Cross-border Mobility in European Countries: Associations between Cross-border Worker Status and Health Outcomes

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Abstract

Background. Mobility of workers living in one country and working in a different country has increased in the European Union. Exposed to commuting factors, cross-border workers (CBWs) constitute a potential high-risk population. But the relationships between health and commuting abroad are under-documented. Our aims were to: (1) measure the prevalence of the perceived health status and the physical health outcomes (activity limitation, chronic diseases, disability and no leisure activities), (2) analyse their associations with commuting status and countries of destination, and (3) confirm the positive association between wage and health index for both CBWs and non-cross border workers (NCBWs).

Methods. Based on the ’Enquête Emploi’, the French cross-sectional survey segment of the European Labour Force Survey (EU LFS), the population was composed of 2,546,802 workers. Inclusion criteria for the samples were aged between 20 and 60 years and living in the French cross-border departments of Germany, Belgium, Switzerland and Luxembourg. The Health Index is an additional measure obtained with five health variables. A logistic model was used to estimate the odds ratios of each group of CBWs, taking NCBWs as the reference group, controlling by demographic background and labour status variables.

Results. A sample of 34,362 observations (3,453 CBWs vs. 30,909 NCBWs) was retained. The CBW status is positively associated with a better perceived health, activity limitation, chronic diseases and disability. A marginal improvement of the health index is correlated with a wage premium for both NCBWs and CBWs. Commuters to Switzerland have the higher health outcomes among all CBWs. Commuters to Germany report lower disability and more leisure activities.

Conclusion. CBWs are healthier and have more income. This main finding suggests (1) a healthy cross-border phenomenon stemming from a social selection and a positive association between income and the health index is confirmed; (2) the existence of major health disparities among CBWs; and (3) the rejection of the spillover phenomenon assumption for CBWs. The newly founded European Labour Authority (ELA) should take into account health policies as a promising way to support the cross-border mobility within the European Union.

Background

Between 2017 and 2018, the number of cross-border workers (CBWs) increased from 1.4 million to 1.5 million workers in the European Union (EU) [1], making cross-border mobility a phenomenon of growing interest. Since freedom of movement for workers has been defined as the cornerstone of the EU, commuting abroad became a preoccupation of and major challenge for the states such as transport (Bike2Work EU’s project of 2014-2017) (ESPN 2019) but also for the European Public Health and Social Policy a major challenge. Commuters have less time to participate in activities that are beneficial for their health such as sport, meditation or socialising [2]. The link between CBWs and health was mainly addressed regarding the commuters’ access to the healthcare system [3].

CBWs are experiencing a specific and common lifestyle, while commuting more than the rest of the workforce [4]. Commuting may affect workers’ health, and projections indicate that more and more workers will be commuting abroad in the future [5], therefore, CBWs represent a potential high-risk population combining several drawbacks which may impact their health. European Social Policy might be soon confronted with a declining health status of workers leading to a rise of health expenditures. In this perspective, an increased understanding of cross-border health issues is a matter of prime importance. Consequently, our main research question is: do health disparities between Cross-Border Workers (CBWs) and Non-Cross-Border Workers (NCWBs) exist?

Scientific works have tried to capture the complex relationship between commuting and health by mainly focusing on the understanding of the commuting effects on workers’ health [6]. Commuting deteriorates commuters’ health through two separate channels, a quantitative one related to commuting time and a qualitative one related to the commuters’ ways of commuting.

A long commute is associated with a higher mortality risk [7], greater exposure to pollution [8], increased stress [9], exhaustion [10], sleep disorders [11] and lower satisfaction felt during socialising [12] and leisure [13]. For example, in France, the mean duration of one-way commuting time between the place of residence and the workplace increased from 38.3 minutes in 2005 to 44.9 minutes in 2015 [14].

Secondly, modes of commuting generate specific health problems. Physical activity has been more often observed among pedestrians [15], cyclists [16] and public transport users [17] than by car users. Pedestrians, cyclists and public transport users have a
lower body mass index (BMI) than car drivers [18; 19]. In contrast, high stress was found among car drivers and low stress among active commuters i.e., pedestrians and cyclists [20; 21]. In addition, active commuters reported higher satisfaction's levels than car drivers and public transport users [22]. Passive commuting i.e., car and public transports, is associated with a low perceived health among workers [2]. Self-perceived health is a widely used indicator in the literature [2; 23].

Commuting is not the only factor that affects CBW's health. Higher incomes allow people to buy more or better goods (e.g. organic food), or to participate in sports or leisure activities with positive health benefits [24]. An income hypothesis can be suggested here and would imply that each additional euro of income would raise individual health. Between income and self-perceived health, a positive association was highlighted [25]. In contrast, a negative relationship exists between income and BMI [26; 27] and also between income and health problems such as asthma, hearing problems and dental symptoms [28]. In the same vein, low income is correlated with low self-perceived health [29], more activity limitation [30], more chronic diseases [31], more disability [32] and lower participation in sports [33].

As each member state of the UE maintains its own social security national institutions, information about CBWs remains piecemeal [34]. De facto, widespread international datasets commonly used to analyse workers’ health, such as the European Working Conditions Survey (EWCS), the European Health Interview Survey (EHIS) or the EU Statistics on Income and Living Conditions (EU-SILC), are unusable in this case owing to the impossibility to identify CBWs. Since 1950, the labour survey ('Enquête Emploi') driven by the National Institute of Statistics and Economics Studies ('Institut National de la Statistique et des Etudes Economiques' - INSEE) constitutes the main source of information on the French labour market and workforce [35]. Based on the European Union Labour Force Survey (EU LFS), the labour survey section 'Enquête Emploi' was the only dataset allowing researchers to identify and to better understand the commuting behaviours of CBWs.

