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Mobile Applications Aiming to Facilitate Immigrants' Societal Integration and Overall Level of Integration, Health and Mental Health: Does Artificial Intelligence Enhance Outcomes?

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## ABSTRACT

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# Mobile Applications Aiming to Facilitate Immigrants' Societal Integration and Overall Level of Integration, Health and Mental Health: Does Artificial Intelligence Enhance Outcomes?\*

Using panel data on immigrant populations from European, Asian and African countries the study estimates positive associations between the number of mobile applications in use aiming to facilitate immigrants' societal integration (m-Integration) and increased level of integration (Ethnosizer), good overall health (EQ-VAS) and mental health (CESD-20). It is estimated that the patterns are gender sensitive. In addition, it is found that m-Integration applications in relation to translation and voice assistants, public services, and medical services provide the highest returns on immigrants' level of integration, health/mental health status. For instance, translation and voice assistant applications are associated with a 4% increase in integration and a 0.8% increase in good overall health. Moreover, m-Integration applications aided by artificial intelligence (AI) are associated with increased health/mental health and integration levels among immigrants. We indicate that AI by providing customized search results, peer reviewed e-learning, professional coaching on pronunciation, real-time translations, and virtual communication for finding possible explanations for health conditions might bring better quality services facilitating immigrants' needs. This is the first known study to introduce the term 'm-Integration', quantify associations between applications, health/mental health and integration for immigrants, and assess AI's role in enhancing the aforementioned outcomes.

**JEL Classification:** O3, O31, I1, J15

**Keywords:** mobile applications, m-Integration, m-Health, artificial intelligence, integration, immigrants, refugees, health, mental health

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## 1. Introduction

Information and communications technologies (ICT) have become leading features of contemporary immigration waves (Opas and McMurray, 2015). The Oxford Dictionary of English (2010) defines technology as ‘the use of science in industry, engineering, etc., to invent useful things or to solve problems’, which captures how in the last decade industries and web science have been responding to increased immigration by developing specialized mobile applications to facilitate immigrants’ needs (Hendler and Mulvehill, 2016; Opas and McMurray, 2015; Hendler et al., 2008). Smartphones’ ability to access the internet and to provide applications make them computers in miniature (Rotondi et al., 2017; Zhang, 2015). Given the massive use of smartphones among immigrant populations, authors consider these technologies a ‘new ecosystem in a migrant’s life’ (St. George, 2017; Fortunati et al., 2013). For immigrants, smartphones have become a strategic tool for their needs, given the availability of applications which provide socialisation, communication, localization, information acquisition, distance learning, banking, and government services (Diminescu, 2020; Alencar, 2019; Rotondi et al., 2017; Miller et al., 2016; Gerlich et al., 2015; Jung, 2014; Panagakos and Horst, 2006).

In this study we utilize Sen’s (1999; 1992; 1985) capability approach framework to examine whether mobile applications aiming to facilitate immigrants’ societal integration (m-Integration) are associated with higher levels of societal integration, better health, and mental health status. We utilize three scales to measure immigrants’ outcomes. Ethnosizer scale is used to measure the intensity of an immigrant’s ethnic identity (Constant et al., 2009). EQ-VAS scale is utilized to provide a global assessment of individuals’ health (Priestman and Baum, 1976; McDowell, 2006). Moreover, CESD-20 scale is employed to measure depressive symptoms (Radloff, 1977; Van Dam and Earleywine, 2011). In addition, in the present study we examine whether m-Integration applications which are aided by Artificial Intelligence (AI) are associated with better integration, health, and mental health outcomes. The study utilizes data on the period between 2018 and 2019 for immigrant population groups from European, Asian and African countries who participate in language classes, free of charge, in Greece - a country which is perceived as a first-entry EU country for immigrants (World Health Organization, 2015). In this study, the term ‘immigrant’ is an umbrella term used to refer to people who live in a host country who might, or might not, have been granted a permit to live and work in the host country (Oxford Dictionary of English, 2010).

This research contributes to the field in several ways. The use of everyday mobile applications in immigrant population groups is still under-researched. In this study, we introduce the term ‘m-Integration’. The m-Integration framework is developed to form a vector of applications including, among others, m-Government, m-Learning and m-Health applications which

could be positively associated with immigrants' outcomes in relation to their levels of integration and health/mental health status (Bradley et al. 2017; Jones et al. 2017; Amante et al., 2015; Mosa et al. 2012). Most empirical studies assess how a certain application is associated with a corresponding outcome, i.e. m-Learning on human capital or m-Health on health (Devroey, 2018; Amante et al. 2015; Hamine et al. 2015; Mosa et al. 2012). Based on the nature of this study we indicate that m-Learning and m-Health could also be associated with immigrants' level of integration, since human capital, health and mental health are crucial determinants of integration (World Health Organization, 2018a; OECD, 2016; Aoki and Santiago, 2018; Clarke and Ispording, 2016; Giannoni et al., 2016; Malmusi, 2015; Drydakis, 2013; 2012a).

Furthermore, in the present study, we examine whether AI, part of each m-Integration application, could boost integration and health-oriented outcomes. There is limited research assessing AI's payoffs (Haleem et al., 2019; Yu et al., 2018; Hamet and Tremblay, 2017; Goksel-Canbek and Mutlu, 2016; Markowitz, 2013). Whether AI in mobile applications could provide better outcomes for immigrants' integration needs has not yet received significant empirical attention. In addition, most studies on immigrants' use of mobile applications have adopted a qualitative orientation approach utilizing relatively small samples (Bradley et al., 2017; Gillespie et al., 2016; Kukulska-Hulme et al., 2015; Alam and Imran, 2015). In this study a longitudinal data set has been utilized to offer better-informed evaluations (Morgan, 2013; Andreß et al., 2013). The literature has highlighted the difficulty of recruiting immigrant populations for longitudinal study designs (Keusch et al., 2019; Morville et al., 2015).

The study's outcomes will indicate that m-Integration applications in use, such as applications in relation to administration, public services, city transportation and maps, translation, voice assistants and mental health, are associated with enhanced levels of societal integration, good health and mental health. Policy makers and humanitarian organizations might have an interest to observe the study's implications in relation to the importance of digital literacy and its positive consequences for immigrants' integration and health/mental health status. Access to technology, connectivity and digital literacy might be a driver for immigrants' development in host countries. In addition, the study will present that m-Integration applications aided by AI are associated with increased levels of immigrant integration and a good health/mental health status. The assigned pattern might be of interest to technology professionals. It may be the case that AI features in m-Integration applications such as search engine and text analytics, speech recognition, pronunciation and translation, space and mapping and virtual communication, could be associated with a better match between immigrants' needs and outcomes.

