress, and Exposure Index by Country

Category		Total	Chile	Perú	Bolivia	$p^2_{\chi^2}$ Monte Carlo
		(N = 489)	(n = 137)	(n = 200)	(n = 152)	
		n (%)	n (%)	n (%)	N (%)	
Descriptives						
Age (y)	<30	158 (32.4)	11 (8)	78 (39)	69 (45.8)	<0.001
	30-39	149 (30.4)	18 (13.1)	83 (41.5)	48 (31.4)	
	40+	182 (37.1)	108 (78.8)	39 (19.5)	35 (22.9)	
Sex	Male	489 (100)	137 (100)	200 (100)	152 (100)	1.00
Duration of employment(y)	>Median (4 years)	218 (44.8) [†]	64 (47.2) [†]	63 (31.5)	91 (59.9)	<0.001
Type of job	Supervisor	25 (5.1)	17 (12.4)	8 (4)	0 (0)	<0.001
	Technician	23 (4.7)	5 (3.6)	18 (9)	0 (0)	
	Driver	15 (3.1)	4 (2.9)	11 (5.5)	0 (0)	
	Equipment operator	278 (56.9)	41 (29.9)	142 (71)	95 (62.5)	
	Field operator	148 (30.3)	70 (51.1)	21 (10.5)	57 (37.5)	
Psychosocial work environment						
Job security	Low [†]	133 (27.2)	42 (30.7)	56 (28)	35 (23)	0.001
	Medium	188 (38.4)	60 (43.8)	83 (41.5)	45 (29.6)	
	High	168 (34.4)	35 (25.5)	61 (30.5)	72 (47.4)	
Work-place violence	Yes	257 (55) [‡]	24 (18) [§]	119 (63.6)	114 (77.6) [¶]	<0.001
High support	>Median [#]	186 (38)	93 (67.9)	48 (24)	45 (29.6)	<0.001
High demand	>Median ^{**}	205 (41.9)	35 (25.5)	67 (33.5)	103 (62.8)	<0.001
High control	>Median ^{††}	215 (44.1) ^{††}	91 (67.4) [†]	34 (17)	90 (59.2)	<0.001
Job strain	Low strain	122 (25.1) [†]	71 (52.6) [†]	25 (12.5)	26 (17.1)	<.0001
	Passive	160 (32.9)	29 (21.5)	108 (54)	23 (15.1)	
	Active	93 (19.1)	20 (14.8)	9 (4.5)	64 (42.1)	
	High strain	112 (23)	15 (11.1)	58 (29)	39 (25.7)	
Outcome: Psychological distress assessed via General Health Questionnaire						
GHQ-12	>4	211 (43.1)	30 (21.9)	57 (28.5)	124 (81.6)	<0.001
GHQ-12	>5	150 (30.7)	18 (13.1)	38 (19)	94 (61.8)	<0.001
GHQ-12	>6	66 (13.5)	11 (8)	12 (6)	43 (28.3)	<0.001

* N_{missing} = 2.
[†] The low category includes "unknown."
[‡] N_{missing} = 22.
[§] N_{missing} = 4.
^{||} N_{missing} = 13.
[¶] N_{missing} = 5.
[#] Median = 5.5 on a scale from 3 to 6.
^{**} Median = 6 on a scale from 4 to 8.
^{††} Median = 12.5 on a scale from 7 to 14.

the Chilean miners reported distress, >80% of Bolivian miners stated distress ($p^2_{\chi^2} < 0.001$).

Associations Between Psychosocial Work Environment and Distress. For the total study population, prevalence of distress was higher in a) those with an employment duration above the median (54%) compared with those with a shorter employment duration (35%); b) those who experienced workplace violence (57%) compared with those not suffering workplace violence (28%); and c) those who considered their job more demanding than the median (57%) compared with those who reported

their jobs as less demanding (34%; all $p^2_{\chi^2} < 0.001$; Table 3). Using the 4 job-strain categories of the demand-control model, the prevalence of distress was highest in active (70%) and high-strain jobs (47%) compared with passive (38%) and low-strain jobs (28%; $p^2_{\chi^2} < 0.001$). Prevalence of distress did not statistically significantly decrease with increasing age ($p^2_{\chi^2} = 0.06$) or with type of job ($p^2_{\chi^2} = 0.07$). Those experiencing high social support (32%) in their work environment reported less distress than those reporting lower social support (51%; $p^2_{\chi^2} < 0.001$).

