

Do all migrants decline equally? Gender and occupational status differences in post-migration health in Italy

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ABSTRACT

Migration research has consistently documented migrants' initial health advantage and its erosion with increasing exposure to destination contexts. However, evidence of within-individual health change across the migration process remains limited, particularly in Southern Europe, where research has largely relied on post-arrival data and indirect proxies. This article analyses whether post-migration health deterioration is socially stratified by gender and occupational status.

Using retrospective pre-migration health information from the 2025 MIGHTY Survey, we compare self-rated health before departure and at interview among migrants residing in Lombardy, Italy. We estimate correlated random-effects ordinal logistic models and use adjusted predictions to assess heterogeneity by gender, occupational status, and their interaction.

Results document a deterioration in self-rated health following migration that is not uniformly distributed. Once ageing over the migration interval is accounted for, deterioration is significant among women but not distinguishable from age-related change among men – a pattern consistent with cumulative exposure to structurally disadvantaged conditions in the destination society. Occupational status differentiates the decline significantly among men, concentrated in self-employment and marginal labour market positions, but not among women, where deterioration is relatively uniform across occupational categories.

By directly comparing pre- and post-migration health, this study provides the first within-individual assessment of post-migration health change in Italy based on retrospectively reported self-rated health, and one of the first in Southern Europe. The findings show that migrant health deterioration is not a uniform process but a socially patterned one, concentrated among women and structured by occupational status among men.

1. Introduction

Migration has become a defining feature of contemporary European societies, yet its implications for health over time remain insufficiently understood. A large body of research shows that migrants often exhibit better health and lower mortality than native-born populations (e.g., Domnich et al., 2012; Kennedy et al., 2015; Trappolini et al., 2021; Wallace & Wilson, 2022), a pattern commonly referred to as the *Immigrant Health Paradox* (Abraído-Lanza et al., 1999; Ruiz et al., 2013). However, evidence from European contexts indicates that this initial advantage tends to erode with increasing exposure to the host-country context (e.g., Holz, 2022; Riosmena et al., 2017). This deterioration, often described as the *exhausted migrant effect* (Bollini & Siem, 1995), has been linked to cumulative exposure to adverse conditions (Beiser,

2005), including poor socioeconomic conditions (e.g., Wilkinson & Marmot, 2003), negative health acculturation (e.g., Abraído-Lanza et al., 2006; Riosmena et al., 2017), psychological stressors (e.g., Cela & Barbiano di Belgiojoso, 2021), and barriers to healthcare access (e.g., Ferrara et al., 2024) in destination societies.

Despite robust evidence of post-migration health decline, three key limitations constrain our understanding of its magnitude and social distribution. First, most European research, particularly in Southern Europe, relies on cross-sectional data and infers health decline indirectly, using proxies such as duration of stay, age at arrival or comparisons with native-born populations (Lu et al., 2017; Zheng & Yu, 2022). While informative, these approaches cannot capture within-individual health change, relying instead on comparisons across groups that may differ in composition (Ferrara et al., 2024). Second, a life course

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perspective on migrant health explicitly requires, whenever possible, direct information on pre-migration conditions in order to distinguish the health consequences of migration itself from pre-existing differences (Loi, 2025; Spallek et al., 2011). Yet such information remains rare: existing longitudinal studies typically address the selection problem indirectly, either by using age at migration as a proxy for the strength of health selection (Gubernskaya, 2015) or by relying on individual fixed effects, which absorb pre-migration selection without being able to quantify it (Jang et al., 2023). To our knowledge, only Pellet and de Talancé (2023) have used retrospective self-rated pre-migration health measures to assess within-individual change directly, in a specific context of Central Asian circular migration to Russia – a setting that limits generalisability to Western and Southern Europe. Third, existing research has largely treated post-migration health deterioration as a homogeneous process, paying limited attention to how it may be socially differentiated.

Against this background, a fundamental question remains unanswered: *does post-migration health deterioration affect all migrants equally, or is it structured by social inequalities?* We focus on two dimensions that are central to migrants' incorporation into destination societies: gender and occupational status. These dimensions shape exposure to health risks, access to resources, and labour market opportunities, and may therefore generate unequal post-migration health trajectories (Heath & Cheung, 2007; Khlal & Guillot, 2017). Moreover, gender and occupational status are likely to interact, producing cumulative forms of disadvantage that cannot be understood by examining either dimension in isolation (Gkiouleka & Huijts, 2020).

We address these questions using retrospective pre-migration health data from the 2025 MIGHTY Survey of migrants in Lombardy, Italy (Rimoldi et al., 2026). By directly comparing migrants' self-rated health (SRH) before and after migration, we make three contributions. First, we provide a direct assessment of within-individual health change, overcoming the reliance on proxy measures. Our design does not, however, address selection through return or onward migration, since we observe only migrants present in Italy at interview. Second, we extend evidence on the exhausted migrant effect to a Southern European context, where longitudinal data remain scarce. Third, we analyse whether post-migration health deterioration is socially differentiated by gender, occupational status, and their interaction.

Italy is one of Europe's fastest-ageing societies and has become increasingly reliant on migrant labour to compensate for its ageing workforce (Alderotti et al., 2025). Italy exemplifies the Southern European model of migrant labour market incorporation, characterised by strong segmentation and gendered occupational concentration: women are concentrated in domestic and care work, whereas men are more likely to work in physically demanding sectors (Fellini & Fullin, 2016). These features make Italy an important case for examining how gender and occupational position shape post-migration health deterioration.

By identifying the groups among whom deterioration is most concentrated, rather than treating migrants as a homogeneous population, this study provides a basis for more targeted migrant health and occupational policies.

2. Literature background

2.1. Migrant health advantage and its erosion over time

Research consistently shows that migrants tend to exhibit better health and lower mortality than native-born populations – the *Healthy Immigrant Effect* (HIE) – often attributed to positive health selection, whereby healthier individuals are more likely to migrate because they are better able to bear the costs and risks associated with migration (Abraido-Lanza et al., 1999; Grossman, 1972; Sjaastad, 1962). This advantage has been documented relative to both the destination-country population (e.g., Holz, 2022; Ichou & Wallace, 2019; Loi et al., 2025; Loi & Hale, 2019) and non-migrants in origin countries (Arsenijevic &

Groot, 2018; Barbiano di Belgiojoso et al., 2024; Constant & Milewski, 2021). However, such comparisons provide only indirect evidence of health change over the migration process.

The observed advantage may also partly reflect selective return migration, known as the *Salmon Bias* hypothesis (Abraido-Lanza et al., 1999). Nevertheless, evidence suggests that migrants' health and mortality advantage persists even after accounting for this mechanism (Di Napoli et al., 2021; Wallace & Wilson, 2022).

Migrants' initial health advantage may erode with prolonged exposure to the host-country context, with convergence often occurring downward toward native-born levels. This process – described as the *Exhausted Migrant Effect* (Bollini & Siem, 1995) or *Negative Acculturation* (Abraido-Lanza et al., 2006) – has been associated with the adoption of less healthy behaviours (Vang et al., 2017), discrimination and social isolation (Allegrì et al., 2025; Pearlin et al., 2005), and prolonged exposure to stressful living and working conditions and socioeconomic precarity (Forde et al., 2019). Migrants' vulnerability to adverse life events, such as job loss or union dissolution, may further accelerate this decline (Loi et al., 2024).