In this study we indicate that if immigrants' integration has benefits, policy makers should consider which policies facilitate the process (Drydakís, 2012a). Exploring emerging practices such as m-Integration applications could be a way forward for Europe to administrate the increased immigration waves and benefit from integration's payoffs (Migration Policy Institute, 2014; Drydakís, 2013). In 2017 the estimated number of immigrants was 258 million people, almost double that of 2000 (United Nation, 2017). Social inclusion of immigrants is a priority in host countries given the positive effects which integrated immigrants can bring to society and the economy (United Nations, 2015; World Bank, 2013; Drydakís, 2013; 2012a). Acquisition of host country language skills and cultural understanding could increase the knowledge required to succeed in the host country, entailing increases in employment, entrepreneurship, innovation, income and health (World Health Organization, 2018a; Simon et al., 2015; Malmusi, 2015; Giannoni et al., 2016; Clarke and Isphording, 2016; Drydakís, 2013; 2012a). However, communication and civil participation barriers, poor health and a lower mental health status could reduce immigrants' integration and economic payoffs (Home Office, 2019; World Health Organization, 2018a; Puchner et al., 2018; Trummer and Krasnik, 2017; Clarke and Isphording, 2016; Giannoni et al., 2016, Malmusi, 2015). The present study adds to literature which indicates that mobile applications not only could empower individual users, but also could enrich their lifestyles and livelihoods, and boost the economy as a whole (World Bank, 2012).

The rest of the study is organized as follows. In the next section we offer a theoretical framework. In Section 3 we offer insights on immigrant populations in the subject country. In Section 4 we present the data gathering, and in Section 5 we present the variables. Then, in Section 6, we offer the descriptive statistics and in Section 7 we present the estimation strategy. In Section 8 we present the estimates and in the final sections (9 and 10) a discussion and conclusions are offered.

## **2. Theoretical considerations**

In this section, we define the m-Integration applications framework and we utilize Sen's (1999, 1992; 1985) capability approach theory to evaluate how m-Integration applications could facilitate immigrants' needs in relation to societal integration (*Section 2.1*). We evaluate how a vector of m-Integration applications, including administration, communication, information sharing, education and health applications, could boost immigrants' integration, health and mental health (*Sections 2.2 and 2.3*). Then, we discuss how m-Integration applications of AI could boost the aforementioned outcomes (*Section 2.4*).

### *2.1. M-Integration applications and capability approach*

The recent increase in immigration in Europe and the US has driven researchers to develop a plethora of specialized applications aiming to facilitate immigrant population groups' needs and boost their human capabilities (Greene, 2019; Alencar, 2019; World Health Organization, 2018a; OECD, 2016; Gaebel et al., 2016; Kukulska-Hulme et al., 2015; Moughrabieh and Weinert, 2016). Studies have shown that immigrants use smartphones and mobile applications in order to acquire information in relation to destinations, visas, legal rights, housing (Alencar, 2018; Díaz Andrade and Doolin, 2016), learn a language (Bradley et al., 2017; Rutkin, 2016; Kukulska-Hulme et al., 2015), access occupational and employment opportunities (Rutkin, 2016; Alam and Imran, 2015), maintain and build social networks (Alencar, 2019; Dekker et al., 2018; Gillespie et al., 2016; Tudsri and Hebbani, 2015; Alam and Imran, 2015; Leung et al. 2009), and to promote wellbeing needs (Moughrabieh and Weinert, 2016; Walker et al., 2015; Aitken and Gauntlett, 2013; Mosa et al., 2012).

In this study, we define m-Integration applications, an abbreviation of mobile integration applications, as the use of mobile applications to support immigrants' needs in relation to societal integration in host countries. We indicate that m-Integration applications aim to coordinate technology with a social policy agenda on integration and immigrant populations' needs. Integration touches upon the mechanisms that are supposed to promote smooth inclusion and development within a society, including public services, health care and well-being provision, language and employment programmes, and networking (United Nations, 2015; World Bank, 2013; Drydakis, 2013; 2012a). Integration is perceived as a two-way process in which host societies and immigrants work together to build sustainable communities (Drydakis, 2013). We argue that m-Integration applications might be able to facilitate integration given the provision of research-informed services from disciplines as diverse as public administration, legislation, education, health and mental health. We indicate that m-Integration applications capture multivariate relationships between technology and agents (i.e., governments, immigrants, society). M-Integration applications can be perceived as a vector of applications including, among others, m-Government, m-Learning and m-Health applications, which work to support newcomers.

We utilize Sen's (1999, 1992; 1985) capability approach to evaluate how m-Integration applications can facilitate immigrants' needs, and boost integration levels and well-being (Gigler, 2015). Sen's (1999) capability approach conceptualizes development as individual freedom (Kleine, 2013). Based on Sen (1999), capabilities are an individual's opportunity to achieve valuable kinds of functioning, which are defined as various things a person may value doing or being, such as identifying supporting mechanisms to access public services and find a job in a host country (St.



George, 2017; Alkire, 2005). Following Sen (1999), individuals who are free to choose should be able to maximize their capabilities, i.e. potential functioning, achieve a life of value and experience increased levels of well-being. Based on Sen (1985), the central characteristic of well-being should be a person's ability to achieve valuable functioning (Kleine, 2013; Sen, 1985).

We indicate that m-Integration applications could be considered as providing capability-enhancing freedom for immigrants. Mobile applications have been found to offer possibilities for immigrants' communication and information-gathering in a plethora of domains including public services, employment, health and education (Alencar, 2018; St. George, 2017; Díaz Andrade and Doolin, 2016; Kleine, 2013; Bert et al., 2014; Benton, 2014). M-Integration applications allow immigrants to use voice assistants and translation platforms, facilitating interactions and acquiring information, allowing online language training to be accessed at anytime and anywhere and facilitating communication skills, providing electronic access to public services and overcoming language barriers, facilitating the reduction of participation barriers, and providing health and mental health information (Migration Policy Institute, 2014). For immigrants, m-Integration applications are critical tools and constant companions before the initiation of their journeys, during their journeys, and upon arriving in the desired host country (Kukulska-Hulme, 2019; Alencar, 2018; Díaz Andrade and Doolin, 2016; Kukulska-Hulme et al., 2015; Komito, 2011).