Table 3. Prevalence of Psychosocial Distress (GHQ-12 Score >4) by Age and Psychosocial Work Factors Stratified by Country (Complete Case Analyses)

		Total		Chile		Peru		Bolivia	
		(N = 463)		(n = 129)		(n = 187)		(n = 147)	
		N	%	n	%	N	%	N	%
Age (y)	$p^2_{\chi^2}$ Monte-Carlo	0.06		0.14		0.44		0.54	
	<30	73	49.7	1	10	19	26.8	53	80.3
	30-39	66	45.5	1	5.6	28	35	37	78.7
	40+	63	36.8	24	23.8	9	25	30	88.2
Duration of employment	$p^2_{\chi^2}$ Monte-Carlo	< 0.001		0.05		0.87		0.08	
	≤ Median	89	35.3	9	13.2	37	29.4	43	74.1
	> Median	113	53.6	17	27.9	19	31.1	77	86.5
Type of job	$p^2_{\chi^2}$ Monte-Carlo	0.07		0.84		0.80		0.39	
	Supervisor	7	29.2	4	25	3	37.5	0	0.0
	Technician	5	22.7	1	25	4	22.2	0	0.0
	Driver	4	26.7	1	25	3	27.3	0	0.0
	Equipment operator	120	46.0	5	13.2	42	32.1	73	79.3
	Field operator	66	46.8	15	22.4	4	21.1	47	85.5
Job security	$p^2_{\chi^2}$ Monte-Carlo	0.13		0.43		0.41		0.50	
	Low or unknown	49	41.5	10	27	15	30.6	24	75
	Medium	74	40.9	11	19	27	34.2	36	81.8
	High	79	48.2	5	14.7	14	23.7	60	84.5
Workplace violence	$p^2_{\chi^2}$ Monte-Carlo	<0.001		<0.001		0.32		0.44	
	No	57	27.5	15	14.2	17	25	25	75.8
	Yes	145	56.6	11	47.8	39	32.8	95	83.3
High support	$p^2_{\chi^2}$ Monte-Carlo	<0.001		0.008		0.10		0.65	
	≤ Median	144	50.7	14	35.0	47	33.3	83	80.6
	> Median	58	32.4	12	13.5	9	19.6	37	84.1
High demand	$p^2_{\chi^2}$ Monte-Carlo	<0.001		<0.001		0.74		0.17	
	≤ Median	89	33.6	11	11.3	38	30.9	40	88.9
	> Median	113	57.1	15	46.9	18	28.1	80	78.4
High control	$p^2_{\chi^2}$ Monte-Carlo	0.40		0.34		0.30		0.66	
	≤ Median	105	41.7	10	25.6	49	31.6	46	79.3
	> Median	97	46	16	17.8	7	21.9	74	83.1
Job strain	$p^2_{\chi^2}$ Monte-Carlo	<0.001		<0.001		0.67		0.15	
	Low strain	33	27.7	7	10	5	20.8	21	84
	Passive job	56	38.4	4	14.8	33	33.3	19	95
	Active job	64	69.6	9	45	2	25	53	82.8
	High strain	49	46.2	6	50	16	28.6	27	71.1

Stratifying for country, associations between psychosocial work environment and distress were confirmed for Chilean miners. In Bolivia, increased job tenure was weakly related to a higher prevalence of distress (87% vs 74%; $p^2_{\chi^2} = 0.08$). In Perú, only higher social support (20%) compared with lower social support (33%) was related to low distress; however, results did not reach the level of statistical significance ($p^2_{\chi^2} = 0.10$; Table 3).

Results of the Logistic Regression Models. The associations between psychosocial work environment and distress were basically confirmed in the

logistic regression models (Table 4). After adjustment for country and further relevant exposure variables, miners in passive (OR, 1.98; 95% CI, 1.01-3.87) and active jobs (OR, 2.19; 95% CI, 1.04-4.59) were at increased odds of distress compared with miners in low-strain jobs. Considering effect modification by country, job strain remained significantly associated with distress. In this model, the OR for passive jobs were below significance. However, the ORs for active (6.83; 95% CI, 2.05-22.7) and high-strain jobs (7.19; 95% CI, 1.73-29.88) increased. This was mainly due to the

Table 4. Association between Occupational Exposures and Psychological Distress in 463 Underground Miners from Chile, Perú, and Bolivia: Results of the Logistic Regression Models