Because of their commuting activity, the CBW status constitutes a potential risk factor but the relationships between commuting abroad for work, health outcomes and income are under-documented. This is why, studies are still needed that aim to identify if some groups are at more risk for ill health than others [2]. Our study aims to: (1) measure the prevalence for the perceived health status and the physical health factors (such as activity limitation, chronic diseases, disability and no leisure activities), (2) analyse their associations with commuting status as well as (3) with income and health index between CBWs (commuting to Germany, Belgium, Switzerland and Luxembourg) and NCBWs controlling by demographic background and labour status covariates.

In the absence of CBWs’ self-selection or employers’ selection, we should expect that commuting will worsen CBWs’ health, but that their higher incomes will improve their health compared to NCBWs. We assume that CBWs report a lower perceived health status, higher limitation of activities, a higher number of chronic diseases and disability, and fewer leisure activities than NCBWs.

**Methods**

**Design**

Between 2013 and 2018, 2,546,802 subjects were surveyed in a repeated-cross sectional survey conducted with a representative sample of the French population. The questionnaire [36] was administered face to face (for the first and the final measurement) and by telephone (for all other measurements). Since we cannot determine the number of people contacted people who fulfilled our inclusion criteria in this dataset, the response rate cannot be calculated. Nevertheless, the INSEE indicates a response rate of 80%, and we have no reason to believe that our response rate is different.

**Initial Population and Sample**

A sample of workers characterised by different workplace locations was extracted from the labour survey. Our sample fulfilled the following inclusion criteria: aged between 20 and 60 years, employed workers according to the International Labour Office (ILO) definition and residing in the French territory within the French cross-border departments (see Figure 1: The French cross-border regions.). The French state is decomposed into three administrative districts: the 'Communes' (town), the 'Départements' (county) and the 'Régions' (states) (UK regions) (there are 34,970 Communes, 101 Départements called departments from now on) and 13 Régions). All departments in which at least 50 CBWs lived and in which CBWs represent at least 1% of the workforce were included in
the analyses. Four commute destinations were retained, namely Germany (DE), Belgium (BE), Switzerland (CH) and Luxembourg (LU), since these countries attracted 92% of the French's CBWs [37]. The final sample was composed of 34,362 workers.

Data Collection

Since 2013, the survey integrated information about workers’ health, and the module assessing this is composed of four questions (see health variables). Between 2013 and 2018, the number of CBWs per year (e.g. 490 for 2015) leads to combine the labour survey individual folders for years and the health questions. The labour survey benefits from the approval of the Institutional Review Board called Comité du Label de la Statistique Publique, which depends on the Conseil National de l’Information Statistique (CNIL). The questionnaire of the mother study has been previously published and only the relevant questions were kept.

Exposure Variables: ‘CBW status’

Two parameters were considered to describe the worker's situation, his commuting status and his country of destination. A worker can decide either to work in France or to commute abroad.

Health Outcomes

Four questions assessing health outcomes were included in the labour survey and one question not directly linked to health issues was used to generate a variable relating to leisure activity participation.

Perceived Health Status

- **Low perceived health**: This subjective scale included one item: ‘How do you rate your overall health?’ and responses options were: (1) very good, (2) good, (3) fair, (4) poor, and (5) very poor, (6) refusal and (7) do not know.

For the statistical analyses, the score was dichotomised: (3), (4) and (5) were coded ‘low self-perceived health’ following the recommended cut-off scores [24; 25]. (6) and (7) were coded as missing values.

Physical Health Factors

- **Activity limitation**: ‘Have you experienced restrictions in performing activities that people typically do because of a health problem for at least six months?’ Response options were: (1) yes heavily restricted, (2) yes, limited but not strongly, (3) no, not limited at all, (4) refusal and (5) do not know.

Responses were coded: (1) and (2) ‘limitations due to health reasons’ and response (3) was coded as ‘no limitations due to health reasons’. (4) and (5) were coded as missing values.

- **Chronic diseases**: ‘Do you have an illness or health problem that is chronic or of a lasting nature?’ Responses options were: (1) yes, (2) no, (3) refusal and (4) do not know.

Responses were coded: 1) ‘having a chronic disease’ vs. 2) ‘no chronic disease’. Responses 3) and 4) were coded as missing values.

- **Disability**: ‘Is your disability or loss of autonomy recognised by the administration?’ Response options were: (1) yes, (2) demand under review, (3) no, (4) refusal and (5) do not know.

Responses were coded: (1) and (2) ‘handicapped’ vs. (3) ‘not handicapped’. Responses (4) and (5) were coded as missing values.

- **No leisure activities**: ‘During the past three months, did you take sports lessons or courses related to cultural or leisure activities?’ Response options were (1) yes and (2) no.

Responses were coded: (2) ‘no physical or cultural activities’ vs. (1) ‘physical or cultural activities’.
Covariates

Consolidated variables are those composed by the respondents’ answers to several questions.

