

REVIEW

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Migration and cognitive function: a conceptual framework for Global Health Research

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Abstract

Background: Migration is a fundamental demographic process that has been observed globally. It is suggested that migration is an issue of global health importance that can have an immediate and lasting impact on an individual's health and well-being. There is now an increasing body of evidence linking migration with cognitive function in older adults. In this paper, we synthesized the current evidence to develop a general conceptual framework to understand the factors contributing to the association between migration and cognitive function.

Methods: A comprehensive review of the literature was conducted on the associations between migration and cognition among middle-aged and older adults.

Results: Five potential mechanisms were identified from the literature: 1) socioeconomic status—including education, occupation, and income; 2) psychosocial factors—including social networks, social support, social stressors, and discrimination; 3) behavioral factors—including smoking, drinking, and health service utilization; 4) physical and psychological health status—including chronic conditions, physical function, and depression; and 5) environmental factors—including both physical and social environment. Several underlying factors were also identified—including early-life conditions, gender, and genetic factors.

Conclusions: The factors linking migration and cognitive function are multidimensional and complex. This conceptual framework highlights potential implications for global health policies and planning on healthy aging and migrant health. Additional studies are needed to further examine these mechanisms to extend and refine our general conceptual framework.

Background

Migration is the geographic movement of individuals across a specified boundary for the purpose of establishing a new residence [1]. Migrant populations, both within countries and internationally, have been increasing for the past few decades [2]. According to recent estimates, in 2013, there were more than 232 million international migrants; and another 740 million internal migrants worldwide [2]. This dramatic increase in the migrant populations has drawn particular attention to migration and health and highlights the needs to identify best

practices to promote healthy aging for migrant populations. Cognitive impairment, often defined as an individual's experienced difficulties in remembering things, learning new skills, concentrating on tasks, or making decisions, is a common problem in old age [3]. As these migrant populations get older, many will experience cognitive decline [4–6]. Increasing number of older adults experiencing some level of cognitive decline continue to put enormous strain on healthcare systems and on caregivers who provide care for people with cognitive impairment [6, 7]. Thus, it is important to understand how migration may relate to initial levels of cognitive function and the rate of cognitive change over time [8]. A variety of factors—such as sociodemographic background, health behaviors, and genetic traits—can influence levels of cognitive function and changes over time [9]. Likewise, the migration process is related to many

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of these factors and, therefore, may be important mechanisms in the association between migration and cognitive function.

The purpose of this paper is to present a general conceptual framework of the linkages between migration and cognitive function. We conduct a comprehensive review of the literature and discuss the possible mechanisms that may explain the association between migration and cognitive function. Furthermore, synthesizing the current evidence to provide a conceptual framework will help elucidate important mechanisms and provide guidance for researchers to develop effective approaches to prevent cognitive decline among older adult populations. In addition, this conceptual framework will highlight potential actionable areas that inform the development of global health policies and planning on healthy aging and migrant health.

Theories and current literature on migration and cognitive function

Our previous systematic review synthesized the current literature on migration and cognitive function [10]. We found that different migration patterns have different impacts on cognitive function [10]. We also found that there is a lack of a conceptual framework that elucidates the potential pathways between migration and cognitive function in the current literature [10]. Existing theories, such as the push-pull theory that has been widely used by economists, do not explicitly explain how migration might influence an individual's cognitive status [11, 12]. Given the sheer number of migrants across the globe, it is important to develop a conceptual framework to examine the underlying linkages that connect migration and cognition. Building on our published systematic review, we first reviewed three theories and models that have been used in the current literature related to migration and health.

Life course perspective

The life course perspective has served as a useful interdisciplinary framework in social, behavioral, and health science research [13–15]. Elder and colleagues describe the life course as “consisting of age-graded patterns that are embedded in social institutions and history” [15]. To illustrate, social and physical exposures during critical periods (e.g. gestation, childhood, and adulthood) may have cumulative effects on health status in later life, such as through increasing the risk of chronic conditions and influencing functional status [16]. In the context of migration and cognitive function, migration may alter an individual's trajectory of cognitive function. The timing and duration of migration might have an impact on the magnitude of the relationship between migration and cognition. Still, the life course perspective fails to incorporate the determinants of health status—cognitive function in this case—and the reasons for migration. Therefore, other theories and models

are needed to address the limitation of life course theory in guiding future research on migration and cognition.