Based on the capability approach framework (Sen, 1985) m-Integration applications may be able to increase integration, and boost development and well-being (Zheng and Walsham, 2008). Andrade and Doolin (2016) indicate a variety of categories of achieved types of functioning and their corresponding capabilities that m-Integration applications might provide to immigrants, such as participating in the information society, communicating effectively through translation devices and m-learning, understanding a new society and establishing a legal identity, being socially connected, and expressing a cultural identity. Gigler (2015) evaluates that the applications included in the m-Integration applications vector could be positively associated with immigrants' self-esteem, socialization, ability to find a job and integration into society.

In this study, we hypothesize that m-Integration applications could turn information, knowledge and provided services into learning decisions for value actions (St. George, 2017; Gigler, 2015; Heeks, 2002). Subsequently, enhanced informational capabilities might be associated with increased levels of integration, health and mental health (St. George, 2017; Gigler, 2015; Zheng and Walsham, 2008; Heeks, 2002). The extent to which m-Integration applications increase immigrants' informational capabilities could determine their associations with levels of integration and well-being (World Health Organization, 2018a; St. George, 2017; OECD, 2016; Gigler, 2015; Heeks, 2002).

## *2.2. M-Integration applications in relation to public services, communication and education*

The development of mobile applications has created new opportunities for governments mostly applied to mediate public services with citizens' needs (Sharma et al., 2018; Ganapati, 2015). M-Government applications provide interactive and transactional services which can be accessed anytime and anywhere (Sharma et al., 2018; Nixon, 2016; Abaza and Saif, 2015; Ganapati, 2015). Through m-Integration applications immigrants are able to overcome face to face language barriers and proceed with visa requirements, health cards and driving license applications (Mancini et al., 2019). Díaz Andrade and Doolin (2019; 2016) evaluated that mobile applications can boost immigrants' opportunities to exercise their agency and achieve improvements in their well-being that enhance their participation in society and control over their circumstances.

For immigrants, communication and information sharing through m-Integration applications stimulate sensations such as confidence, enthusiasm, energy, joy, hope, relaxation, reassurance and security (Diminescu, 2020; Greene, 2019; Alencar, 2019, Twigt, 2018; Díaz Andrade and Doolin, 2016; Witteborn, 2015; Marino, 2015; Leung, 2011; Komito 2011). In Germany Keusch et al. (2019) and in Italy St. George (2017) evaluated the psychological importance to immigrant populations of being connected and online with their families and networks in their countries of origin, as well as in their host countries. In Turkey, Greece, Germany and the Netherlands Zijlstra and van Liempt (2017) found that smartphones enable immigrants to become more self-reliant due to providing access to important information. Moreover, in China Nie et al. (2020) found an association between smartphone use and increases in both life satisfaction and happiness.

M-Learning has been utilized to relate education to immigrants' physical contexts in a process of providing them with access to location-specific language materials such as expressions that could be useful in everyday interactions (Godwin-Jones, 2018; Brooker et al., 2017; Andrade and Doolin, 2016; Jarvis and Orr, 2016; Gillespie et al., 2018; Pegrum, 2014; Kukulska-Hulme, 2009). In the UK, Spain and Austria Kukulska-Hulme et al. (2015) found that language applications supported immigrants' personalized learning (Kukulska-Hulme et al., 2015). M-Learning applications have been found to foster language learning, better speech flow and intonation, self-confidence in speaking and skills development that allowed for a faster integration of immigrants in host countries (Mancini et al., 2019; Dahya and Dryden-Peterson, 2017; O'Mara and Harris, 2016; Tudsri and Hebbani, 2015). In Sweden, Bradley et al. (2017) found that pronunciation applications were useful for immigrants to excel in language learning. In Korea, Kim and Lee (2014) found that foreign language-based applications were facilitated immigrants acquiring knowledge and information to live an independent life in Korea. In Denmark, Gough and Gough (2019) evaluated the positive role of smartphones as translation devices. Moreover, in the UK, Jones et al. (2017)

indicated that m-Learning applications supported immigrants' language learning. In the same time, international studies indicated the importance of language learning for immigrant population groups (Aoki and Santiago, 2018; Clarke and Isphording, 2016). For instance, language barriers and limited literacy skills could have negative impacts on immigrants' well-being (Aoki and Santiago, 2018; Clarke and Isphording, 2016; Eichler et al. 2009; De Walt et al. 2004). Clarke and Isphording (2016) evaluated that language proficiency could affect the access to inputs into health production such as access to jobs that pay higher wages and involve greater well-being standards and safety. Language facilitates access and use of public services, such as those related to healthcare and education, which can impact on educational achievements, level of social integration and well-being (Aoki and Santiago, 2018; Drydakis 2013; 2012a).

Thus, in this study, based on the literature surveyed, we hypothesize that m-Integration applications, such as public administration, communication, information and language-learning applications, could support and enhance immigrants' human, social and informational capabilities, which might be associated with increased levels of societal integration and better health/mental health statuses (Kukulska-Hulme et al., 2015; Duman et al., 2015; Burston, 2013).

### *2.3 M-integration applications in relation to health and mental health*

Researching health-related information on the internet has become a common practice among the general public (Beck et al., 2014; World Health Organization, 2011). In the US, Bauer et al. (2014) found that 35.5% of smartphone patients sought health information from their smartphones, 22.0% accessed an m-Health application, and 20.8% tracked or managed health conditions via mobile devices. In Belgium, Mutebi and Devroey (2018) estimated that 41% of their study's participants used m-Health applications for general health check-ups, and 18% for follow-up of chronic illnesses. Gallup (2018), utilized data for 142 countries and found that mobile phone ownership supplemented with internet access was associated with an improvement in average life evaluations and net positive emotions. Mobile technology's mobility, instantaneous access, and direct communication allow for faster transfer of health information, which in turn could support health practices (World Health Organization, 2011; Lim et al., 2011). M-Health applications may improve patient-provider communication and assistance in disease management, disease prevention, diagnosis, treatment, and monitoring (Bennion et al., 2019; Chandrashekar, 2018; Marcolino et al., 2018; Meskó et al., 2017; Whittaker et al., 2016; Mohapatra et al., 2015; Hamine et al., 2015; Hall et al., 2014; Mosa et al. 2012). Ghahramani and Wang (2019) found that US smartphone users tracking health information experienced better quality of life. Marcolino et al.'s (2018) literature

review study indicated that a beneficial impact of m-Health applications was observed in chronic disease management, improved heart failure symptoms, reduced blood pressure in hypertensive patients' reduced weight in overweight and obese patients, and reduced deaths and hospitalization. Wattanapisit et al. (2020) indicated that m-Health applications have the potential to replace some GP practices such as taking medical histories and making a diagnosis, performing some physical examinations, supporting disease-specific care, and performing health promotions.