However, most evidence on post-migration health dynamics is based on indirect comparisons – between recent and long-term migrants (Constant & Milewski, 2021; Holz, 2022; Loi & Hale, 2019; Trappolini & Giudici, 2021), first- and second-generation migrants (Arsenijevic & Groot, 2018; Ichou & Wallace, 2019; Wallace, 2022), or migrants and return migrants (Di Napoli et al., 2021; Wallace & Wilson, 2022) – which cannot directly identify within-individual health change and may be affected by migration cohort differences, selective return migration, or differential mortality (Vang et al., 2017). Longitudinal or administrative data offer a stronger design (Constant & Milewski, 2021; Loi et al., 2025; Trappolini et al., 2021) but generally observe migrants only after arrival, leaving pre-migration health unobserved (Ferrara et al., 2024).

Evidence directly linking pre- and post-migration health remains limited. Prospective studies provide pre-departure measures for individuals who subsequently migrate and can therefore identify health selection into migration, but they do not necessarily capture health change across the migration process (Diaz et al., 2018; Rubalcava et al., 2008). Retrospective studies can offer complementary access to that transition, although their estimates may be affected by recall bias (Pellet & de Talancé, 2023).

This distinction points to a persistent gap in the literature, particularly in European welfare contexts: the limited availability of data that capture both pre- and post-migration health for the same individuals. Addressing this gap, we hypothesise that migrants report worse SRH after migration than before, net of sociodemographic characteristics (H1).

2.2. Beyond average effects: heterogeneity by gender and occupational status

While the exhausted migrant effect is well documented, less attention has been paid to heterogeneity in post-migration health deterioration across migrant groups. Two dimensions are particularly relevant: gender and occupational status (Gkiouleka & Huijts, 2020; Malmusi et al., 2010).

2.2.1. Gender and health

Gender shapes both migration processes and post-migration experiences. Men and women often migrate through different pathways, resulting in distinct patterns of health selection and exposure to risks (Donato & Gabaccia, 2015; Lutz, 2010). Men often migrate initially as labour migrants and are later joined by family members (Barbiano di Belgiojoso & Terzera, 2018), which may imply stronger positive health selection among men (Read & Reynolds, 2012; Trappolini & Giudici, 2021). By contrast, family migration may be less health-selective because it is driven by family considerations (Read & Reynolds, 2012). However, in other contexts, women, especially those

from Latin America, the Philippines, or Eastern Europe, migrate independently as labour migrants, particularly in response to the demand for care and domestic workers, potentially weakening or reversing conventional gender differences in selection (Canova et al., 2024; Llácer et al., 2007).

Gender also structures post-migration experiences (Gkiouleka & Huijts, 2020; Llácer et al., 2007; Read & Reynolds, 2012). Migrant women often face a “double burden,” combining paid employment with disproportionate unpaid and transnational caregiving responsibilities, while managing multiple roles as workers, mothers, partners, and breadwinners (Antecol & Bedard, 2006; Loi et al., 2025; Lopez-Gonzalez et al., 2005; Villar-Bustos et al., 2024). These demands may increase psychological stress and contribute to faster health deterioration.

Consistent with this possibility, some studies find steeper post-migration health declines among women than men (Loi et al., 2024, 2025; Trappolini & Giudici, 2021). Yet, because most rely exclusively on post-migration data, they cannot establish whether these differences reflect gendered health deterioration or pre-existing health gaps.

We therefore formulate two competing hypotheses.

- Migrant women may experience steeper post-migration health deterioration than men, reflecting cumulative psychosocial strain, multiple role demands, and caregiving responsibilities (H2a).
- Migrant men may experience steeper post-migration health deterioration than women, reflecting greater exposure to physically demanding occupations and cumulative physical strain (H2b).

2.2.2. Occupational status and health

Labour market participation is a key dimension of migrants' integration (Baglioni et al., 2022), but its health implications depend not only on employment status but also on the conditions and physical demands of work, which shape exposure to physical and psychosocial risks over time (Wilkinson & Marmot, 2003). From a labour market segmentation perspective (Piore, 1979), these occupational positions may therefore structure post-migration health deterioration.

In Southern European labour markets, migrants face systematic disadvantages relative to natives, regardless of their pre-migration education or skill levels, a pattern often described as the “ethnic penalty” (e. g., Damelang et al., 2021). They are disproportionately concentrated in jobs characterised by precarious contracts, limited upward mobility, high physical demands, low autonomy, occupational hazards, irregular schedules, and weak social protections (Cantalini et al., 2023; Fellini & Guetto, 2018; Fuller & Martin, 2012). Prolonged exposure to these conditions may contribute to cumulative health disadvantage (Dannefer, 2020). Self-employment among migrants, often adopted in response to limited opportunities in formal employment, may similarly involve economic insecurity, long working hours, and weak access to social protections (Ambrosini, 2018).

Non-employment may also shape health trajectories, although its implications are heterogeneous. Unemployment is associated with income loss, economic insecurity, stress, and social exclusion, whereas employment – even under adverse conditions – may provide income, social contact, and daily structure (Villar-Bustos et al., 2024). Economic inactivity includes students, retirees, homemakers, and individuals unable to work, and may therefore reflect both voluntary and constrained circumstances with different health implications.

Building on these considerations, we hypothesise that post-migration health deterioration varies across occupational positions, with greater declines among migrants in more vulnerable or physically demanding occupational positions than among those in relatively protected positions (H3).

2.2.3. The joint role of gender and occupational status in migrant health

Gender and labour market position jointly shape health by structuring exposure to risks and access to resources over time (Gkiouleka & Huijts, 2020; Viruell-Fuentes et al., 2012). These dimensions do not

operate independently but combine to produce differentiated health trajectories through the accumulation of advantages or disadvantages across multiple domains (Dannefer, 2020).

Labour market segmentation is strongly gendered. Migrant women are disproportionately concentrated in domestic and care work, where they may face social isolation, emotional demands, irregular schedules, blurred work–rest boundaries, and limited labour protections (Palumbo, 2024; Vianello et al., 2024). Migrant men are more often concentrated in physically demanding sectors such as construction, agriculture, and manufacturing (Fleury, 2016). Consequently, women and men may be exposed to different combinations of psychosocial and physical risks (Hargreaves et al., 2019; Palumbo, 2024). European evidence further suggests that the health disadvantage associated with less advantaged occupational positions may be stronger among migrant women than among migrant men (Gkiouleka & Huijts, 2020), whereas unemployment and job insecurity may have particularly adverse effects among men (Loi et al., 2024; Villar-Bustos et al., 2024).

However, existing research has focused mainly on cross-sectional health outcomes rather than changes over time. It therefore remains unclear whether gender and occupational status jointly shape post-migration health deterioration. Drawing on a cumulative disadvantage perspective, we hypothesise that the extent of post-migration health deterioration varies jointly by gender and occupational status. In particular, we expect this deterioration to differ across combinations of gender and occupational status, rather than following a uniform pattern across labour market positions (H4).