**Demographic background**

- (Var.1) **Sex**: (2 categories: men women)
- (Var.2) **Age**: (4 categories: 20-29, 30-39, 40-49, 50-60)
- (Var.3) **Education**: (3 categories: up to secondary school, up to Bachelor’s degree, Master’s degree & above)
- (Var.4) **Occupational category**: (5 categories: white collars, intermediate professions, employees, blue collars)
- (Var.5) **Father’s occupational category**: assessed at the end of the respondent’s own schooling. (6 categories: farmers; artisans, merchants, company directors; white collars; intermediate professions; employees, blue collars)
- (Var.6) **Born abroad**: (2 categories: born in France born abroad) Respondents were asked ‘Where were you born?’. Responses options were 1) in France and 2) not in France.
- (Var.7) **Cohabitating**: (2 categories: living together with someone living alone) Respondents were asked ‘Are you living together with someone in one household?’. Response options were (1) yes and (2) no.
- (Var.8) **Children**: (2 categories: has a child(ren) does not have child(ren)) Respondents were asked ‘Do you have children in the household or in alternate care?’. Response options were (1) yes and (2) no.
- (Var.9) **Departments**: (11 categories: departments of residence (see Figure 1: The French cross-border regions)
- (Var.10) **Urban area**: (2 categories: place of residence located in an urban area with fewer than 200,000 inhabitants with 200,000 inhabitants or more)

Sex, age, education, occupational category, father’s occupational category, departments, and urban area are consolidated variables.

**Labour status**

- (Var.11) **Permanency of the job**: (3 categories: permanent contract, temporary contract, interim contract)
- (Var.12) **Sector**: (9 categories: agriculture; industry-construction; trade-transport-accommodation and catering; information and communication; finance and insurance; real estate; scientific activities and administrative services; public administration; other services)
- (Var.13) **Number of persons working at the local unit**: (4 categories: 1 to 9 workers, 10 to 49 workers, 50 to 499 workers, 500 workers and more). Respondents were asked ‘How many employees are approximately on the site which employs you?’.
- (Var.14) **Wage**: (3 categories: up to 2,000 net € per month, premiums included, between 2,001 and 4,000€, 4,001€ and higher) Nominal wage.
- (Var.15) **Full-time/part-time employment**: (2 categories: full-time employment part-time employment)
- (Var.16) **Overtime**: (2 categories: overtime no overtime) Respondents were asked ‘How many extra hours do you usually work per week in your professional job?’.

Permanency of the job, sector, number of persons working at the local unit, wage and full-time/part-time employment are consolidated variables.

**Statistical Analysis**

To distinguish CBW from NCBW, a dichotomous variable was generated as well as four binary variables, one for each country of destination. Example, the variable for Germany was coded as: 1) is working in Germany and 0) is working in France but lives in the same department, as CBW working in Germany. To preselect the covariates, chi-square tests were used for qualitative variables and Student’s t-tests for the quantitative ones, including those which were significant (p<0.10) for at least one of the health outcomes. The covariates were selected based on the previously described theoretical frameworks and introduced in three steps. A logistic model
was estimated for each health variables and covariates were introduced in order to predict the probability of CBWs to report a health issue compared to NCBWs.

In a first step, only the commuting status was introduced in the model (unadjusted model). In a second step, the demographic background of the individuals was introduced in the adjusted model. In a third step, the labour status of the individuals was introduced in the fully adjusted model.

The variable cohabiting was preferred to the marital status i.e., the legal recognition of cohabitation, because it allows us to capture all the workers that benefited from a lower mortality rate [38] and not only those having the legal recognition of their situations. All the outcome variables were coded with the aim to model the probability of being in ill health according to the cross-border worker status. An odds-ratio greater than one can also be understood as verification of ill health for CBWs compared to NCBWs, whereas an odds-ratio smaller than one indicated a better health in the group of CBWs compared to the reference group of NCBWs.

The Health Index (5 items) was an additional measure obtained with the score of four physical health variables and the perceived health score: ‘the higher the score, the healthier the worker’. For each item, one point was assigned if the answer indicated a high health state and no point if the answer indicated a poor health. For example, the absence of disability was considered as an indication of a good health state. For the perceived health, one point was assigned if the respondents estimated their health as ‘very good’ or ‘good’, whereas a zero score was assigned if the answer was ‘fair’, ‘poor’ or ‘very poor’.

Binary logistic regression modelling was used to determine associations between the commuting status and each of the five health outcomes. Odds ratios were estimated with a 5% risk of error i.e., 95% confidence intervals (CI)). Covariates were added to the model to provide adjusted and fully adjusted associations for CBWs as a whole as well as for CBWs of the different country destinations. All statistical analyses were performed using the software STATA 16.0.

**Results**

For the analysis, 34,362 observations (3,453 CBWs vs. 30,909 NCBWs) were retained.

**Demographic background and labour status by countries of destination (see Table 1).**

The sample consisted of 8 groups of workers from 4 countries of destination: for example, CBWs working in Germany (n = 309) and NCBWs working in France but living in the same departments as the CBWs to Germany (n = 10,331).
Table 1
Demographic background and labour status by commuting status and countries of destination in %.