M-Health applications can positively impact patients who are less inclined to engage with traditional health services and those who do not have access to health care services, and reduce the burden of diseases linked to poverty (Amante et al., 2015; Hamine et al., 2015; Carter et al., 2015; Gurman et al., 2012; Donner, 2008). A review study by Kim and Xie (2015) found that touchscreen-based applications facilitated users with low health literacy to achieve understanding of and education about medical treatments. Also, Aboueid et al. (2019) found that individuals who do not have access to health care and perceive themselves as having a stigmatizing condition were more likely to use m-Health applications for self-diagnosis.

In relation to m-Mental health applications, these cover many stages of clinical care provision such as crisis intervention, prevention, diagnosis, primary treatment, supplementing in-person therapy, and post-treatment condition management (National Institute of Mental Health, 2017; Price et al., 2014). Studies have found that mobile technology provides tools to enhance treatment for mental health concerns (Nie et al., 2020; Goodwin et al., 2016; Anthes, 2016; Kolar et al., 2016; Yuan et al., 2015; Sagar and Pattanayak, 2015; Gajecki et al., 2014; Donker et al., 2013; Mosa et al., 2012; Reid et al., 2011). A meta-analysis concluded that using applications to alleviate symptoms and self-manage depression significantly reduced patients' depressive symptoms (Firth et al., 2017). A systematic review on using smartphone applications for treating symptoms of schizophrenia demonstrated broad-ranging clinical benefits (Firth, et al., 2017). Moreover, a review study evaluated that, overall, m-Mental health applications were reported to be beneficial for adolescents (Gindidis et al., 2019). M-Mental health applications allow for so-called 'anywhere, anytime' access and it is indicated that they reduce the stigma associated with seeking face-to-face consultation (Jones and Moffitt, 2016). Moreover, m-Mental health applications reach population groups who might otherwise not have access to mental health or other clinical care (Ryan and Lewis, 2015; Dahl and Boulos, 2013; Cahill et al., 2007).

Mucic (2010) evaluated that immigrants occasionally experience difficulties in accessing health services tailored to their needs. Carroll et al. (2017), Talhouk et al. (2016) and Gaebel et al. (2016) indicated that smartphones could enable immigrants to facilitate their access to healthcare. There are m-Health applications, tele-intensive care units, and cloud-based electronic medical and

medication administration records that are provided in immigrants' own languages, are easily accessible, guarantee anonymity and are free of charge (Gaebel et al., 2016; Moughrabieh and Weinert, 2016). Also, there are applications which send people on the move alerts in different languages about medical assistance in their destination country (Rutkin, 2016).

Mobile applications which can be used totally or partially offline, in situations of limited connectivity, which are shorter than the traditional ones, and partially automated allow for a widespread access by immigrants and help them to monitor their symptoms, to learn and practice some useful skills, to be educated about their conditions, and to practice in scenarios relevant to their recovery plan (Sandoval et al, 2017; Tomita, 2016). A review study indicated that there are some promising results of digital interventions for improving the quality of life and preventing some mental disorder relapse for immigrants with mental health issues (Liem et al., 2020). Immigrant population groups reported satisfaction and positive attitudes toward applications of digital health in mental health care, and positive improvement on their anxiety, depression, and post-traumatic stress disorder symptoms (Liem et al. 2020). In addition, studies found that m-Health and m-Mental health applications supported immigrants' well-being, empowerment and self-affirmation (Mancini et al., 2019; Rae et al., 2018; Leurs, 2017; Witteborn, 2015).

In this study, we hypothesize that m-Integration applications in relations to health and mental health could enhance informational capabilities associated with increased levels of health/mental health and societal integration (World Health Organization, 2018a; St. George, 2017; Gigler, 2015; Simon et al., 2015; Heeks, 2002). We argue that using health and mental health-oriented applications might encourage immigrants to engage in more informed actions, possibly adding to general health and societal integration (Ghahramani and Wang, 2019; Marcolino et al., 2018; OECD, 2016; Hamine et al., 2015; Carter et al., 2015; Pandey et al., 2013; Katz, 2008; Kim, 2008; Dutta-Bergman, 2004).

#### *2.4 M-Integration applications of artificial intelligence*

AI systems aim to think humanly and act humanly with the ultimate goal of obtaining rational outcomes (Van Roy et al., 2020; European Commission, 2020; Ertel, 2018; Russell and Norvig, 2016). AI is associated with attempts to imitate and surpass humans' natural intelligence (i.e., learning, understanding, reasoning and/or interacting) through rational and logical calculations (Van Roy et al., 2020; Ertel, 2018; OECD, 2017; Russell and Norvig, 2016). An AI system consists of three main elements: sensors, operational logic, and actuators. Sensors collect raw data from the environment, operational logic provides output for the actuators, and actuators act to change the

state of the environment by providing predictions, recommendations or decisions (OECD, 2019). From an economic point of view AI either decreases the costs of prediction or improves the quality of predictions available at the same cost (OECD, 2019). AI applications in public administration, education, and healthcare have been found to improve the life quality for the citizens and efficiency of governance (Sharma et al., 2020; Kankanhalli et al., 2019; Marda, 2018).

Mobile applications aided by AI enable users to access customized information and services 24/7 (Esmailzadeh, 2020; Goksel-Canbek and Mutlu, 2016; Castro and New, 2016). AI mobile applications enable communication development between users and their devices (Goksel-Canbek and Mutlu, 2016). AI assistants use cognitive computing technologies for storing initial information and preferences, performing actions and offering services (Briganti and Le Moine, 2020; Goksel-Canbek and Mutlu, 2016; Hauswald et al. 2015).

M-Learning applications aided with AI are used for self-learning a foreign language and can improve listening and speaking skills of the learners (Goksel-Canbek and Mutlu, 2016; Markowitz, 2013; Miangah and Nezarat, 2012). AI in translation, language education and speech assistants offers real-time translations of whole sentences, natural speech, professional coaching on pronunciation and peer reviewed e-learning guidance (Goksel-Canbek and Mutlu, 2016; Markowitz, 2013; Miangah and Nezarat, 2012).