3. The Italian context

Italy provides a particularly relevant setting for our analysis. As one of Europe's fastest-ageing societies, Italy has become increasingly reliant on migrant labour, particularly as its workforce continues to age. Migrants are now a structural component of both the Italian labour force and the wider population (Alderotti et al., 2025).

Italy exemplifies the Southern European model of migrant labour market incorporation, characterised by relatively easy access to employment but poor job quality (Fellini & Fullin, 2016). Migrants are disproportionately employed in low-skilled sectors involving high physical demands, irregular schedules, weak labour protections, and limited access to social benefits (Reyneri & Fullin, 2011). These patterns are strongly gendered: migrant women are concentrated primarily in domestic and care work, whereas migrant men are more often employed in construction, agriculture, manufacturing, and logistics (Avola, 2022; Barbiano di Belgiojoso, 2019; Fellini & Guetto 2019). Such employment patterns expose migrants to distinct combinations of physical, psychosocial, and economic risks that may shape their post-migration health trajectories.

Previous Italian studies have documented both migrants' initial health advantage and its erosion over time (Barbiano di Belgiojoso et al., 2024; Caselli et al., 2017; Loi & Hale, 2019; Pacelli et al., 2016; Trappolini et al., 2021; Trappolini & Giudici, 2021). However, they rely primarily on post-arrival observations or indirect measures of health change. As a result, little is known about within-individual health trajectories across the migration process or about how health deterioration varies by gender and occupational status.

4. Data and methods

4.1. Data description and sample selection

The data come from the MIGrants' HealTh and healthcare access in Italy (MIGHTY) survey, a cross-sectional survey conducted between November 2024 and February 2025 in Lombardy (NUTS - ITC4) and Marche (NUTS- ITI3). The survey collects detailed information on health, healthcare access, and sociodemographic characteristics among foreign citizens, including undocumented migrants, and foreign-born

individuals who acquired Italian citizenship. Informed consent was obtained from all participants before the interview was conducted.

Respondents were selected using the Centre Sampling Methodology, a strategy specifically designed for hard-to-reach populations and contexts lacking adequate sampling frames to cover the entire population, including irregular and naturalized immigrants (Baio et al., 2011). This methodology identifies a representative sample of the target population in each region (*ibidem*). The present analysis draws on the Lombardy sample. Data were collected using Computer-Assisted Personal Interview (CAPI) and the LimeSurvey platform. Further details, including weights, response rate and aggregation centres, are available in the survey documentation.¹

A distinctive feature of the survey is the collection of retrospective self-rated health (SRH) prior to migration alongside SRH at the time of interview, allowing direct assessment of within-individual health change across the migration process; a design exceptionally rare in European datasets.

For the present analysis, we restrict the sample to individuals aged 18–84 at the time of the interview who were residing in Lombardy, which accounts for the majority of survey respondents (2838 of 3660 total) and hosts Italy's largest migrant population, with relatively longer and more stable settlement duration compared to other regions, making it a suitable context to study health deterioration over the migration process.

We exclude second-generation migrants (individuals born in Italy; $N = 367$). They fall outside the scope of our research question, which concerns health changes associated with the migration experience itself, and by definition they have not undergone migration and therefore have no pre-migration health to report. Together with 140 respondents with missing data on key variables, this yields a final analytical sample of 2331 individuals (50.1% women).² Descriptive statistics are provided in Table 1A in the Supplementary Material.

4.1.1. Dependent variable

The dependent variable is SRH, measured through the question “How is your health in general?”, with five ordered response categories ranging from “very good” to “very bad”.

SRH is widely used in population health research because it provides a reliable summary measure of overall health status, integrating dimensions that may not be fully reflected in disease-specific indicators or clinical diagnoses (Trappolini et al., 2026). Although subjective, numerous studies have shown that SRH strongly predicts subsequent mortality, morbidity, and functional outcomes (e.g., Idler & Benyamini, 1997; Loreo et al., 2020) across diverse populations (Jylhä et al., 1998).

4.1.2. Main explanatory and control variables

The main explanatory variable is migration timing, a binary indicator distinguishing “pre-migration” SRH, retrospectively assessed for the period before migration, and “post-migration” SRH, reported at the time of interview. This measure captures within-individual differences in perceived health associated with the migration experience.

Gender is a central analytical dimension of this study. Respondents are identified in the survey as women or men. We use the term *gender* rather than *sex* because our theoretical framework focuses on socially structured differences in migration pathways, labour market incorporation, care responsibilities, and health trajectories. We acknowledge that this binary measure does not capture the full diversity of gender identities.

Control variables are selected based on previous research on migrant health. Age is time-varying: it is measured at departure for the pre-migration observation and at interview for the post-migration observation. It is entered as a continuous variable with a quadratic term to account for non-linear health gradients. Education is classified into four categories (no/primary – *reference*, lower secondary, upper secondary, tertiary). It is included both as an independent determinant of health, operating through cognitive, behavioural and informational pathways, as well as an indicator of broader socioeconomic resources (Cutler & Lleras-Muney, 2010). In Italy, however, education only partially captures socioeconomic resources because of labour market segmentation and the limited recognition of migrants' foreign qualifications (Fullin and Reyneri 2011). Occupational status captures labour market position and exposure to potentially adverse working conditions in the destination country. It combines employment condition with occupation, recorded in eleven predefined survey categories. We first distinguish employees from the self-employed and then classify occupations as ‘physically demanding’ or ‘non-physically demanding’, based on the categories available in the survey. Manual, service, transport, food-service, retail and direct-care occupations are classified as physically demanding; managerial, professional, clerical, teaching, entrepreneurial and commercial occupations are classified as non-physically demanding. This yields six categories: (1) employees in physically demanding occupations, (2) employees in non-physically demanding occupations, (3) self-employed workers in physically demanding occupations, (4) self-employed workers in non-physically demanding occupations, (5) unemployed or inactive respondents, and (6) respondents in “other” positions (that is, outside standard employment conditions). The unemployed/inactive category combines respondents seeking work and those reporting themselves as homemakers, the latter being almost exclusively women. Marital status captures family context and social support (single – *reference*, partnered with a foreign citizen, mixed couple with an Italian citizen, divorced/widowed). Country of origin is classified according to the largest migrant groups in Lombardy (Albania – *reference*, Egypt, Morocco, Bangladesh, Senegal) plus broader regional categories (Central and Eastern Europe - CEE, Africa, Asia and the Middle-East, and Latin-America and the Caribbean). Legal status captures juridical vulnerability and includes citizenship (*reference*), long-term residence, temporary residence permit, undocumented status, and a separate category for respondents who did not report their status.

Except for age, all control variables are measured at interview and treated as time-invariant, with the same values assigned to the pre- and post-migration observations. This is appropriate for fixed characteristics (e.g., origin country) or for relatively stable characteristics over the migration process (e.g., education), but it also reflects a limitation of the data: changes in socioeconomic conditions during the migration process (e.g., occupational and marital status) cannot be observed. These variables should therefore be interpreted as concurrent correlates of post-migration health and focus on identifying for whom health decline is more pronounced rather than establishing causal pathways. This caveat applies with particular force to occupational status, which is central to our analysis. We return to this point in the discussion.