| Adjustment variables: Demographic background | DE NCBWs | DE CBWs | BE NCBWs | BE CBWs | CH NCBWs | CH CBWs | LU NCBWs | LU CBWs | Total NCBWs | Total CBWs | p1 |
|---------------------------------------------|----------|--------|----------|--------|----------|--------|----------|--------|-------------|-------------|----|
| Sex: Male                                   |          |        |          |        |          |        |          |        |              |              |***|
| Age: Mean years                             | 50       | 66     | 51       | 63     | 48       | 64     | 50       | 66     | 50          | 65          |   |
| Education: Up to secondary education        | 45       | 40     | 39       | 39     | 40       | 40     | 40       | 39     | 40          | 40          | NS|
| Occupational category: Blue collar          | 65       | 70     | 60       | 68     | 67       | 58     | 64       | 66     | 63          | 62          | NS|
| Father's occupational category: Blue collar | 28       | 45     | 23       | 50     | 28       | 32     | 26       | 40     | 26          | 37          |***|
| Born abroad                                 | 44       | 43     | 48       | 40     | 38       | 45     | 51       | 42     | 43          | 43          | NS|
| Cohabiting                                  | 12       | 25     | 6        | 21     | 10       | 19     | 9        | 14     | 9           | 18          |***|
| Children                                    | 65       | 74     | 68       | 70     | 69       | 70     | 65       | 69     | 67          | 70          |   |
| Urban area                                  | 47       | 50     | 55       | 51     | 52       | 48     | 54       | 50     | 52          | 52          | NS|
| Urban area                                  | 40       | 43     | 43       | 10     | 6        | 43     | 40       | 34     | 14          | 14          |***|
| Full adjustment variables: Labour status    |          |        |          |        |          |        |          |        |              |              |    |
| Permanency of the job: Permanent contract   | 84       | 87     | 83       | 81     | 85       | 92     | 83       | 87     | 84          | 89          |***|
| Sector: Industry & construction             | 44       | 75     | 39       | 66     | 47       | 59     | 42       | 59     | 43          | 61          |***|
| Number of persons working at the local unit: >= 500 workers | 18 | 32 | 17 | 15 | 12 | 21 | 15 | 21 | 16 | 22 |***|
| Wage: Mean €                                | 1,744    | 2,674  | 1,724    | 2,170  | 1,722    | 3,891  | 1,747    | 2,485  | 1,735       | 3,272       |***|
| Full-time/part-time employment: Full-time employment | 80 | 88 | 79 | 87 | 80 | 77 | 79 | 85 | 80 | 81 | NS|
| Overtime                                    | 33       | 40     | 33       | 30     | 35       | 36     | 34       | 30     | 34          | 34          | NS|
| Observations (N)                            | 10,331   | 309    | 12,560   | 397    | 10,566   | 1,862  | 5,865    | 854    | 30,909      | 3,453       |    |

p1: significance p* ≤ 0.1 | p** ≤ 0.05 | p*** ≤ 0.01; chi-square test for qualitative variables and Fisher's exact test for quantitative variables; significance level of the difference between the total NCBWs and the total CBWs.
CBWs’ profile

more often men, blue-collars, born abroad, employed under permanent contract, in the industry and the construction, in large companies and higher wages than the NCBWs.

Remark

Commuters to Germany were of a special interest. Male workers were overrepresented. They were the oldest group of CBWs, less educated, more often employed in full-time jobs, in the industry and construction sector, in large companies, and working more overtime than other CBW.

Health disparities between CBWs vs. NCBWs, and for CBWs of the different country destinations (see Table 2).

CBWs declared less often than NCBWs: low self-perceived health, activity limitation, chronic diseases and disability and more often no leisure activities. CBWs do not differ from NCBWs regarding no leisure activities.

Distinguishing characteristics of commuters to Germany were a higher prevalence of low perceived health, limitations, chronic diseases and with the lower prevalence of no leisure activities. In contrast, commuters to Switzerland reported the lowest prevalence of low perceived health and activity limitation, whereas commuters to Luxembourg had the highest prevalence of no leisure activities.

| Table 2: Descriptive values of health outcomes by countries of destination. % |
|-----------------------------------------------|
|                | DE NCBWs | DE CBWs | BE NCBWs | BE CBWs | CH NCBWs | CH CBWs | LU NCBWs | LU CBWs | Total NCBWs | Total CBWs | p1       |
| Low perceived health | 18       | 17      | 17       | 14      | 16       | 12      | 17       | 13      | 17         | 13         | ***     |
| Activity limitation  | 12       | 13      | 12       | 10      | 12       | 8       | 13       | 10      | 12         | 9          | ***     |
| Chronic diseases     | 23       | 27      | 22       | 19      | 22       | 18      | 24       | 18      | 22         | 19         | ***     |
| Disability           | 5        | 2       | 5        | 3       | 5        | 2       | 5        | 3       | 5          | 2          | ***     |
| No leisure activities| 86       | 82      | 83       | 87      | 84       | 84      | 86       | 90      | 84         | 86         | NS      |

p1: significance p* ≤ 0.1 | p** ≤ 0.05 | p*** ≤ 0.01 chi-square test for the difference between total NCBWs and total CBWs

Prevalence of the high perceived health by UE states and OECD indicators (see Table 3).

From the annual Health at a Glance reports, published by the OECD and covering the periods of the survey, the high perceived health indicators of the countries and the OECD indicators were reported to compare them with the different prevalence rates obtained by each group. We observed that all frequencies of the workers’ groups are higher than the EU states’ indicators and the OECD indicators. Furthermore, Germans citizens reported the lowest share of high perceived health whereas Swiss citizens had the highest one, which is consistent with our precedents results. Belgians and Luxembourgers citizens being in an intermediate position between these two extreme cases.
Table 3
Good/very good perceived health status and countries’ indicators in 2013, 2015, and 2017.

| Good and very good | DE NCBWs | DE CBWs | BE NCBWs | BE CBWs | CH NCBWs | CH CBWs | LU NCBWs | LU CBWs | Total NCBWs | Total CBWs |
|--------------------|----------|---------|----------|---------|----------|---------|----------|---------|-------------|------------|
| High perceived health |          |         |          |         |          |         |          |         |             |             |
|                     | 82       | 83      | 83       | 86      | 83       | 88      | 83       | 87      | 83          | 87         |
| Indicators 2017*    | 65       | 74      | 81       | 72      |          |         |          |         | 67          | 69         |
| Indicators 2015*    | 65       | 75      | 79       | 70      |          |         |          |         | 68          | 68         |
| Indicators 2013 *   | 65       | 74      | 80       | 71      |          |         |          |         |             |            |

* Health at a Glance reports: 2015, 2017, 2019 [39]; see references

Associations between CBW status and health outcomes (see Table 4).