Studies evaluated the positive impact of AI in medicine (Yu et al., 2018; Hamet and Tremblay, 2017), as well as on population and personalized health (Shaban-Nejad et al., 2018). Healthcare data are analyzed by using AI techniques such as machine learning, deep learning and natural language processing to achieve better patient education, prevention and checkup, diagnosis, medical record, predictive modeling, decision support and treatment outcomes (Esmailzadeh, 2020; Sim, 2019; Haleem et al., 2019; Shaban-Nejad et al., 2018; Briganti and Le Moine, 2020; Jing et al., 2017). AI assistants in m-Health applications learn from historical examples, analyze data, and provide the most appropriate therapeutic program (Lo et al., 2018; Lawton et al., 2018; Halcox et al, 2017). For instance, Lo et al. (2018) demonstrated the positive effects of using m-Health applications of AI to provide personalized therapeutic exercise programs to self-manage chronic neck and back pain. In addition, m-Health applications of AI are more likely to identify atrial fibrillation than routine care (Halcox et al, 2017), and can enable patients to optimize their blood glucose control and reduce stigma associated with hypoglycemic episodes (Lawton et al., 2018).

M-Integration applications of AI, in relation to interactivity with host government, availability of education and linguistic resources, communicability with home country,

connectedness with public population and accessibility to information, can improve efforts to assist displaced people, or to liberate them in being more able to help each other, or both (Bock et al., 2020, AbuJarour et al., 2019; Fernandez-Luque and Imran 2018; Castro and New, 2016). M-Health applications of AI designed for immigrants use natural language processing to enable conversations with users via text message (Castro and New, 2016). These applications analyze immigrants' emotional states and provide recommendations which can help improve their mental health (Castro and New, 2016). In addition, AI applications have been found to provide an early warning system for communicable diseases in immigrant populations by incorporating AI driven meta data with real time immigration statistics and regional infectious disease prevalence (Jarral et al., 2020). Vulnerable populations can look for health symptoms, while affected people can ask treatment-related questions (Fernandez-Luque and Imran, 2018). Occasionally immigrants found to prefer multi-adaptive psychological screening software with voice output and translation features over meeting mental health professional directly (Liem et al., 2020).

Based on the available studies we hypothesize that m-Integration applications of AI, including m-Government, m-Learning and m-Health, might improve the quality and accuracy of services and create a better match between immigrants' needs and the services provided, leading to greater valuable informational capabilities and outcomes (Bock et al., 2020; Esmaeilzadeh, 2020; Sim, 2019; Sharma et al., 2020; Kankanhalli et al., 2019; Sim, 2019; Haleem et al., 2019; Marda, 2018; Goksel-Canbek and Mutlu, 2016; Castro and New, 2016). Successful outcomes can take the form of information and services relevant to immigrants' needs, customised recommendations on visa and citizenship application processes, interactive language learning, virtual communication for finding possible explanations for illnesses, health, emotional and psychological support, which can increase their societal integration and health/mental health outcomes (Bock et al., 2020, AbuJarour et al., 2019). Some examples of relevant m-Integration applications of AI in education, translation, networking, employment opportunities and health information are: Doctor-X, edSeed, InfoAid, Integreat, Karim, Love-Europe, Mapp, MedShr, PLACE, Rafiqi, RefAid, RefugeeEd.Hub, Refugee.Info, SchoolX, Shifra, SPEAK, TaQadam, w2eu.

### **3. Immigrants in Greece**

Studies on immigrants' realities in Greece have mainly focused on acculturation policies (Drydakis, 2013; 2012a), employment (Drydakis, 2017; Drydakis and Vlassis, 2010) and health status (Gkiouleka et al., 2018; Stathopoulou, 2018). The 2011 Greek census data registered 11.1 million people, 8.3% of whom were immigrants (6.5% non-EU nationals and 1.8% EU-nationals).

Since the beginning of 2014 more than a million immigrants have arrived in Greece from Turkey (Operational Portal Refugee Situations, 2018). However, due to the Greek economic crisis, increased unemployment and poverty the majority of immigrants have relocated to Germany and Sweden (Eurostat, 2018; United Nations High Commissioner for Refugees, 2018).

Greek studies have found that immigrants and second-generation immigrants experience higher unemployment, lower income, and higher poverty rates than natives (Gemi and Triandafyllidou, 2018; Cavounidis, 2018; Drydakis, 2017; 2012a; Drydakis and Vlassis, 2010). In 2008 it was estimated that the risk of poverty for immigrants was 32%, compared to 19% for Greeks. However, in 2016 the risk of poverty was 41% for immigrants and 19% for Greeks (Cavounidis, 2018). In Greece, immigrants were found to experience labour and housing discrimination (Drydakis, 2010; 2011; 2012b; Drydakis and Vlassis, 2010). Greek studies have found that integration can boost immigrants' employment levels and wages (Drydakis, 2013; 2012a). The determinants of immigrants' integration in Greece are being of a young age, being a man, having higher education, having knowledge of the English language, being a Christian, and having a longer stay in Greece (Drydakis, 2012a; 2013). Deteriorated health seems to lead to separation for immigrants (Drydakis, 2013). In addition, Greek studies suggest that financial strain and childhood experiences of economic hardship, as well as experiences of perceived discrimination, appear to be associated with increased levels of depressive symptoms for immigrants, while social trust has a protective impact (Gkiouleka et al., 2018; Stathopoulou, 2018).

#### **4. Data gathering**

Studies have found that learning a host country's language is a vital need for immigrants in order to smoothly integrate into a new society (Drydakis, 2012a; 2013). In Greece ministries, non-governmental organizations, and immigrant and humanitarian centres provide language programmes for newcomers (European Commission, 2016; Brinia and Tsaprazi, 2015; Mattheoudakis, 2005). The language courses aim to train adult immigrants to communicate in both speech and writing (Brinia and Tsaprazi, 2015; Mattheoudakis, 2005). Participation in these courses is high and immigrants become aware of the provided programmes through their networks (Brinia and Tsaprazi, 2015; Mattheoudakis, 2005).

In early 2018 the research team for this study identified through an internet search bodies offering Greek language courses, free of charge, to adult immigrants in the Attica region of Greece, which compasses the entire metropolitan area of Athens and has a population of 3.8 million people (or, one third of Greece's population). Thirty bodies were identified offering relevant programmes.