4.2. Analytical strategy

The data are structured in long format, with two observations per individual: one capturing retrospectively reported pre-migration SRH and one measuring current post-migration SRH. We estimate correlated random-effects ordinal logistic regression models with individual-level random intercepts and include the within-individual means of the time-varying covariates, following Mundlak (1978). This specification identifies within-individual variation in time-varying regressors while

¹ <https://github.com/QmLHS/Demography/tree/main/MIGHTY>.

² The gender composition of the analytical sample (50.1% women) closely matches the corresponding figure for the resident foreign population of Lombardy (50.2%; ISTAT, 2026), notwithstanding that our target population also includes undocumented migrants and naturalized citizens, who are not fully captured in residence-based statistics.

retaining time-invariant covariates. Joint tests reject the equality restriction on the Mundlak terms in all pooled specifications ($\chi^2(2) = 19.03, 18.51$ and 16.38 respectively, all $p < 0.001$).³

The proportional-odds assumption underlying the ordinal model is violated for migration timing ($p = 0.004$), gender ($p = 0.002$), the quadratic age term ($p < 0.001$), and all occupational categories ($p < 0.001$), as tested with generalised ordered logit models with partial proportional odds. We therefore present category-specific adjusted marginal predictions throughout, allowing the association between the covariates and SRH to vary across outcome categories rather than imposing a parallel-lines restriction.

The analysis proceeds in two steps. First, to assess overall health change and gender-specific patterns (H1), we estimate separate models for men and women (Table 1). Model 1 includes migration timing (pre vs. post), age and its square, the corresponding Mundlak terms, and individual random effects. Models 2 to 4 successively add education and occupational status (Model 2), marital status (Model 3), and country of origin and legal status (Model 4). Because all covariates except migration timing and age are time-invariant, their main effects are identified from between-individual variation and represent cross-sectional associations. They do not alter the within-individual pre-post contrast, which is identified by migration timing. Heterogeneity in the migration-related change is assessed through interactions between migration timing and the relevant covariates (H2–H4).

Second, to test heterogeneity by gender and occupational status (H2–H4), we estimate pooled models including interactions between migration timing and gender (H2), migration timing and occupational status (H3), and a three-way interaction between migration timing, gender, and occupational status (H4). Full estimates and joint tests are reported in the Supplementary Material (Tables 2A–4A). For ease of interpretation, we present adjusted average marginal effects (AME) of migration timing on the probability of reporting each SRH category, averaged over the observed distribution of covariates (Figs. 1–3). Reporting effects separately for each category preserves information across the full ordinal distribution rather than collapsing SRH into a binary outcome.

All models are estimated using individual-level survey sampling weights to ensure that the sample is representative of the target migrant population (Baio et al., 2011).

We assess robustness through additional analyses reported in Supplementary Material, Section B. These include comparison with fixed-effects specifications and Hausman tests (Tables 1B–3B), models using dichotomised outcomes at three cut-points (Tables 4B–7B), interactions between migration timing and duration of stay (Fig. 1B), models with gender-specific age slopes to test whether the assumption of common age effects affects our conclusions (Table 8B), and a bounding analysis assessing sensitivity to differential recall of pre-migration health (Table 9B). Duration of stay is excluded from the main models because it is mechanically linked to the within-individual change in age.

5. Results

5.1. Associations between migration timing and SRH

Table 1 shows differences by gender. Among women, post-migration observations are associated with significantly higher odds of reporting poorer health across all specifications. Among men, the migration-timing coefficient is not statistically significant in any model. Thus, once ageing is accounted for, the deterioration in SRH associated with migration appears to be concentrated among women. The coefficient on migration timing remains largely stable across specifications within

each gender. This difference is formally tested in the pooled model presented in Section 5.2.

Age displays a U-shaped association with poorer health in both groups, while education shows a strong protective gradient. Occupational status is associated with SRH mainly among men: unemployment or inactivity is related to higher odds of poor health, whereas self-employment in non-physically demanding occupations is associated with lower odds. Among women, differences across occupational categories are weaker and not statistically significant in the fully adjusted model (M4).

Women partnered with foreign citizens are less likely to report poor health than single women. Legal status also displays gendered patterns: among women, undocumented status is associated with substantially higher odds of poor health relative to citizenship; among men, this association is weaker and not statistically significant, whereas long-term residence is associated with higher odds of poor health. Country of origin shows few consistent associations in the fully adjusted models.

5.2. Heterogeneity in post-migration SRH

5.2.1. By gender

Fig. 1 shows that the probability of reporting “very good” health declines by 13.4 percentage points (p.p.) among women and 9.3 p.p. among men. This is the largest gap observed across SRH categories. This decline is statistically significant among women and marginally significant among men⁴; consistent with the stratified models discussed above, in which migration-timing coefficient is not statistically significant for men once ageing is accounted for.

Before migration, men and women report virtually identical probabilities of “very good” health (38.5% for men, 38.0% for women). After migration, the probability declines to 29.1% among men and 24.6% among women, producing a clear gender gap (Fig. 1A in the Supplementary Material).

The decline in “very good” health is accompanied mainly by an increase in “fair” health, particularly among women (+7 p.p., compared with +4 p.p. among men). The probability of reporting “good” health increases modestly and similarly for both groups, while changes in the “bad” and “very bad” categories are small for both genders, although slightly larger among women.

Overall, gender differences are concentrated at the top of the SRH distribution: women experience a substantially greater loss of “very good” health, whereas the two groups show limited differences in transitions into the poorest health categories. This pattern is consistent with the threshold-specific results robustness analyses, which also locate the gender difference primarily in the loss of very good health rather than in the onset of poor health (Tables 4B–7B in the Supplementary Material).

5.2.2. Occupational and gender differences in post-migration SRH

Fig. 2 shows substantial heterogeneity in the change in the probability of reporting “very good” health after migration across occupational groups. The decline ranges from 4.8 p.p. among employees in non-physically demanding occupations to 19.9 p.p. among respondents in the “other” category.⁵ Self-employed workers in non-physically demanding occupations also experience a marked decline (approximately 16.0 p.p.), while employees and self-employed workers in physically demanding jobs, as well as unemployed or inactive respondents, occupy an intermediate position (approximately 10–12 p.p.)

⁴ The gender difference in post-migration deterioration is confirmed by the joint test of the migration timing $\times$ gender interaction ($\chi^2(1) = 7.44$, $p = 0.006$; see Table 2A in the Supplementary Material).

⁵ The effect of migration on SRH varies significantly across occupational categories (joint test of the time $\times$ occupational status interaction: $\chi^2(5) = 18.24$, $p = 0.003$; see Table 3A in the Supplementary Material).

³ Migration timing itself exhibits no between-individual variation, since each respondent contributes exactly one pre-migration and one post-migration observation; no Mundlak term is constructed for it and its coefficient is identified exclusively from within-individual variation.