For the fully adjusted model, the CBW status is significantly associated with health outcomes. We found a lower probability of CBW to report limitations in their activities, chronic diseases and disability compared to NCBW. These results suggest that CBWs are healthier than their NCBWs counterparts. However, no association was found between being a CBW and low perceived health, and reporting no leisure activity. The full regression tables are available in the (see Additional files).

Health disparities among CBWs

Commuters to Germany were the only group of CBWs for which a negative association between CBW status and no leisure activities i.e., the only workers who did not agree with the statement of no leisure activities, was found. Compared to their NCBWs counterparts, they had a lower probability to report no leisure activities whereas other CBWs had a higher probability to do so. Thus, the association between CBW status and no leisure activities is more marked regarding commuters to Germany. Furthermore, a negative association was found between being a CBW to Germany and disability. This negative association is more marked for commuters to Germany than for all other groups of CBWs. Commuters to Switzerland were less likely to report activity limitation and disability compared to NCBWs, suggesting that they were the healthiest group of CBWs in our sample.

We can observe that the introduction of the demographic background controls did not lead to large changes in the estimates (with the exception of no leisure activities), indicating that demographic background variables are weak confounders in the relationship between CBW status and health outcomes. The use of the fully adjusted model led to less marked associations between CBW status and health outcomes except for no leisure activities, suggesting that labour status variables are relevant cofounders interfering in the relationship between the CBW status and health outcomes.
Table 4
Associations between CBW status and health outcomes.

| Model of regression | DE CBWs | p1 | BE CBWs | p1 | CH CBWs | p1 | LU CBWs | p1 | Total CBWs | p1 |
|---------------------|---------|----|---------|----|---------|----|---------|----|------------|----|
| **Unadjusted**      |         |    |         |    |         |    |         |    |            |    |
| Low perceived health | 0.95    | NS | 0.80    | NS | 0.69    | ***| 0.71    | ***| 0.71       | ***|
|                     | (0.69−1.30) |  | (0.59−1.10) |  | (0.57−0.83) |  | (0.56−0.91) |  | (0.62−0.80) |  |
| Activity limitation | 1.04    | NS | 0.82    | NS | 0.62    | ***| 0.70    | ** | 0.71       | ***|
|                     | (0.73−1.48) |  | (0.56−1.20) |  | (0.50−0.77) |  | (0.53−0.93) |  | (0.61−0.82) |  |
| Chronic diseases    | 1.26    | *  | 0.83    | NS | 0.79    | ***| 0.68    | ***| 0.82       | ***|
|                     | (0.97−1.65) |  | (0.62−1.10) |  | (0.68−0.92) |  | (0.55−0.83) |  | (0.74−0.91) |  |
| Disability          | 0.36    | ** | 0.48    | ** | 0.39    | ***| 0.55    | ***| 0.44       | ***|
|                     | (0.15−0.82) |  | (0.25−0.92) |  | (0.23−0.64) |  | (0.36−0.86) |  | (0.33−0.59) |  |
| No leisure activities| 0.75    | *  | 1.35    | *  | 1.00    | NS | 1.57    | ***| 1.13       | ** |
|                     | (0.55−1.02) |  | (0.97−1.86) |  | (0.85−1.19) |  | (1.21−2.03) |  | (1.00−1.28) |  |
| **Adjusted**        |         |    |         |    |         |    |         |    |            |    |
| Low perceived health | 0.85    | NS | 0.77    | NS | 0.72    | ***| 0.82    | NS | 0.76       | ***|
|                     | (0.61−1.20) |  | (0.54−1.09) |  | (0.59−0.87) |  | (0.63−1.08) |  | (0.66−0.87) |  |
| Activity limitation | 0.77    | NS | 0.87    | NS | 0.63    | ***| 0.75    | *  | 0.71       | ***|
|                     | (0.51−1.14) |  | (0.57−1.32) |  | (0.50−0.80) |  | (0.55−1.02) |  | (0.61−0.84) |  |
| Chronic diseases    | 1.08    | NS | 0.83    | NS | 0.82    | ** | 0.79    | ** | 0.83       | ***|
|                     | (0.80−1.46) |  | (0.61−1.14) |  | (0.69−0.96) |  | (0.63−0.99) |  | (0.74−0.93) |  |
| Disability          | 0.24    | *** | 0.51    | ** | 0.40    | ***| 0.66    | *  | 0.47       | ***|
|                     | (0.09−0.67) |  | (0.26−1.00) |  | (0.23−0.71) |  | (0.41−1.06) |  | (0.34−0.65) |  |
| No leisure activities| 0.55    | *** | 1.08    | NS | 0.93    | NS | 1.29    | *  | 1.01       | NS |
|                     | (0.38−0.78) |  | (0.77−1.53) |  | (0.77−1.12) |  | (0.98−1.71) |  | (0.88−1.15) |  |
| **Fully adjusted**  |         |    |         |    |         |    |         |    |            |    |
| Low perceived health | 0.99    | NS | 0.86    | NS | 0.84    | NS | 0.95    | NS | 0.87       | *  |
|                     | (0.69−1.41) |  | (0.59−1.25) |  | (0.65−1.08) |  | (0.71−1.28) |  | (0.74−1.01) |  |
| Activity limitation | 0.86    | NS | 0.94    | NS | 0.64    | ***| 0.83    | NS | 0.80       | ** |
|                     | (0.57−1.30) |  | (0.60−1.48) |  | (0.47−0.87) |  | (0.59−1.18) |  | (0.67−0.96) |  |
**NBCWs = reference group value 1**