Social determinants of health

The World Health Organization first introduced the concept “determinants of health” to illustrate the idea that an individual's health status is determined by many factors together [17]. Based on the social determinants of health model, factors that influence health status include but are not limited to 1) the social and economic environment (e.g. income, education), 2) the physical environment (e.g. clean water, safe housing), and 3) the individual's characteristics and behaviors (e.g. access to healthcare, smoking). The social determinants of health model has been widely embedded in studies related to disease and functional status [18–20]. A recent study has comprehensively summarized the key risks and protective factors related to cognitive impairment [9]. However, while this model is very useful, it does not specifically elucidate the pathways between migration and cognition.

Push and pull theory

The push-pull theory has been widely used in geography and economics research to examine factors that influence people's decision to migrate [21, 22]. To illustrate, this theory emphasizes the interplay between sending- and receiving place factors that govern the migration process. Push factors often include dissatisfying conditions (e.g. political instability, heavy taxation) in the sending places that motivate people to migrate. In contrast to push factors, pull factors are favorable conditions (e.g. less polluted environment, health care system) in receiving countries that facilitate the migration process. Although the push-pull theory emphasizes that factors in both sending- and receiving places are important to the migration decision, whether these factors can cause accumulation of disease risks and whether migration is associated with certain health outcomes are only vaguely implied in this theory.

In sum, only using one theory is not sufficient to help us elucidate the associations between migration and cognitive function. Therefore, we further reviewed current empirical findings related to migration, cognition, and factors associated with cognitive function, incorporated these empirical findings into the three theories, and ultimately developed a general conceptual framework of the relationships between migration and cognitive function. We did not include all the literature but highlighted several studies that illustrate each potential mechanism.

Potential mechanisms impacting relationships between migration and cognitive function

Migration status

An individual's migration status consists of several inter-correlated key elements, including geographic patterns, age at migration/length of stay, and reasons for migration. A major trend in migration in the world today is that people tend to move from less developed areas (e.g. rural settings, low- and middle-income countries) to more developed places (e.g. urban areas, high-income countries) for more working opportunities, better education, or higher payment [1]. For example, in China, millions of people have migrated from rural areas into cities for employment since the economic reform in 1979 [23]. Similar patterns have also been observed in the immigrant populations: a significant number of laborers from Mexico or other Latin American countries moved to the U.S. and worked in the manufacturing or service sectors [24, 25]. In addition to this type of migration that is often described as upward social mobility, other types of geographic movements also exist, including involuntary migration due to natural disasters, or migration for the purpose of marriage or family union [26–28]. For example, rural to rural migration is commonly seen among women in India; and a significant proportion of this rural to rural migration is related to marriage [29, 30].

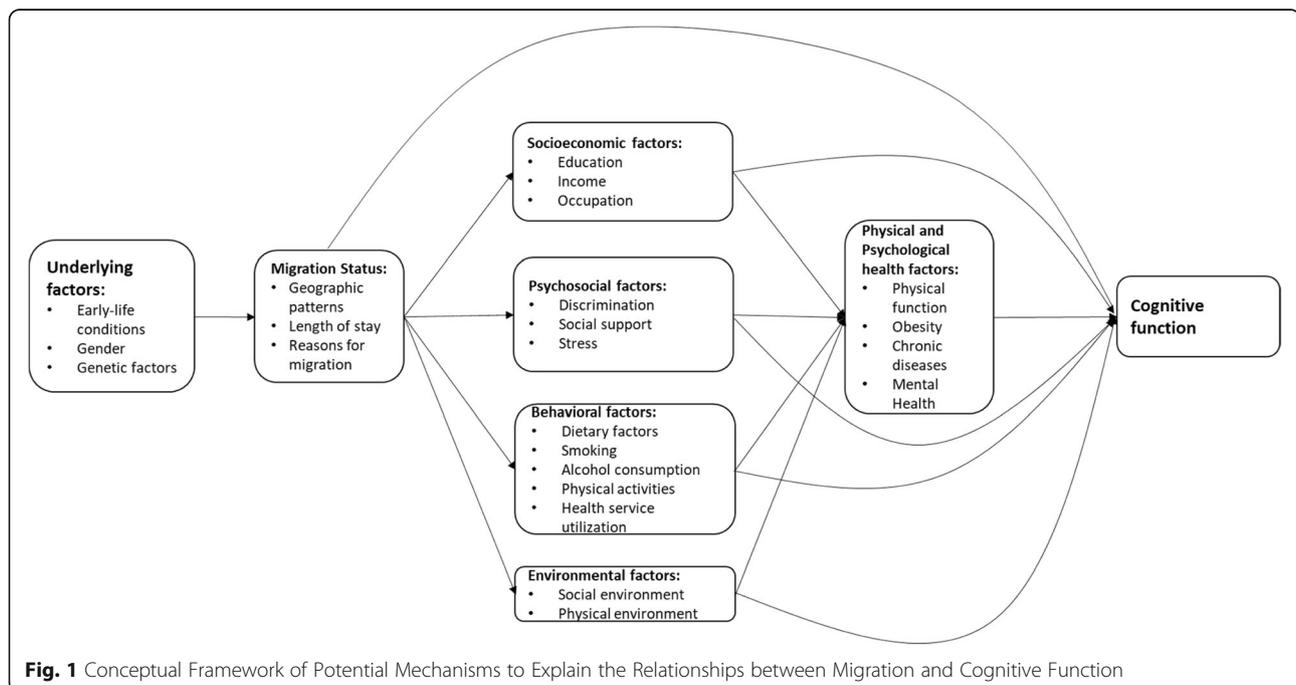
Age at migration (or length of stay) is another critical component of an individual's migration status. First, age at migration is likely to be associated with the length of exposure to certain physical and social environments. Additionally, people tend to migrate for specific reasons