Table 1

OR from correlated random-effects ordinal logistic regression of SRH, by gender (Panel a: men; Panel b: women).

a)	Model 1	Model 2	Model 3	Model 4
Time (ref. Pre-migration)				
Post-migration	1.384 [0.866;2.211]	1.361 [0.843;2.197]	1.339 [0.828;2.164]	1.337 [0.827;2.163]
Age (time-varying)	0.929 [0.902;0.957]	0.930 [0.902;0.958]	0.932 [0.904;0.960]	0.931 [0.904;0.960]
Age squared/100 (time-varying)	1.200 [1.158;1.244]	1.202 [1.160;1.247]	1.200 [1.157;1.244]	1.201 [1.158;1.245]
Mean age (Mundlak term)	0.982 [0.918;1.051]	1.072 [1.000;1.149]	1.080 [1.006;1.159]	1.093 [1.007;1.185]
Mean age squared/100 (Mundlak term)	1.028 [0.932;1.133]	0.908 [0.822;1.003]	0.898 [0.812;0.993]	0.898 [0.805;1.001]
Education (ref. No/Primary)				
Lower-sec		0.417 [0.260;0.669]	0.434 [0.270;0.697]	0.499 [0.311;0.802]
Upper-sec		0.147 [0.091;0.237]	0.151 [0.093;0.245]	0.197 [0.120;0.323]
Tertiary		0.111 [0.061;0.201]	0.115 [0.063;0.209]	0.159 [0.086;0.291]
Occupational status (ref. Employed - Physically demanding)				
Employed – Non-physically demanding		0.781 [0.409;1.490]	0.769 [0.400;1.478]	0.794 [0.415;1.519]
Self-employed – Physically demanding		0.756 [0.341;1.675]	0.729 [0.328;1.618]	0.753 [0.342;1.656]
Self-employed – Non-physically demanding		0.493 [0.281;0.864]	0.504 [0.287;0.887]	0.518 [0.295;0.911]
Unemployed/Inactive		4.454 [2.661;7.455]	4.275 [2.533;7.217]	4.021 [2.346;6.890]
Other		1.320 [0.736;2.369]	1.277 [0.703;2.320]	1.448 [0.794;2.643]
Marital status (ref. Single)				
Couple-partner w/for-cit			0.895 [0.590;1.358]	0.843 [0.553;1.283]
Mixed couple			0.763 [0.379;1.533]	0.761 [0.380;1.525]
Divorced/Widowed			1.438 [0.707;2.924]	1.313 [0.648;2.661]
Legal status (ref. Citizenship)				
Long-term resident				1.583 [1.043;2.402]
Temporary permit				1.241 [0.719;2.144]
Undocumented				1.780 [0.700;4.521]
Not-declare				6.422 [0.634;65.090]
Country/Area of origin (ref. Albania)				
Egypt				0.615 [0.268;1.415]
Morocco				0.725 [0.302;1.738]
Bangladesh				1.037 [0.423;2.538]
Senegal				0.576 [0.231;1.439]
CEE				0.871 [0.344;2.203]
Africa				1.959 [0.873;4.397]
Asia and Middle-East				0.704 [0.322;1.535]
Latin-America & Caribbean				0.473 [0.202;1.108]
cut1	–1.430 [–2.295;–0.057]	–1.505 [–2.454;–0.556]	–1.415 [–2.371;–0.459]	–0.885 [–2.453;0.684]
cut2	2.455 [1.577;3.333]	2.382 [1.423;3.342]	2.474 [1.506;3.442]	3.007 [1.428;4.587]
cut3	4.961 [4.042;5.879]	4.888 [3.888;5.888]	4.987 [3.977;5.997]	5.518 [3.907;7.128]
cut4	7.231 [6.199;8.263]	7.208 [6.091;8.326]	7.301 [6.174;8.428]	7.825 [6.136;9.513]
(_cons)	5.735 [4.717;6.974]	4.697 [3.812;5.786]	4.687 [3.801;5.779]	4.476 [3.621;5.533]
Observations	2326			

b)				
	Model 1	Model 2	Model 3	Model 4
Time (ref. Pre-migration)				
Post-migration	4.082 [2.551;6.533]	3.957 [2.465;6.350]	4.088 [2.535;6.595]	4.099 [2.540;6.615]
Age (time-varying)	0.917 [0.891;0.943]	0.916 [0.890;0.943]	0.915 [0.889;0.942]	0.915 [0.889;0.942]
Age squared/100 (time-varying)	1.166 [1.128;1.205]	1.168 [1.130;1.207]	1.168 [1.130;1.208]	1.168 [1.129;1.207]
Mean age (Mundlak term)	1.026 [0.972;1.084]	1.052 [0.993;1.113]	1.062 [1.003;1.125]	1.076 [1.006;1.150]
Mean age squared/100 (Mundlak term)	1.027 [0.952;1.108]	0.986 [0.911;1.067]	0.971 [0.897;1.052]	0.968 [0.885;1.058]
Education (ref. No/Primary)				
Lower-sec		0.373 [0.224;0.622]	0.364 [0.217;0.610]	0.387 [0.232;0.645]
Upper-sec		0.169 [0.105;0.275]	0.170 [0.104;0.277]	0.199 [0.121;0.327]
Tertiary		0.151 [0.090;0.252]	0.154 [0.091;0.259]	0.169 [0.099;0.289]
Occupational status (ref. Employed - Physically demanding)				
Employed – Non-physically demanding		1.169 [0.739;1.850]	1.164 [0.736;1.841]	1.208 [0.766;1.904]
Self-employed – Physically demanding		0.636 [0.213;1.899]	0.667 [0.226;1.971]	0.673 [0.231;1.954]
Self-employed – Non-physically demanding		0.652 [0.362;1.173]	0.727 [0.404;1.308]	0.784 [0.436;1.412]
Unemployed/Inactive		1.151 [0.836;1.583]	1.321 [0.951;1.835]	1.165 [0.833;1.630]
Other		1.279 [0.769;2.125]	1.223 [0.729;2.051]	1.066 [0.634;1.791]
Marital status (ref. Single)				
Couple-partner w/for-cit			0.703 [0.484;1.022]	0.640 [0.437;0.938]
Mixed couple			0.721 [0.455;1.144]	0.717 [0.454;1.133]
Divorced/Widowed			1.286 [0.816;2.027]	1.076 [0.683;1.696]
Legal status (ref. Citizenship)				
Long-term resident				1.367 [0.979;1.910]
Temporary permit				1.218 [0.786;1.888]
Undocumented				4.098 [1.473;11.402]
Not-declare				0.816 [0.131;5.106]
Country/Area of origin (ref. Albania)				
Egypt				1.019 [0.514;2.023]
Morocco				0.929 [0.483;1.786]
Bangladesh				1.124 [0.502;2.516]
Senegal				0.760 [0.325;1.782]
CEE				1.443 [0.809;2.572]
Africa				1.642 [0.876;3.078]
Asia and Middle-East				0.600 [0.334;1.077]
Latin-America & Caribbean				0.559 [0.311;1.005]
cut1	–0.463 [–1.165;0.239]	–1.646 [–2.540;–0.752]	–1.659 [–2.575;–0.744]	–1.261 [–2.576;0.054]
cut2	3.272 [2.536;4.008]	2.059 [1.157;2.961]	2.030 [1.106;2.953]	2.431 [1.106;3.756]
cut3	5.710 [4.921;6.499]	4.522 [3.584;5.459]	4.478 [3.520;5.436]	4.875 [3.524;6.226]
cut4	7.566 [6.675;8.457]	6.403 [5.379;7.427]	6.325 [5.284;7.366]	6.723 [5.312;8.134]
(_cons)	3.167 [2.530;3.965]	2.773 [2.189;3.512]	2.677 [2.103;3.407]	2.514 [1.965;3.217]
Observations	2336			