|                        | 0.87 (NS) | 0.85 (NS) | 0.82 (NS) | 0.87 (**NS**) |
|------------------------|-----------|-----------|-----------|--------------|
| Chronic diseases       | (0.63–1.21)| (0.69–1.05)| (0.63–1.06)| (0.76–0.99)  |
| Disability             | 0.29 (**NS**) | 0.54 (**NS**) | 0.93 (NS) | 0.64 (**NS**) |
|                        | (0.11–0.81) | (0.31–0.94) | (0.53–1.65) | (0.47–0.89)  |
| No leisure activities  | 0.48 (**NS**) | 1.15 (**NS**) | 1.01 (NS) | 1.04 (NS)   |
|                        | (0.34–0.69) | (0.81–1.26) | (1.00–1.89) | (0.90–1.21)  |

*N: 309 399 1,867 854 3,460*

*p: significance p* ≤ 0.1 | *p** ≤ 0.05 | *p*** ≤ 0.01; Wald test.

**Associations between wage and health index among CBWs vs. NCBWs (see Table 5)**

A health index (consisting of 5 items) was calculated with values between 0 and 5. For each worker, scores of the five items were aggregated. A linear model was used to investigate the relationship between income and health index. An interaction term between being a CBW and the health index was introduced in order to predict which wage is needed to reach a certain unit of the health index. For the whole sample of workers, a higher income is associated with a higher health index, since a wage premium of 94 euros (€) led to a marginal improvement in the health index. Specifically by group of workers, a marginal improvement in the health index is correlated with a wage premium of 77 € for NCBWs and 99 € for CBWs. This positive association between health index and wage is highly significant for each group of workers. Since only 29 CBWs had a health index equal to 0 and the wide confident intervals, the prediction for this level of the health index might be considered as an outlier, confirming the positive relationship between wage and health index for both CBWs and CBWs.

| Health index | 0 = low | 1p | 1 | 1p | 2 | 1p | 3 | 1p | 4 | 1p | 5 = high | 1p |
|--------------|---------|----|---|----|---|----|---|----|---|----|----------|----|
| NCBWs        |         |    |   |    |   |    |   |    |   |    |          |    |
| Wage (€)     | 1,358 ***| 1,491***| 1,681***| 1,734***| 1,750***| 1,862***|   |    |   |    |          |    |
| Marginal health index increase (€) | 77 ***| 77 ***| 77 ***| 77 ***| 77 ***| 77 ***|   |    |   |    |          |    |
| CBWs         |         |    |   |    |   |    |   |    |   |    |          |    |
| Wage (€)     | 3,306 ***| 2,913***| 3,175***| 3,270***| 3,257***| 3,563***|   |    |   |    |          |    |
| Marginal health index increase (€) | 99 ***| 99 ***| 99 ***| 99 ***| 99 ***| 99 ***|   |    |   |    |          |    |
| Total        |         |    |   |    |   |    |   |    |   |    |          |    |
| Wage (€)     | 1,562 ***| 1,640 ***| 1,838 ***| 1,895 ***| 1,908 ***| 2,041 ***|   |    |   |    |          |    |
| Marginal health index increase (€) | 94 ***| 94 ***| 94 ***| 94 ***| 94 ***| 94 ***|   |    |   |    |          |    |

*1p: significance p***< 0.01; Fisher's exact test*

**Discussion**

Our research aimed to highlight health disparities between CBWs and NCBWs and in the specific CBW group. Our key findings are: (1) CBWs are healthier than NCBWs. (2) Stronger health disparities were found in the different CBWs’ groups from different work...
destinations with commuters to Switzerland exhibiting the best health outcomes. (3) Based on these data, the spillover phenomenon assumption must be rejected. Our main findings between CBW status and higher health outcomes are in contrast to findings of previous studies [2; 9; 10; 11; 20; 21]. Importantly, our study pointed out a CBW paradox, because being a commuter in this study constitutes a risk-free factor that protected workers against ill health. How is that possible?

The health gap between CBWs and NCBWs might be explained by the fact that CBWs perceived higher wages than NCBWs, since higher incomes have been associated with better health outcomes in the literature. Compared to NCBWs, CBWs have a better access to health-friendly consumption or activities (like purchasing organic food, seeking alternative medicine and participating in expensive sports). For both NCBWs and CBWs, the positive association between wage and health index is confirmed in our analysis. Nevertheless, even after controlling our results for wages, CBWs are still in better health than NCBWs, with our data exhibiting high estimated coefficients. Thus, this health gap can only be interpreted by the existence of a social selection processes.

The social selection of the workers can originate from either the side of the workers or the employers. The so-called healthy worker effect, a well-known phenomenon in epidemiology [40], was first observed among workers compared to the whole population [41]. The healthy commuter theory [2] argues that only the healthiest workers will undertake longer commutes whereas those affected by ill health will choose to reduce their commuting time in order to minimise stress, tiredness and dissatisfaction resulting from commuting. Our study emphasises this phenomenon among CBWs too, suggesting that only the healthiest workers make the decision to work in a neighbouring country. This could explain why, even after being affected by the negative consequences of commuting, they still report a better health state than NCBWs. That could be the case if the positive dynamic resulting from the self-selection process is stronger than the negative one of commuting on workers’ health. In this respect, our findings are consistent with the healthy commuter theory [2].