at different stages of the life course. For example, upward social mobility is more likely to occur during young adulthood [31].

The potential pathways through which migration affects cognitive function are complex and multifactorial. Different geographic movements and the related reasons for migration are likely to affect cognitive function through different pathways. These potential mechanisms can be categorized in terms of socioeconomic, psychosocial and behavioral factors, physical and psychological health, and environmental factors. Age at migration can determine the duration of exposure that ultimately impacts the magnitude of these effects on cognitive function. Figure 1, which is an extension and elaboration of the figure in our previous systematic review [10], depicts factors that are associated with an individual's cognitive function and how the migration process may change some of those factors.

Socioeconomic status (SES)

Socioeconomic factors are often assessed in the literature using measures such as educational attainment, income level, and occupational status [4]. A number of studies have shown that adult SES such as education, income, and occupation are protective factors against cognitive decline [8, 32–34]. Migrants who moved from poorer areas to more developed places are likely to achieve socioeconomic advancement, which is often described as upward social mobility [31].



Education

Moving from rural areas into cities, or from developing countries to developed countries, is likely to lead to more or better education opportunities [23, 30]. People who receive higher levels of education demonstrated better cognitive function [35, 36]. One possible explanation is that brain function is stimulated through learning activities or social engagement [37]. Therefore, higher education is related to more cognitive reserve that helps people maintain their brain function [38].

Income

In addition to education, research has shown that migrants are likely to receive higher income from their new job after migration than what they could earn back home [1, 23, 39]. Prior research has found that controlling for education and other factors, higher income has been independently associated with higher scores in cognition tests [8, 32]. Higher income level may allow people to afford a good quality diet and better living environment that, in turn, may have a positive impact on cognitive health [40, 41]. It is also possible that migration can lead to an improvement in financial status that increases the likelihood for migrants to obtain health insurance and use healthcare services [42, 43], resulting in more preventative care to reduce the risk of diseases that negatively affect cognitive function in later life [44].

Occupation

It is likely that migration results in changes in occupations [23, 30]. Studies have reported the association between a highly-skilled occupation and better cognitive function while adjusting for education and income factors [33, 34]. Occupation often reflects different work exposures and activities [45]. Therefore, migrants may benefit from intellectual stimulation by working on different tasks and learning new skills, which are associated with better cognitive function [35–37, 46].

Psychosocial factors

Migration involves many psychosocial changes [47]. The following section describes how these migration-related psychosocial changes are associated with cognitive function.

Perceived discrimination

A number of studies have documented the hostility and discrimination that migrants experience [48, 49]. For example, rural-to-urban migrants in China have often been denied access to many of the social welfare programs such as health insurance and unemployment benefits that are available to their urban counterparts, even if they were doing the same job [50]. Among immigrants, discrimination and segregation in host countries are also

often reported [51, 52]. Perceived discrimination may result in social isolation; and previous studies found that social isolation is a risk factor for cognitive impairment and dementia [53, 54].