OR (95% CI)	Crude	Adjusted for country	Mutually adjusted	Mutually adjusted + interaction term Job strain × country
Country				
Chile	1	-	1	1
Perú	1.69 (1.00-2.88)	-	0.98 (0.51-1.90)	1.62 (0.44-5.99)
Bolivia	17.61 (9.67-32.06)	-	9.34 (4.77-18.31)	27.70 (6.97-110.02)
Duration of employment				
>Median	2.11 (1.45-3.07)	1.66 (1.06-2.58)	1.65 (1.04-2.60)	1.63 (1.02-2.61)
Workplace violence				
No	1	1	1	1
Yes	3.44 (2.32-5.09)	2.05 (1.26-3.33)	1.85 (1.12-3.04)	1.86 (1.11-3.13)
Social support				
Low	1	1	1	1
High	0.47 (0.32-0.69)	0.55 (0.34-0.90)	0.67 (0.40-1.12)	0.65 (0.38-1.11)
Job strain				
Low strain	1	1	1	1
Passive	1.62 (0.96-2.73)	1.99 (1.04-3.78)	1.98 (1.01-3.87)	1.43 (0.37-5.49)
Active	5.96 (3.27-10.84)	2.45 (1.19-5.02)	2.19 (1.04-4.59)	6.83 (2.05-22.71)
High strain	2.24 (1.29-3.90)	1.62 (0.82-3.20)	1.50 (0.73-3.07)	7.19 (1.73-29.88)
Country × Job Strain				
Passive × Perú	-	-	-	1.27 (0.22-7.28)
Passive × Bolivia	-	-	-	3.16 (0.22-46.37)
Active × Perú	-	-	-	0.16 (0.02-1.54)
Active × Bolivia	-	-	-	0.12 (0.02-0.71)
High × Perú	-	-	-	0.19 (0.03-1.22)
High × Bolivia	-	-	-	0.07 (0.01-0.46)

statistically significant interaction between Bolivia and these 2 job strain categories. No effect modification by social support could be shown (Supplementary Table 1).

Additional adjustment for age and job security did not change the results. Likewise, using 5 to 6 instead of 4 to 5 as the cutoff for the definition of distress did not substantially influence the risk estimates. Raising the cutoff of the GHQ-12 to 6 to 7 CIs became wider and associations lost statistical significance (Supplementary Table 2). Applying country-specific cutoff points for the GHQ-12, country was no longer associated with GHQ-12 and also the interaction term between job strain and country lost statistical significance. In this model, social support was inversely related to distress (OR, 0.56; 95% CI, 0.34-0.93), whereas violence in the workplace lost statistical significance (OR, 1.60; 95% CI, 0.97-2.63; Supplementary Table 3). Restricting the analyses to equipment and field operators did not change the results (Supplementary Table 4).

DISCUSSION

This 3-country study intended to describe psychosocial working conditions and psychological distress in miners engaged in different facilities across the

Andean region. The results demonstrated a very high prevalence of psychological distress, reaching up to 82% in Bolivian miners. More than half of the miners experienced some form of workplace violence over the 12 months before the study. Employment conditions were precarious. As expected, psychosocial factors were substantially associated with psychological distress. Furthermore, country-specific influences on these associations were found.

Strengths of this study included the high number of miners enrolled, taking into account that the not formally employed miners are difficult to reach. The standardized questionnaire, Spanish version of the European Working Condition Survey (EWCS),¹⁸ increased the reliability and validity of the information on miners psychosocial work environment. We used an established approach to define psychosocial working conditions according to the demand-control model.¹⁹ We acknowledge that the short form serves as a screening assessment for the work environment because it does not consider all items listed in the EWCS.¹⁸ Consistent with the EWCS, self-reported exposure and outcome was investigated, which is valid especially because health effects of the psychosocial work environment largely depended on the personal evaluation of the situation.²³

The GHQ-12 is a globally used tool to assess common mental health problems. It has been validated in Chile. Because of potential illiteracy among the miners, trained interviewers anonymously administered the questionnaires to reduce reporting bias. Potential confounding by age, duration of employment, and country were taken into account.

We cannot assess the extent to which selection bias might have influenced these results because we were not able to obtain random samples of miners in Bolivia and Chile. It could be that mainly miners concerned about working conditions and health participated. However, because the majority are self-employed and cooperative miners, respectively, it is very likely that personal interest motivated participation. In contrast, all of the Peruvian miners participated because the study was organized by the mines' occupational health office and the interviews were offered during working hours. As one of the authors (S.Q.) is one of the mine's doctors, the high response might indicate a positive working relationship with the miners.