Likewise, health may play a role in the selection of CBWs by recruiters during the matching process in the country of destination. Because hiring can be considered as an investment into uncertainty, recruiters want to minimise risks during the hiring procedure. Recruiters anticipate that commuting is gruelling and consider health as a longevity capital upon the cross-border labour market. Another argument could be that due to the higher labour cost in the destination countries, employers might have more productivity expectations leading them to examine the candidates’ health status more closely. This could be especially the case in demanding business areas (like the industry, construction or catering), in which French commuters are overrepresented. Sociologists will argue that recruiters might be more demanding health-wise with CBWs because they are not considered to be a part of the national community in the country of destination but simply a production factor. Therefore, we can presume that recruiters carefully analyse minor health signals that candidates involuntarily share, and, for example, exclude candidates who exhibit difficulties in sitting down, a livid skin colour, tiredness, overweight [42] or physical disabilities [43].

CBWs compare two possible situations: (1) working in their country of residence (less commuting and lower wages) or (2) working abroad (more commuting and higher wages). Let us suppose that the net gain from cross-border mobility (G) is equal to the wage gap between the country of destination and the country of residence (W), minus the temporal and health consequences of the mobility (C). Then, workers with a poorer health status than the average will face higher mobility cost and, thus, will obtain a smaller net gain from their mobility. For example, handicapped workers in wheelchairs will need more time to commute the same distance as non-disabled workers, leading to a higher mobility cost and finally to a smaller net profit. In other words, disability might be interpreted as a disincentive to commute abroad. In this respect, health is defined as a major driver of the cross-border mobility. We can assume that workers have the capacity to estimate their resilience regarding a particular professional context, and this estimation might be a parameter in the decision to work abroad. Such an ability has already been observed among workers. For example, candidates for shiftwork had more compatible sleep behaviours than those who applied for day work [44].

Secondly, major health disparities arose within the groups of CBWs, regarding the country of destination. Our analyses revealed that commuters to Switzerland are the healthiest workers in our sample but did not lend support to the poorer health state of the commuters to Germany observed in the descriptive analysis, since indicators going in this direction are not significant i.e., low perceived health, activity limitation and chronic diseases. Our findings concerning commuters to Switzerland are consistent with European and OECD indicators, as Swiss citizens have a better perception of their health. How can we explain health disparities among CBWs?

Let us contextualise our findings concerning the main health disparities that arose within the groups of CBWs regarding the countries of destination. If commuters to Germany are less handicapped than other CBWs, this is probably because they are mainly working in
sectors (e.g. industry and construction) in which jobs are hardly suitable for disabled workers. Furthermore, commuters to Germany single themselves out, since they are the only group of CBWs reporting less no leisure activities than the NCBWs. Physical activity is higher in Germany than in France [45], which could indicate the existence of stronger sport-friendly norms in German society. A possible explanation might be that CBWs are socialised into the countries of destination, appropriating themselves some of the local norms and values operative in the foreign societies. This socialisation is even more possible knowing that three-quarters of the French workers commuting to Germany are living in the Alsace (see Fig. 1: The French cross-border regions), a French area strongly influenced by German culture as is apparent in the dialect, the cuisine, the architecture, or even in the names of the villages (Alsace was a Reichland (Imperial territory) from 1871 to 1918 and occupied by the Nazis from 1940 to 1944).

Commuters to Switzerland might be the healthiest CBWs because they receive the highest wages due to the strength of the Swiss Franc. However, as a control was introduced in the model for income, no explanation has been found.

We must remark that when we controlled for demographic background variables, estimated odds-ratios (OR) decreased slightly, indicating that health inequalities between workers had less to do with workers’ demographic background. The introduction of the labour status entailed a major reduction of the OR for all health outcomes with the exception of no leisure activities, which may indicate the important contribution of the labour status in health inequalities among workers.

Finally, to start this paper we assumed that CBWs are enduring indirect consequences of their specific lifestyle on their health. Because CBWs commute longer than NCBWs to their place of employment, we expected that their professional lifestyle reduces their free time. As a consequence, the supplementary time spent in traffic cannot be invested in health-friendly activities (such as sport, meditation, socialising) leading them to report more no leisure activities than the NCBWs. Although a spillover phenomenon has been highlighted for commuters [2], our results lead us to reject such an assumption for the CBWs.

Strengths And Limitations

One strength point of our study is the large sample size, which makes the analysis of the association between being a commuter and health factors possible. More importantly, our study design avoids possible bias resulting from different demographic background and labour statuses, which may explain morbidity differences between workers [40]. Controlling results with 16 demographic background and labour status variables may seriously reduce these biases in the statistical analysis. Furthermore, no subjects were included twice in our sample. Only the first occurrence or the last one of each observation were kept since the health module of the labour survey is only assessed at the first and the final interview of each individual. The use of the labour survey excludes the risk of representative bias, considering that only a representative part of the population was investigated. The demographic background of the commuters in our sample is consistent with the commuter profiles found in other studies [34; 46].