Social support

Previous research has reported that migrants often experienced various stressful life events, such as separating from family, both during and after the migration process [55]. Family separation is likely related to reduced social support [52, 56, 57]. Small social networks and less social support have been shown to be risk factors for cognitive decline [58–60]. It is also possible that adequate social support and a large social network can facilitate an individual's access to health care and promote healthy behaviors, ultimately reducing the impact of other risk factors that affect cognitive function [61].

Stress

In addition to experiencing reduced social networks and social support, migrants are often under great stress during the migration process [62, 63]. Studies have shown that stressful life events may affect elderly participants' inhibitory control in attentional and sensorimotor domains and therefore influence their cognitive function [64]. However, a longer stay in a hosting place has been shown to be associated with less stress and an improved social network [65]. As a result, the effects of these negative psychosocial factors such as reduced social network and increased stress on cognitive function may decrease as migrants stay longer in hosting places.

Behavioral factors

Changes in health behaviors are often observed in migrant populations. Migrants from less developed areas are likely to adopt westernized life styles that can negatively affect health, such as high calorie intake, physical inactivity, sedentary employment, and tobacco use [66–68]. These high-risk lifestyles lead to disorders that directly affect an individual's cognitive function [69, 70], and also serve as mediators in the relationship between migration and cognitive function.

Dietary factors

Dietary acculturation has been observed among immigrants [67, 71]. Studies that examined the change of dietary patterns among immigrants in the United States indicate that immigrants tend to consume more calorie-dense food but less fruits and vegetables after arriving in the United States [67, 71]. In addition, a longer stay in the United States has been associated with more westernized dietary patterns [71]. Research shows that similar patterns occur in the rural-to-urban migrant populations in developing countries [72–74]. Previous

studies have reported that regular intake of fruits, vegetables, and fiber is associated with better cognitive function [70, 75], while westernized food consumption is related to poorer cognitive performance [76, 77]. Therefore, migration may trigger changes in migrants' dietary behaviors that generate negative effects on their later-life cognitive function.

Smoking

An increasing prevalence of smoking has been observed among migrant populations, which may partially explain the poorer cognitive function found in migrants than those who did not move. Studies in China and Guatemala have indicated that moving into cities is associated with higher likelihood of smoking [78, 79]. Female immigrants appear more likely to smoke than their counterparts who remain in home countries [66, 80]. A wealth of data has shown the negative effect of smoking on cognitive function [81–84], which may occur due to increased risk of cardiovascular diseases and inflammation [85].

Alcohol consumption

Unlike smoking, light-to-moderate alcohol consumption has been shown to reduce the risk of developing dementia [86, 87]. One possible explanation is that light-to-moderate drinking might be cardio protective [86, 88]. However, previous research has yielded inconsistent results on the association between heavy drinking and cognitive function [85, 89]. Therefore, the relationship between alcohol consumption and cognitive function might be an inverted U-shape [90]. Still, an increasing trend of alcohol consumption has occurred in both immigrant and internal migrant populations [78, 91].

Physical activities

A growing body of literature has demonstrated lower physical activity among rural-to-urban migrants compared to rural residents, which may be explained by sedentary employment in the cities [78, 92]. Similarly, immigrants are also found to be less likely to participate in physical activities, and longer stays in a hosting country will increase this likelihood [93, 94]. Physical activities have long-term positive effects on later-life cognitive function [95–97]. One possible linkage between physical activity and cognition is that physical activity leads to improvements in cardiorespiratory fitness that are beneficial for cognitive function [96].

Health services utilization

Despite the negative health behaviors that are related to migration, people who move to more developed areas or countries may improve their access to better healthcare services. It is believed that healthcare in developed countries is generally better than in developing countries

[98]. Similarly, in developing countries where massive internal migration occurs, the best healthcare is centralized in urban areas [99, 100]. Although migrants from developing countries or rural areas may have better access to healthcare after migration, the utilization of these services may not be improved immediately. It may take some time for these migrants to be fully aware of and gain access to the available healthcare resources [101, 102].

Physical and psychological health

As discussed in previous sections, migration may trigger changes in several risk and protective factors, including SES, psychosocial, and behavioral factors. These migration-related factors not only directly interact with cognitive function, but also have impacts on individuals' physical and psychological health and ultimately influence cognitive function [69, 103].

Physical function

A growing body of literature has demonstrated the association between physical function and cognitive function. For example, a recent study has demonstrated that decline in gait and balance function preceded decline in neurological processing speed tasks [104]. Therefore, factors that are associated with an individual's physical function may have indirect effects on cognitive function. Physical function is associated with several factors such as SES [105, 106], health behaviors [106, 107], and social support [108]. These factors are likely to change during the migration process. Therefore, migration may indirectly affect an individual's cognitive function through the pathways that we described above.