Notes: (1) ORs with 95% CIs in [brackets]. (2) ORs greater than 1 indicate higher odds of being in a worse health category (given that 1 = “very good” health and 5 = “very bad” health). (3) Models include the within-individual means of the time-varying age terms (Mundlak, 1978); coefficients on time-varying regressors thus recover within-individual variation. (4) Joint tests of the Mundlak terms reject the equality of between- and within-individual age effects among women

($\chi^2(2) = 17.70, p < 0.001$) but not among men ($\chi^2(2) = 4.60, p = 0.100$); the same specification is retained for both groups so that estimates remain directly comparable. (5) Intraclass correlation coefficient (ICC): 0.576 for men (Panel a); 0.433 for women (Panel b). The lower ICC among women reflects greater within-individual variation, consistent with the larger post-migration decline observed in this group. (6) Models use the survey sampling weights. Source: Authors' elaboration on MIGHTY data (2024/2025).

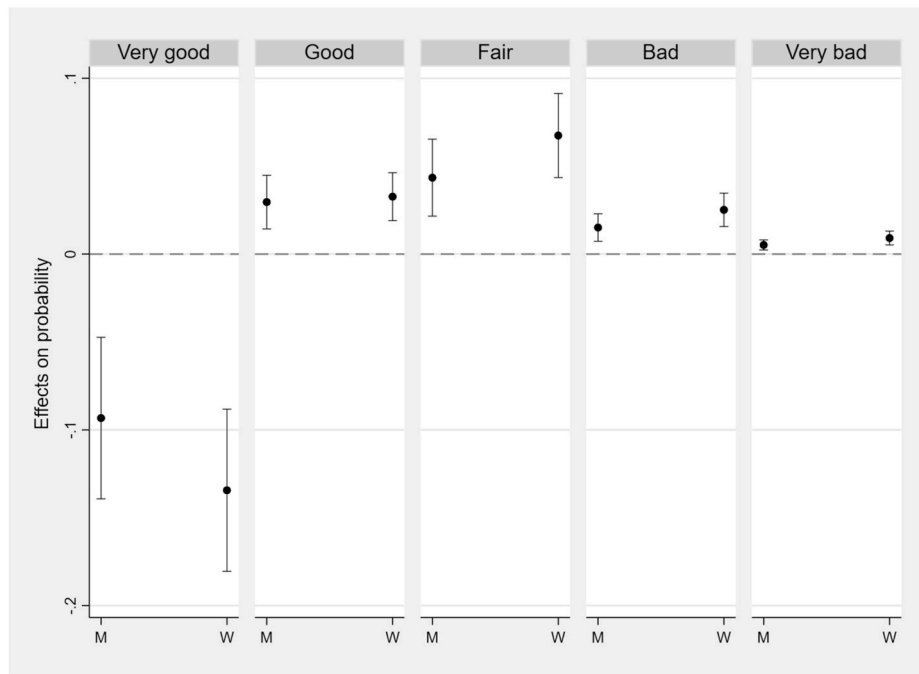


Fig. 1. Average marginal effect of migration timing on the probability of reporting each SRH category, by gender.

Notes: (1) Estimates from the correlated random-effects ordinal model with the interaction between migration timing and gender. The full model is reported in Table 2A in the Supplementary Material. M = men, W = women. (2) Bars show 95% CIs. A negative effect indicates a reduced probability of reporting that category after migration. (3) Joint test of the migration timing $\times$ gender interaction: $\chi^2(1) = 7.44, p = 0.006$. (4) The model uses the survey sampling weights.

Source: Authors' elaboration on MIGHTY data (2024/2025).

These reductions are redistributed towards “fair” health, with the largest increases occurring in the same groups that experience the steepest decline in “very good” health. Movements into “bad” and “very bad” health are small across all occupational groups, although slightly more pronounced among the unemployed or inactive respondents and the “other” group. The occupational gradient thus operates mainly in the upper part of the distribution, in the loss of very good health rather than in entry into poor health.

Fig. 3 further analyses whether the association between occupational positions and post-migration deterioration differs by gender (H4).⁶ The three-way interaction is statistically significant ($\chi^2(5) = 12.61, p = 0.027$), indicating that occupational patterning differs between men and women. Among men (Panel a), the decline varies significantly across occupational positions ($\chi^2(5) = 27.50, p < 0.001$), driven primarily by respondents in the “other” category and, to a lesser extent, by the self-employed in non-physically demanding occupations. Among women (Panel b), the decline in “very good” health is relatively uniform across occupational groups, and the interaction between migration timing and occupational status is not significant ($\chi^2(5) = 5.68, p = 0.339$).

Post-migration deterioration is therefore asymmetrical: it is occupationally structure among men but more uniform among women, although its overall level, as shown above, is higher among women. As in the previous results, the redistribution concentrates in the “fair”

category, and movements into “bad” and “very bad” health remain small for both genders.

These findings are robust to a range of alternative specifications, reported in the Supplementary Material (Tables 1B–9B; Fig. 1B).

6. Discussion

Using retrospectively reported pre-migration health data from the 2025 MIGHTY Survey, this study provides the first within-individual assessment of post-migration health change in Italy based on retrospectively reported SRH and one of the first in Southern Europe. Our findings document a deterioration in SRH following migration (H1), consistent with the exhausted migrant effect framework (Bollini & Siem, 1995). This deterioration is not uniform: as we discuss below, once ageing is accounted for, it is concentrated among women rather than shared equally across genders. Because it is based on a within-individual comparison, it is not confounded by stable compositional differences between migrants. Although our data do not allow us to identify specific causal mechanisms, the pattern is suggestive of cumulative exposure to structurally disadvantaged conditions in the destination society.

Post-migration health deterioration is more pronounced among women than men, consistent with H2a. Pre-migration probabilities of reporting very good health are nearly identical across genders, whereas a clear gap emerges after migration, suggesting that the gender difference is linked to post-migration experiences rather than differential selection. The difference cannot be attributed to differential ageing: robustness analyses show that age trajectories in SRH do not differ statistically between migrant men and women. The steeper female decline is consistent with research linking migrant women's health disadvantage

⁶ Results are based on a single model including the three-way interaction between migration timing, gender and occupational status; the two panels separate men and women for readability.