Controlling for demographic background variables, like department and urban area, aid to avoid a local selection bias. Indeed, some areas might have better health conditions than other areas, due to an easier access to health care or a higher diagnostic quality (resulting from newer equipment or better medical training) explaining health differences between workers [47]. Our results confirmed that indicators of labour status (permanency of the job, sector, number of persons working at the local unit, wage, full-time/part-time employment and overtime) need to be considered in the analysis as a main source of health inequalities among workers. For example, it has been shown that workers in large companies have better access to health care, which can constitute a protective factor against diseases [48]. Furthermore, adjusting for overtime allows separating the association between being a CBW and health from other work-related choices [2]. As a validation process of the relevance of our exposure variable being a CBW, we summarise (see Additional files) the coefficients significance and the mean coefficient values in order to determine which variables are the most associated with health outcomes (except no leisure activities) for the fully adjusted model. We only retained variables for which the significant summation is greater than three, meaning that coefficients are significant for at least three health variables, and we only displayed the mean coefficient values for these retained variables. As expected, age is positively associated with health limitations. A healthy worker portrait can be outlined from these results: CBW, young, educated, white collar, cohabiting, working in a small local unit, earning a high wage and working full-time. Our results stressed the importance of the commuting status in health inequalities among workers, since being a CBW had a high significance summation score i.e., 3/4, and an estimated coefficient of the same magnitude as education and wage. CBW status is to be considered of similar importance as other ‘heavy variables’ like major demographic background and labour status variables.
One of the limitations of our study is probably its 'French focus'. Even if our study might have an international scope because of the spread of French workers in four different countries, our findings cannot be generalised without complementary studies on this topic from other countries. Finally, our estimates might have underestimated the health gap between the two groups, since a control for wage was introduced in the regression.

**Conclusion: Policy Perspectives**

As a consequence, the newly founded European Labour Authority (ELA) should take into account health policies as a promising way to support the cross-border mobility among countries of the European Union.

Firstly, our study highlighted a free rider phenomenon among European countries. Some countries are using the healthiest workforce of the surrounding countries, without having to bear health expenditures of other workers, or for the inactive part of the population stayed behind the border. The countries where CBWs are employed only compensate the health expenditures of the CBWs. As CBWs and their employers pay their social contribution in the country of employment, this should represent a deadweight loss for the country of residence, since healthy workers should pay for those who are in poorer health. The creation of a European social security system might solve this issue, thus making the benefits of a healthy and mobile workforce shared by all European countries.

Secondly, the European principle of free movement of workers grants EU citizens the 'right to work in another member state' [49] whereas in reality, only the healthiest workers commute to other countries. Health disparities among individuals have created a differentiated access to the cross-border labour market, leading to the generation of economic inequalities within the EU. This situation is questioning the *isonomia* principle of the European law, which might feed the anti-EU feeling across the population, in a tense context marked by the awakening of populism and the disruption of EU values. As a consequence, to reduce economic inequalities, a health policy aiming to compensate health disparities is recommended. Several potential pathways are practicable: (1) An awareness campaign about cross-border mobility targeting sick people might be useful to increase the cross-border flows of workers among the EU. This campaign could be reinforced by a support programme provided by the national employment agencies. (2) The establishment of a labour organisation more compatible with the ‘sickness career’ [50] for workers in ill health. (3) Decreasing the mobility cost of sick workers will increase the net benefit of the commuting decision as described above, and thus generate more incentives to commute. Specifically, building new car parks, establishing special traffic lanes, or the creation of a free mobility programme in the public transport system for sick workers could be efficient in this respect.

**Abbreviations**

- **CBWs**: Cross-border workers
- **NCBWs**: Non cross-border workers
- **ELA**: European Labour Authority
- **ILO**: International Labour Office

**Declarations**

**Ethical approval and consent to participate**

The dataset exploited in this study is extracted from the research version of the 'Enquête Emploi', the French part of the European Labour Force Survey. The need for consent is deemed unnecessary according to national regulations: the participation is mandatory according to the French law n°51-711 of the 7 June 1951. The 'Enquête Emploi' has been approved by the Conseil National de l'Information Statistique (CNIS) and the Comité du Label de la Statistique Publique which in particular verifies that the survey follows the best practices including the European statistics Code of Practice. The Comité du Label de la Statistique Publique acts as an Institutional Review Board. The survey is conducted by the INSEE the French national statistical institute.

VISA N°2020T017EC (for years 2018-2022)

VISA N°2017T020EC
Consent to publish

The need for consent is deemed unnecessary according to national regulations, because of the mandatory nature and public utility of the labour survey. Mandatory participation following the French law n°51-711 of the 7 June 1951 about the obligation, the coordination and the secret for statistics. The Comité du Label de la Statistique Publique acts as an Institutional Review Board.

Availability of data and materials

Datas supporting our findings can be found in the (see Additional files). The questionnaire was not produced by the authors.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

LN: Conceived the study and the protocol, conducted the literature review, the data analysis, conceived the interpretation of the findings and drafted the paper; MB: Secured the funding to conduct the research, participated in conducting the literature review, interpreting the findings, and drafting and reviewing the paper; ELB: Reviewed the statistical analyses and the paper; PH: Participated in conceiving the data analysis, interpreting the findings and reviewing the paper; LC: Participated in conceiving the data analysis, interpreting the findings and reviewing the paper. All authors read and approved the final paper and consent to publication in this review.

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**Figures**

![Figure 1](image-url)
The French cross-border region is composed of 11 departments: Ain, Ardennes, Doubs, Jura, Meurthe-et-Moselle, Moselle, Nord, Bas-Rhin, Haut-Rhin, Haute-Savoie and Territoire de Belfort. Of the commuters to Germany, 76 lived in Moselle, 191 in the Bas-Rhin, and 42 in the Haut-Rhin. Of those commuting to Belgium, 54 resided in the Ardennes, 46 in Meurthe-et-Moselle and 297 in Nord. Of the commuters to Switzerland, 119 lived in Ain, 354 in Doubs, 81 in Jura, 470 in Haut-Rhin, 755 in Haute-Savoie and 83 in Territoire de Belfort. Of the commuters to Luxembourg, 449 resided in Meurthe-et-Moselle and 405 in Moselle. The departments Meuse and Aisne did not fit the selection criteria and were therefore not included in the analyses. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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