Obesity

Changes in health behaviors, such as adopting a westernized diet and being physical inactive, are likely to increase the risk of obesity in the migrant populations [109, 110]. In addition, a longer stay in the hosting place has been shown to be significantly associated with obesity or overweight [111, 112]. The linkage between obesity and cognitive function is well-established [77, 113]. Therefore, obesity could mediate the effect of health behavior changes that occurred along with the migration process on later-life cognitive function.

Chronic diseases

Similar mediating effects can be found in chronic diseases. On one hand, the changes in migration-related health behaviors not only contribute to the risk of obesity and overweight in the migrant populations; these high-risk lifestyles are also associated with the development of chronic diseases like cardiovascular disease and diabetes [83, 114, 115]. On the other hand, if people experience improvement

in their SES that is due to migration, they may be more likely to use preventive care [116]. Also, migration can lead to improvement in access to healthcare [99, 100], which can promote better prevention and management of chronic diseases [117]. Increasing evidence suggests that chronic diseases such as hypertension, diabetes, and arrhythmias are related to greater risk of cognitive impairment and dementia [69, 103, 118–122]. Although the precise mechanisms underlying the association between chronic diseases and cognitive function remain unclear, one common explanation is that both micro- and macro-vascular complications increase the risk of cognitive impairment [123].

Mental health

Previous research has established linkages between migration-related psychosocial factors and mental health [48, 56, 124, 125]. For example, perceived discrimination has been found to be a risk factor for depressive symptoms [125, 126]. The reduced social networks among immigrants also has been shown to have negative effects on mental health [65, 127]. However, as migrants stay longer in the hosting places, it is possible that they will rebuild their social networks, which will reduce the negative effects on mental health [65]. Additionally, longer stays have been shown to be related to more use of mental health services that would help improve mental health status [128, 129]. Evidence from previous studies suggests that depressive symptoms are associated with mild cognitive impairment and dementia [130, 131]. It is possible that the changes in psychosocial factors during or after migration will negatively impact migrants' mental health status, and therefore increase the risk of cognitive impairment. However, these negative impacts on cognitive function could be reduced gradually as their length of stay increases.

Environmental factors

Moving from one area to another often leads to changes in both physical and social environment. The following section discusses the possible linkages between migration, changes in environmental factors, and cognition.

Social environment

For immigrants, the similarities in social environment between sending and receiving countries may determine the amount of change that immigrants experience in psychosocial and behavioral factors that are associated with physical and psychosocial health, and, thus, with cognitive function [132]. For example, immigrants from low-income countries are more likely to experience discrimination when they migrate to a high-income country [133]. Behavioral changes among immigrants also differ by the countries of origin. For example, the prevalence of smoking varies between Asian and Latino immigrants in the United States; and the gender gap in smoking

prevalence is greater among Asian than Latino immigrants [66]. In addition, country of origin has been shown to be a significant factor that influences changes in dietary patterns and risks of chronic diseases among immigrants [134].

Physical environment

Increasing evidence has suggested that certain physical environments can be a potential risk factor for cognitive impairment. Prior studies have found that people who work in agricultural settings are more likely to be exposed to pesticide that increases the risk of cognitive decline [135]. In addition, people who live in rural areas especially in developing countries still often use open fires for cooking [136–138]. Open fire as a major source of indoor pollution has been shown to be associated with poorer cognitive function [139]. Therefore, when people move out of rural areas with these types of environmental exposures, they may protect their cognitive function in later life. However, there is some new evidence suggesting that exposure to air pollution such as particulate matter or traffic-related air pollution in urban areas may accelerate cognitive decline in older ages [140, 141]. As a result, people who move into cities may also face new environmental risk factors for cognitive decline. Research in this area is still in its infancy. Future research should investigate whether migration and cognition could be linked through changes in physical environment.

Underlying Factors

In addition to many factors that may change during the migration process, there are other time-invariant factors that may affect an individual's cognitive function. For example, early-life conditions, gender, and genetic factors may each affect cognitive function via various pathways.