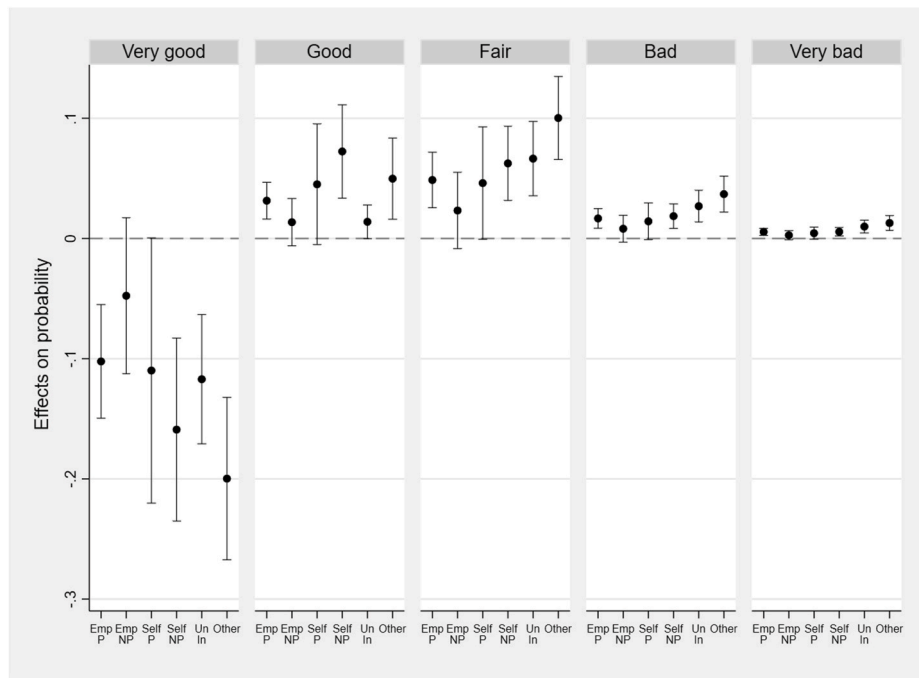


Fig. 2. Average marginal effect of migration timing on the probability of reporting each SRH category, by occupational status.

Notes: (1) Estimates from the correlated random-effects ordinal model with the interaction between migration timing and occupational status. The full model is reported in Table 3A in the Supplementary Material. (2) “Empl P” refers to employed individuals in physically demanding jobs; “Empl NP” refers to employed individuals in non-physically demanding jobs; “Self P” refers to self-employed individuals in physically demanding jobs; “Self NP” refers to self-employed individuals in non-physically demanding jobs. “Un/In” refers to unemployed/inactive individuals. (3) Bars show 95% CIs. (4) A negative effect indicates a reduced probability of reporting that category after migration. (5) Joint test of the migration timing $\times$ occupational status interaction: $\chi^2(5) = 18.24$, $p = 0.003$. (6) The model uses the survey sampling weights.

Source: Authors' elaborations on MIGHTY data.

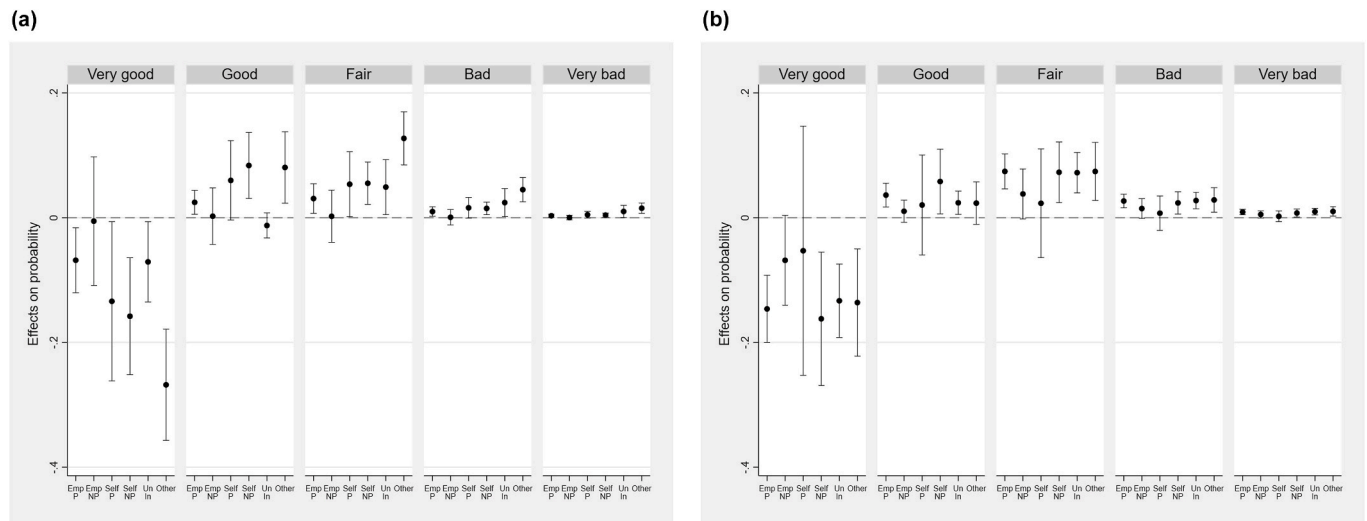


Fig. 3. Average marginal effect of migration timing on the probability of reporting each SRH category by occupational status, for men (Panel a) and women (Panel b).

Notes: (1) Estimates from the correlated random-effects ordinal model with the three-way interaction between migration timing, gender and occupational status. The full model is reported in Table 4A in the Supplementary Material. (2) “Empl P” refers to employed individuals in physically demanding jobs; “Empl NP” refers to employed individuals in non-physically demanding jobs; “Self P” refers to self-employed individuals in physically demanding jobs; “Self NP” refers to self-employed individuals in non-physically demanding jobs. “Un/In” refers to unemployed/inactive individuals. (3) Bars show 95% CIs. (4) A negative effect indicates a reduced probability of reporting that category after migration. (5) Joint test of the three-way time $\times$ gender $\times$ occupational status interaction: $\chi^2(5) = 12.61$, $p = 0.027$. Within-gender tests: $\chi^2(5) = 27.50$, $p < 0.001$ for men; $\chi^2(5) = 5.68$, $p = 0.339$ for women. (6) Estimates for self-employment in physically demanding occupations (Self P) are based on a small sample ($N = 65$: 48 men, 17 women) and are shown with wide confidence intervals; we therefore avoid substantive interpretation of this category.

Source: Authors' elaborations on MIGHTY data.

to the combined demands of paid work and unpaid care responsibilities

(Llácer et al., 2007; Villar-Bustos et al., 2024). We do not test these

mechanisms directly because the survey does not collect information on time use and caregiving; one plausible reading is that gender inequalities in health extend beyond workplace conditions alone (Gkiouleka & Huijts, 2020; Malmusi et al., 2010).

Evidence on occupational status (H3) reveals a more complex pattern than anticipated. Differences between physically demanding and non-physically demanding employment are relatively modest, whereas self-employed migrants show more pronounced deterioration. Because occupational status is measured at interview, after the health change, these associations cannot be interpreted causally and may partly reflect health-related selection into or out of specific occupational positions rather than an effect of those positions on health. This caveat applies across categories. With that in mind, the association with self-employment is consistent with two, non-exclusive readings: in the Italian context, self-employment may reflect an alternative to limited opportunities in standard employment and may involve economic insecurity, long working hours, and weaker access to social protections (Ambrosini & Panichella, 2025), potentially limiting workers' ability to interrupt work when health problems arise. Alternatively, migrants whose health has deteriorated may move into self-employment from more demanding positions, so that the association partly reflects selection. Our data cannot distinguish these processes.