As in any interview-based study, reporting bias due to social desirability may occur. This might have affected responses on physical violence and bullying at the workplace, potentially resulting in an increased item nonresponse. Few minor adaptations of the questionnaire had to be done to make it understandable by the miners. The content of the validated GHQ-12 scale was not changed. The cross-sectional design has to be taken into account as it precludes the possibility to evaluate the timely order of exposure and outcome (eg, mental health problems might be a result of bullying but they might also be the cause of it).

The study populations were chosen to reflect different employment conditions and settings—ranging from a typical relatively large mining town (Bolivia) to a remote mining camp (Peru). Therefore, the differences found in working conditions and outcome may represent a combination of cultural differences and the location. One also has to take into account the fact that tasks in the same type of job might differ considerably across countries. For example, the same manual job in Chile might be done with advanced technical equipment in Perú, but no such equipment might be available for this job for some miners in Bolivia. This especially may affect the grouping into equipment or field operators. This has to be taken into account before generalizing results. However, despite cultural differences, the different settings afford a unique opportunity to describe working conditions

and psychological distress in miners engaged in 3 typical mining activities in the Andean region.

The mean GHQ-12 scores for the Chilean miners (2.8 ± 2.6) were comparable with those found previously in Chile (mean score 3.8 ± 1.8).²⁴ Likewise, the prevalence of distress found in rural and urban Peruvian population (39.4%) was even higher than in our study (28.5%).²⁵ At first glance, the prevalence of psychological distress in Bolivian miners (82%) was particularly high. Unfortunately, no comparison data exist for the Bolivian general population. Given the psychosocial working conditions, the precarious employment situation of these cooperative miners, the rare use of safety equipment (Basagoitia, personal communication, July 2014) and low life expectancy in this community, the results might be plausible. One other aspect that should be taken into account is that culturally specific cut-points may apply for the GHQ-12.²² All these aspects may have contributed to the especially high prevalence of psychological distress observed in Bolivian cooperative miners. However, using country-specific cutoff points in the sensitivity analyses only marginally changed the results on the association between job strain and distress.

Although there are many studies focusing on workplace violence among health care workers, studies in blue-collar workers are limited. In the EWCS, exposure to physical violence was reported by 7% of men; 5% reported bullying.¹⁹ This gives some indication that the overall workplace exposure to violence was extremely high in our study: 55% of the miners experienced at least 1 assault of violence, sexual harassment, or bullying in the 12 months leading up to the study. The median work demand score might also be considered high (median 12.5 on a scale from 7–14). At the same time, it is worth taking into account the high level of social support experienced by the miners (median 5.5 on a scale from 3–6).

The association among demand, control, and social support and mental health seen in our study is in line with previous research.^{26,27} Miners in active and high-strain jobs were at increased risk for distress. This is also in line with recent findings of other studies from Latin America.²⁸ However, we did not find a dose-response relationship between job strain and mental health as previously described.²⁹ This might be because of the specific work environment of the miners where high impact of demands may outweigh the effect of control. Analyzing demand and control separately this was confirmed ([Supplementary Table 5](#)).

We can only speculate why associations between psychosocial working conditions and psychological

distress were strongest in Chile. One reason might be a greater exposure variation and thus better statistical power. The lack of association between exposures and outcome for Perú might have several explanations: Peruvian miners were employed in a relatively large industrial mine offering formal contract, occupational health services, and so on. Therefore, it is plausible that employment and working conditions are better than in Chile and Bolivia. This might be particularly more important in remote facilities and settings. Furthermore, employment duration of Peruvian miners was lowest; therefore, exposure effects might only be observed later.

To our knowledge, this was the first investigation into the effect of psychosocial work environment for the psychological well-being of miners. It indicates that job demands and violence at the workplace contribute to mental health of miners. In this high-risk work environment, one has to take into account that psychological distress not only affects miners' well-being but also affects mortality.³⁰

CONCLUSION

This study indicated that Andean miners working under different employment conditions face severe

psychosocial risks at work. These psychosocial factors are associated with psychological distress as a measure of common mental health problems. Psychological distress reduces quality of life and increases mortality. Therefore, occupational health programs for miners should not only include prevention of occupational accidents and diseases but also should target psychosocial aspects of the work environment.

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SUPPLEMENTARY DATA

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.aogh.2015.06.002>.

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