The bodies were governmental and non-governmental organizations and centres working on immigration, immigrants' issues and integration. In each piece of correspondence, the research team provided opening letters introducing the aim of the study, participation information sheets and a sample questionnaire. The opening letter kindly requested that an appointment be arranged with the bodies so that the research team could present the study's aims. The forms informed the directors that the study was aiming to collect information on immigrants' socioeconomic characteristics, conditions of employment, and health indicators. It was stated that the scope of the initial meeting would be to clarify the ways the team would handle the data gathering during a teaching hour. Also, the aim of the meeting was to clarify how the research team would minimize any potential risk to both the bodies and immigrants by securing anonymity, and to alleviate any concerns.

Six bodies expressed an interest in facilitating the survey and formal meetings took place. The research team asked for permission to visit each language class twice, aiming to collect information from the same class in 2018 and 2019. Each immigrant was to be approached twice and the team was to create a data set consisting of longitudinal information. The team was informed that two courses were being run, for beginners and for those having basic knowledge. It was decided to work with beginners. In the six bodies the duration of the language classes was between 9 and 10 months. Two courses were planned to start in September 2018, and the rest were planned to start in October 2018. The first data gathering took place in November 2018, and the second in May 2019.

The questionnaire was provided in both Greek and each student's native spoken language. Before the data gathering started the team was made aware of the mother-tongue languages in each class in order to provide translated versions of the various papers<sup>1</sup>. The team distributed the survey to the students. The questionnaires were short, and less than 20 minutes were required for participants to complete them. In a few cases students were illiterate. Within each body literate ethnic people supported those in need with completing the survey. Directors had provided us with relevant information and the team was aware of individual needs.

## **5. Questionnaire and variables**

In the questionnaires information relating basic demographics was included, such as gender, years of age, higher or vocational education and employment status. Questions on continent of

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<sup>1</sup> The participants were from the following countries Afghanistan, Albania, Algeria, Armenia, Bulgaria, Congo, Egypt, Ethiopia, Georgia, Ghana, Iran, Iraq, India, Moldova, Nigeria, Pakistan, Philippines, Russia, Syria, and Turkey.

origin, years of immigration in Greece and refugee status<sup>2</sup> were included as well. Questions asked also whether the participants owned a mobile phone, as well as whether or not their mobile phone was a smartphone.

Smartphone owners were given a list of 10 general categories of services provided by smartphone applications developed to support immigrants' societal integration. Participants were asked to select those that applied to their case. The question read: 'If you are a smartphone owner please select from the following list the services provided by applications you might have used/currently used. Select as many services as apply to you. Tick the corresponding box in the following list to indicate your answers. List of application services regarding: Public services, Local news in relation to immigration, Legal services, Housing and accommodation services, Employment and access to jobs services, City transportation and maps services, Languages education, Translation and voice assistants, Medical services, Mental health services.'

To get further insights into the applications in use participants were asked to check their smartphones and name the actual applications. The question read: 'Given the answers in the previous question (list of application services), please check your smartphone device, identify the actual applications which provide the services you have selected in the list, and add the names of the applications in the corresponding boxes'. Examples and guidelines were provided to the participants to facilitate their task. Once the data gathering was completed the research team, in collaboration with professional IT technicians, screened the answers and classified each named application as aided or not aided by AI. The minimum level of AI features per application to be considered in the AI category was at least one AI system in relation to search engine and text analytics, voice including speech recognition, predictive text, pronunciation and translation, location and mapping, automated chat, virtual communication including individual engagement without any human involvement.

Given the aforementioned list of application services two variables were created. The continuous variable, entitled 'm-Integration applications in use', was created by summing the number of applications in use per immigrant that were aiming to support societal integration. Higher scores should indicate an increasing number of relevant applications in use. In addition, the continuous variable entitled 'AI m-Integration applications in use' was created by summing the number of applications in use per immigrant aiming to support their needs and aided by AI. Higher

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<sup>2</sup> In this study, a refugee status was captured if an immigrant had been forced to leave their country or home, because there was a war or for political, religious, or social reasons (Oxford Dictionary of English, 2010).

scores should indicate an increasing number of relevant m-Integration applications in use aided by AI.

In the questionnaire, immigrants' level of integration was captured by utilizing the Ethnosizer inventory (Constant and Zimmermann, 2008; Constant et al., 2009) adapted to a Greek context (Drydakís, 2012a; 2013). According to Berry (2006) an immigrant who holds on to some aspects of her own culture, and at the same time tries to melt into the new cultural environment, is considered to have an integrated identity. The integration questionnaire (Ethnosizer) included five direct questions regarding immigrants' personal devotion to their host country and commitment to the culture of their origin by combining information on language, cultural habits (such as food, media, music and reading), self-identification, social interaction, and future citizenship plans (Drydakís, 2012a; 2013; Nekby and Rodin, 2010; Constant and Zimmermann, 2008). Taking into account the five questions, the integration variable could equal  $x$  if the options corresponding to integration were chosen  $x$  times (Constant and Zimmermann, 2008). Higher scores indicate increasing levels of immigrant integration (Constant and Zimmermann, 2008). Studies report high levels of replicability for the Ethnosizer inventory (Drydakís, 2012a; 2013).

To capture health status, the questionnaire included the EuroQol-Visual Analogue Scale (EQ-VAS) (McDowell, 2006; Priestman and Baum, 1976). The scale is utilized as a means of summarizing overall health status in a way closer to an individual's own perspective (Feng, 2014). The inventory measures individuals' self-rated health on a vertical, visual analogue scale where the endpoints are labelled 'Best imaginable health state' and 'Worst imaginable health state' (McDowell, 2006; Priestman and Baum, 1976; Aitken, 1969). Higher scale scores suggest increasing levels of good quality of health and life (McDowell, 2006), and the literature indicates high levels of validity (Feng, 2014; McDowell, 2006). The EQ-VAS scale correlates well with other general health status scales such as the SF-36 dimension on general health (Lubetkin et al., 2004). Also, the EQ-VAS scale has demonstrated construct validity in representative samples of the Greek general population (Kontodimopoulos et al., 2008).

In addition, the questionnaire included the Center for Epidemiological Studies' Depression Scale (CESD-20) (Radloff, 1977) in order to capture adverse mental health symptoms. The scale is a 20-item self-report depression inventory including questions such as 'I felt depressed, everything I did was an effort, I could not get going in the past week'. The CESD-20 scale has been found to have good psychometric properties (Van Dam and Earleywine, 2011; McDowell, 2006). Higher scale scores indicate increasing levels of depression (McDowell, 2006). The scale has demonstrated validity in representative Greek samples (Drydakís, 2015a).