Unemployed or inactive respondents show smaller declines in the most favourable health categories but larger increases in poor health, consistent with reverse causation or selection processes, whereby those experiencing health problems are also more likely to leave or remain outside employment. Respondents in other non-standard work arrangements show steep declines, but the heterogeneity of this category limits interpretation. A more granular classification would be needed to assess the health consequences of specific forms of non-standard and informal employment.

The interaction between gender and occupational status (H4) produced an unexpected pattern. Occupational status differentiates post-migration deterioration significantly among men but not among women: among women, the decline is both larger and relatively uniform across occupational positions, whereas among men it is less pronounced overall but more clearly structured by occupation. This qualifies a straightforward double-burden interpretation. One possible reading is that the double-burden experienced by migrant women – arising from the combination of paid work and unpaid care responsibilities (Llacer et al., 2007) – cuts across occupational categories, so that occupation adds little differentiation to an already elevated level of deterioration. Among men, by contrast, the health consequences of migration appear more closely tied to specific working conditions.

The male occupational gradient is largely attributable to self-employed workers in non-physically demanding occupations and to respondents in the “other” category (i.e., outside standard employment). These categories point to the vulnerability of men at the margins of the labour market, although this interpretation remains tentative, given both the adverse conditions in these positions and the possibility of health-related selection into these positions, including downgrading from more demanding jobs. This pattern also refines the reading of H2b: although the aggregate findings do not support greater post-migration deterioration among men, they reveal occupational vulnerability among migrant men, concentrated in self-employment in non-physically demanding occupations and marginal labour-market positions rather than in physically demanding work, as originally posited in H2b.

Our analysis does not identify the specific channels through which migration affects health. We deliberately did not adjust for care responsibilities, financial hardship, or social isolation, since in our framework these are plausibly the pathways through which post-migration deterioration operates rather than confounders of it; adjusting for them would absorb the very association we seek to document.

Across all analyses, the probability of reporting “bad” or “very bad” SRH remains low both before and after migration, consistent with the positive health selection of migrants (Rubalcava et al., 2008). Our

findings therefore describe health change among a positively selected population and may not capture the deterioration experienced by more vulnerable migrants, whose poorer health may prevent migration altogether or lead to earlier return.

Some limitations should be acknowledged. First, all control variables are measured at interview and treated as time-invariant. We therefore cannot reconstruct changes in migrants' circumstances over the migration process or identify the causal pathways linking migration, employment trajectories, and health. This is particularly important for occupational status, discussed in the context of H3 above; our analysis documents patterns of health stratification rather than establishing causal mechanisms. Second, our classification of occupations does not fully capture the physical and psychosocial strain of care and domestic work, disproportionately performed by migrant women. This may lead us to underestimate deterioration among women and to obscure differences across occupational positions, and may itself contribute to the relative uniformity of deterioration observed among women across occupational categories. Consistent with this, the gender difference is concentrated in the loss of very good health rather than in movement into the poorest categories.

Third, retrospective SRH may be affected by recall bias (Constant & Milewski, 2021; Pellet & de Talancé, 2023). Some respondents may idealise their pre-migration health (rosy retrospection), others may recall it less favourably, and a related mechanism is response shift – a change in the internal standards against which individuals assess their health (Galenkamp et al., 2012; Spuling et al., 2017). It may plausibly be amplified as migrants integrate into the destination society: as shown for migrants' subjective well-being (Bartram, 2013), the frame of reference against which health is assessed may itself shift, so that SRH reflects not only objective change but also shifts in the comparison group. Robustness analyses suggest that these mechanisms may affect the magnitude of the estimated decline but do not generate it: deterioration is present even among the most recently arrived migrants, the gender difference remains significant in fixed-effects models, and the bounding analysis indicates that only a large and gender-specific recall bias could overturn the result.

Fourth, the analysis is restricted to Lombardy, Italy's most populous region in terms of migrant population and one of its most economically dynamic, limiting the generalizability of our findings. Fifth, because respondents contribute exactly two observations, cumulative exposure to conditions in the destination country and age-related decline in SRH are observationally equivalent in our design; we cannot separately identify the two, and the steeper declines observed among long-term residents are consistent with both processes. Sixth, country-of-origin composition differs systematically between men and women in our sample, reflecting gendered migration channels to Italy – women concentrated in Central and Eastern European and Latin American origins consistent with the demand for domestic and care work, men in African and Asian origins tied to manual labour sectors. Although country of origin is included as a covariate, we cannot fully rule out that norms of health self-reporting vary by origin and interact with gender. Finally, selective out-migration may bias our estimates in either direction: if migrants in worse health are more likely to leave Italy (salmon bias), we would underestimate deterioration, compounding the positive selection into migration discussed above; conversely, onward migration of healthier individuals to other destinations, a less well-documented but plausible mechanism that is consistent with the broader health selectivity of migration, would bias our estimates in the opposite direction. Although salmon bias explains only part of migrants' health advantage (Di Napoli et al., 2021; Wallace & Wilson, 2022), our cross-sectional data cannot distinguish between these mechanisms. Their influence may be particularly relevant among long-term migrants.

Despite these limitations, the study makes several contributions. By incorporating retrospective pre-migration health information, it provides a rare within-individual assessment of health change across the migration process in a Southern European context. It also shows that

post-migration health deterioration is not uniform but stratified by gender and occupational status, highlighting the role of unequal labour market incorporation and gendered social roles in shaping migrants' health trajectories. More broadly, the findings support a view of migrant health inequalities as dynamic processes of cumulative disadvantage rather than static differences between population groups.

From a policy perspective, the uneven distribution of post-migration health deterioration calls for a differentiated approach to migrant health policy (ILO, 2020; World Health Organization Regional Office for Europe, 2024). For men, whose deterioration is more closely tied to occupational position, strengthening labour protections and extending occupational health services to non-standard and undeclared work appears especially relevant. For women, whose deterioration cuts across occupational categories, interventions should reach beyond the workplace to address the combined burden of paid and unpaid care, particularly in the domestic and care sector (Vianello et al., 2024), by extending occupational health surveillance to private households, addressing irregular working hours, improving access to psychosocial support, and strengthening general practitioners' capacity to identify work-related illness among migrant home-care workers (Vianello & Wolkowitz, 2023). Because evidence on the effectiveness of such interventions for migrant workers remains limited, systematic evaluation is needed (Evagora-Campbell et al., 2022).

CRedit authorship contribution statement

Eleonora Trappolini: Writing – review & editing, Writing – original draft, Software, Investigation, Formal analysis, Data curation, Conceptualization, Methodology. **Elisa Barbiano di Belgiojoso:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Stefania M.L. Rimoldi:** Writing – review & editing, Writing – original draft, Conceptualization.

Ethical statement

Ethical approval was not required for this study by University of Milano-Bicocca because it relies exclusively on anonymized secondary data. No direct contact with human participants occurred, and individual privacy was completely protected in accordance with national regulations. Repository of data here, doi: 10.17632/m96z9ssxjw.1.

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Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2026.101971>.

Data availability

The authors do not have permission to share data.

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