Early-life conditions

Studies have shown that early-life exposures to negative events (e.g. hunger and malnutrition) are likely to increase the risk of cognitive decline [142, 143]. People who live in low- and middle-income countries are more likely to experience negative early-life exposures. Even people who survived such negative exposures (e.g. infectious diseases) during their childhood, show a higher risk for developing cognitive impairment later on than those who didn't experience negative exposures [144]. In addition, a parent's educational level has been shown to influence the trajectories of cognitive aging [145, 146]. Recent studies demonstrated that physical measures in early life such as birth length and head circumference are also associated with later-life cognitive function [142, 147]. It is possible that these measures indicate early brain development, which accounts for nearly 50% of a person's total cognitive ability [148].

Gender

Prior research has found that women reported worse cognitive function than men, especially in the oldest old age range [149, 150]. Gender is an underlying factor that influences the relationship between migration and cognitive function through several pathways. First, the migration patterns may differ between men and women. For example, in India, gender differences have been observed in the migration trends. In male populations, rural-to-urban migration is the largest stream (39.0%) and employment and education are the two main reasons for this type of migration [30]. However, in women, rural-to-rural migration is the predominant stream accounting for 70% of all the female migration, primarily for the purpose of marriage [29, 30]. Therefore, changes in SES between male and female migrants may be different due the reasons for migration and geographic patterns: in developing countries, men are more likely to experience upward social mobility [28], and ultimately have better cognitive function [149, 150].

Gender differences have also been found in changes in health behaviors. For example, research indicates that male immigrants are more likely to be adapted to westernized diets than their female counterparts [67, 71]. Additionally, the impact of migration on an individual's smoking behavior differs by gender, with male migrants less likely to smoke than females [66, 80]. As a result, the gender differences in health behaviors among migrants may produce different influences on later-life cognitive function.

Genetic factors

Research has established linkages between dementia and two genes—apolipoprotein E (APOE) and neuronal sortilin-related receptor (SORL1) [151–153]. Studies have shown that APOE $\epsilon 4$ increases the risk of dementia. However, the effect varies by sex, race/ethnicity, age, and geographic location [151, 154–157]. The SORL1 gene has been found as the second most important gene related to cognitive function [151, 158]. Studies that covered a broad range of locations and ethnicity groups have shown SORL1 is a risk gene in cognitive decline [151, 159, 160].

Conclusions

The association between migration and cognition is multi-dimensional and complex. This study identifies several pathways which potentially explain the linkages between migration and later-life cognitive function. An individual's cognitive function is associated with SES, psychosocial and behavioral factors, and physical and psychological health status. These factors mediate the relationship between migration and cognitive function. The migration process may lead to changes in SES, psychosocial and behavioral factors, and these changes will either positively or negatively influence an individual's cognitive function. Such

changes may also impact cognitive function indirectly by improving or harming an individual's physical and psychological health. Age at migration (or the length of stay in the new location) is associated with levels of change in SES, psychosocial and behavioral factors, and physical and psychological health status. Additionally, environmental factors may potentially mediate the relationship between migration and cognition. Underlying factors, such as an individual's early-life exposures, gender, or genetic factors, which will not change through migration, are also related to later-life cognitive function.

This conceptual framework has potential implications for clinical practice and global health policies. First, finding from this paper supports the trends towards 'needs based' rather than age-determined health and social services in countries with both large aging population and migrant populations. Both primary health care providers and policy makers should be aware that cognitive impairment/decline may be more commonly experienced in certain migrant populations. Therefore, it is crucial to promote early screening for potential cognitive impairment in clinical practice and making sure this practice covers these migrant populations.

In addition, factors that are identified in this framework that can potentially be used to design tailored interventions or programs to promote cognitive health. For example, migration can be a stressful event that may have negative impacts on individuals' psychological well-being. In this case, migrants might benefit from interventions such as community-based psychological services that help them cope with stress and improve mood. In addition to that, place-based social activities might be helpful to some migrants to expand their social networks, which might have positive impacts on their cognitive function. We also identified gender to be a potential underlying factor. This finding highlights the needs of designing and implementing programs to promote gender equality and to empower all women and girls in multiple aspects (the Sustainable Development Goal 5). Overall, one of the main outcomes of this paper is a conceptual framework of the potential mechanisms linking migration and cognitive function and related underlying factors. Using this framework, the relative importance of the identified pathways may be empirically refined, tested, and validated.

Abbreviations

APOE: Apolipoprotein E; SES: Socioeconomic status; SORL1: Neuronal sortilin-related receptor

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HX designed, drafted, and revised the text. AAV, ESM, MED, TO, and BW made critical revisions to the paper for significant intellectual content. All authors read and approved the final manuscript.

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