## 6. Descriptive statistics

In Table 1 we present the descriptive statistics. In Panel I we present data for 2018, in Panel II we present data for 2019, and in Panel III we have pooled data (2018 and 2019). In Panel III we observe that 65.4% are men, the mean age is 31.6 years, 9.7% have higher or vocational education and 65% are employed. It is observed that 35.1% of the population self-identifies as refugees. In relation to country of origin, the majority are from Asian countries (54.9%). The rest are from European countries (25.5%) and African countries (19.4%). The population in this data set has been living in Greece for approximately 2.7 years. It is found that all participants have a mobile phone and that 67.8% of the participants own a smartphone and the rest own a non-smartphone. In addition, it is reported that those owning a smartphone utilized, on average, 1.1 m-Integration applications. Moreover, it is observed that the integration (Ethnosizer) index equals 2.45. The health status (EQ-VAS) index is measured at 65.0 and the adverse mental health symptoms (CESD-20) index equals 15.4.

[Table 1]

In the Appendix we provide insights on the m-Integration applications in use. In Panel I we present data for 2018, in Panel II we present data for 2019, and in Panel III we have pooled data. In Panel III, it is observed that, in 57.7% of the cases, smartphone owners have used at least one m-Integration application, whilst in 42.2% of the cases they have not used any m-Integration applications. It is found that 8.6% have used one m-Integration application, 16.8% have used two m-Integration applications, and 15.4% have used three m-Integration applications. No one has used more than seven m-Integration applications. In addition, in Panel III it is observed that 53.1% of the smartphone owners utilize translation and voice assistant applications, followed by 26% using local news applications relating to immigration, 24.4% utilizing public services applications, and 11.9% using medical applications. Moreover, in Panel III, it is observed that in 60.1% of the cases m-Integration applications in use are aided by AI. We observe that the m-Integration applications most often aided by AI are voice assistant applications (71.2%), followed by legal services applications (66.6%), medical applications (63.8%), housing and accommodation services applications (57.8%) and local news relating to immigration applications (57.2%).

Table 2 reports data on smartphone owners. In Panel III, it is observed that the higher the number of m-Integration applications in use the higher the level of integration, good health and mental health status. For instance, if immigrants do not use any m-Integration applications the level of integration equals to 2.57. However, if they use two m-Integration applications the level of

integration is 2.59. Also, if they use four m-Integration applications then the level of integration equals to 2.88.

[Table 2]

In Table 3 we offer the correlation matrix for those owning a smartphone. The number of m-Integration applications in use is found to be positively associated with the level of immigrants' integration ( $r= 0.32, p<0.01$ ) and health status ( $r= 0.69, p<0.01$ ), and negatively associated with adverse mental health symptoms ( $r= -0.61, p<0.01$ ).

[Table 3]

In Table 4 we offer the correlation matrix for those owning a smartphone and using m-Integration applications. The correlation outcomes indicate that the number of m-Integration applications in use aided by AI is positively associated with immigrants' level of integration ( $r= 0.28, p<0.01$ ) and health status ( $r= 0.58, p<0.01$ ), and negatively associated with adverse mental health symptoms ( $r= -0.50, p<0.01$ ).

[Table 4]

## **7. Estimation strategy**

Random effects models (Morgan, 2013; Andreß et al., 2013) are utilized to evaluate the study's objectives. In Model I, to evaluate the relationship between the number of m-Integration applications in use and immigrants' integration, health and mental health, the sample is restricted to smartphone owners. In Model II, to examine the relationship between the number of AI m-Integration applications in use and immigrants' integration, health and mental health, the sample is further restricted to smartphone owners using m-Integration applications. Each model controls for the data gathering period (2018 versus 2019), school effects, immigrants' gender, age, higher or vocational education, refugee status, years of immigration in Greece, continent of origin, and employment status.

In Model I, positive and statistically significant m-Integration application estimates will suggest positive associations between the number of m-Integration applications in use and better integration, health and mental health outcomes. Similarly, in Model II, positive and statistically significant AI m-Integration applications in use estimates will indicate positive associations between the number of AI m-Integration applications in use and better integration, health and mental health outcomes. If the estimates remain statistically significant in each model, where

heterogeneous sub-samples are utilized, this pattern might indicate that the estimated patterns are robust across sub-populations. In addition, if the estimates are statistically significant in each model, given the various controls, then this feature might indicate that the empirical specifications are not sensitive due to some unobserved factors related to m-Integration application in use fluctuations.

In addition, we run Heckman models (Heckman, 1976; 1979) to control for sample selection in Model I and Model II. The new estimates are supposed to capture unobserved factors which could increase the likelihood of (i) having smartphone ownership and being in better health/mental health and more integrated, and (ii) using m-Integration applications and being in better health/mental health and more integrated. Of further interest is an examination of whether the estimates are gender sensitive. Interaction effects between m-Integration applications in use and gender are included in Model I (Drydakis, 2015b). Similarly, interaction effects between AI m-Integration applications in use and gender are included in Model II. Finally, we examine how each one of the ten m-Integration application services might be associated with immigrants' level of integration, health and mental health status. The ten m-Integration applications are included in Model I and the research question is assessed.

In this study, by employing panel data we might be able to capture changes in immigrants' responses and control for potential reverse causality such as from a greater level of integration and health/mental health to higher levels of smartphone ownership (Morgan, 2013; Andreß et al., 2013; Menard, 2008). In addition, since information on employment status is included in Model I and Model II, we might be able to control for relevant spurious relationships and key unobserved heterogeneity (Andreß et al., 2013; Menard, 2008). It is the case that employment could determine the level of income, smartphone ownership, integration and general well-being (World Health Organization, 2018a; Aoki and Santiago, 2018; Clarke and Ispording, 2016; OECD, 2016; Drydakis, 2015a; Drydakis, 2012a; 2013). In addition, each model also controls for the period of data gathering (i.e., 2018 versus 2019). If in the second period (i.e., 2019) immigrants are more integrated and healthier, affecting the key variables of interest, then this pattern should be captured by the empirical specification. However, given the fact that some key information is not captured in this sample, such as family income, pro-immigration socioeconomic conditions, lived experiences during the immigration journey and personality traits, the patterns to be presented in the next section should be interpreted as associations and not as causal effects (Rotondi et al., 2017).

## 8. Regression outcomes

### 8a. Integration (Ethnosizer) estimates

The integration estimates are presented in Table 5. In Model I, a positive association is observed between the number of m-Integration applications in use and level of integration (0.108,  $p < 0.01$ , or 6.9%). Regarding the rest of the covariates, it is estimated that there is a negative association between the first data gathering period and integration (-0.041,  $p < 0.05$ , or -0.8%), and a positive association between immigrants' years of age and integration (0.012,  $p < 0.05$ , or 15.1%).

[Table 5]

In Model II, it is found that there is a positive association between the number of AI m-Integration applications in use and level of integration (0.038,  $p < 0.10$ , or 2.7%). In addition, it is estimated that there is a positive association between non-refugee status and integration (0.191,  $p < 0.05$ , or 5.2%).

### 8b. Health status (EQ-VAS) estimates

In Table 6 we report the health status estimates. In Model I there is a positive association between the number of m-Integration applications in use and health status (2.118,  $p < 0.01$ , or 5.3%). Also, there is a positive association between health status and being a man (3.198,  $p < 0.01$ , or 3.6%), non-refugee status (3.321,  $p < 0.01$ , or 3.5%) and employment (3.423,  $p < 0.01$ , or 3.5%).

[Table 6]

Moreover, in Model II it is estimated that there is a positive association between the number of AI m-Integration applications in use and health status (1.934,  $p < 0.01$ , or 5.3%). A positive association is found between health status and being a man (4.946,  $p < 0.01$ , or 5.5%), non-refugee status (4.303,  $p < 0.05$ , or 4.6%) and employment (4.965,  $p < 0.01$ , or 5.2%).

### 8c. Adverse mental health status (CESD-20) estimates

Table 7 presents the adverse mental health status estimates. In Model I, a negative association is reported between the number of m-Integration applications in use and adverse mental health status (-1.181,  $p < 0.01$ , or -15.4%). The rest of the estimates indicate that there is a positive association between the first data gathering period and adverse mental health (0.469,  $p < 0.05$ , or 1.7%). Furthermore, we observe a negative association between adverse mental health symptoms and

being a man (-2.858,  $p < 0.01$ , or -15.4%), years of age (-0.073,  $p < 0.05$ , or -17.9%), years of immigration in Greece (-0.429,  $p < 0.10$ , or -9.3%), non-refugee status (-2.073,  $p < 0.01$ , or -10.9%), and employment (-1.763,  $p < 0.01$ , or -9%).

[Table 7]

In Model II, a negative association is reported between the number of AI m-Integration applications in use and adverse mental health status (-1.042,  $p < 0.01$ , or -16.2%). Furthermore, a negative association is found between adverse mental health status and being a man (-4.559,  $p < 0.01$ , or -28.7%), years of immigration in Greece (-0.556,  $p < 0.05$ , or -14.5%), non-refugee status (-3.377,  $p < 0.01$ , or -20.5%) and employment (-3.323,  $p < 0.01$ , or -19.6%).

#### 8.d Sample selection

In Sections 8a-8c we examined associations between the number of m-Integration applications in use and the level of immigrants' integration, health and mental health by restricting the sample to smartphone owners. Running Heckman models (Heckman, 1976; 1979) to control for potential sample selection the presented outcomes (in Sections 8a-8c) are found to be held. Associations are estimated between the number of m-Integration applications in use and increased levels of integration (0.082,  $p < 0.01$ , or 4.6%), better health (2.203,  $p < 0.01$ , or 5.7%) and decreased adverse mental health symptoms (-1.260,  $p < 0.01$ , or -13.0%)<sup>3</sup>.

Moreover, in Sections 8a-8c we examined associations between AI m-Integration applications in use and levels of immigrants' integration, health and mental health by restricting the sample to smartphone owners who were using m-Integration applications. Controlling for selection the estimated patterns are found to be held. The new estimates indicate positive associations between the number of AI m-Integration applications in use and increased levels of integration (0.099,  $p < 0.05$ , or 6.9%), better health (3.482,  $p < 0.01$ , or 9.6%) and decreased adverse mental health (-1.840,  $p < 0.01$ , or -29.5%)<sup>4</sup>.

In both selection specifications, given the difficulty of identifying robust selection instruments, the estimates should be considered with caution.

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<sup>3</sup> The smartphone selection equation controls for gender, age, higher or vocational education, years in Greece, immigration status, continent of origin, employment, inactivity status, period and school controls.

<sup>4</sup> The m-Integration applications in use selection equation controls for the same covariates as the smartphone selection equation.



## 8.e Gender-based evaluation

In Table 8 we offer a gender-based interaction effect analysis. In Model I, Panel C presents that the association between the number of m-Integration applications in use and reduction of adverse mental health symptoms is stronger for men than for women (-0.930,  $p < 0.05$ , or -9.6%). Moreover, in Model II, Panel A estimates that the association between the number of AI m-Integration applications in use and level of integration is weaker for men than for women (-0.138,  $p < 0.05$ , or -11%).

[Table 8]

## 8.f M-Integration applications in use estimates

In Table 9 we estimate whether each one of the ten m-Integration application services is associated with immigrants' level of integration (Ethnosizer), health status (EQ-VAS) and mental health (CESD-20). In Panel A it is estimated that there is a positive association between immigrants' integration and applications in relation to public services (0.070,  $p < 0.10$ , or 0.6%), local news in relation to immigration (0.095,  $p < 0.05$ , or 0.9%), city transportation and maps (0.091,  $p < 0.05$ , or 0.3%), translation and voice assistants (0.204,  $p < 0.01$ , or 4.0%) and mental health services (0.119,  $p < 0.05$ , or 0.3%). As is observed, the translation and voice assistant applications provide the highest returns.

[Table 9]

In Panel B it is estimated that all m-Integration applications are positively associated with health status. The highest returns are estimated for applications in relation to local news regarding immigration (2.417,  $p < 0.01$ , or 0.9%), translation and voice assistants (1.142,  $p < 0.05$ , or 0.8%), public services (2.126,  $p < 0.01$ , or 0.7%), and medical services (3.213,  $p < 0.01$ , or 0.5%).

Finally, in Panel C, it is estimated that there is an association between m-Integration applications and adverse mental health symptoms. The highest returns in reducing adverse mental health symptoms are estimated for applications in relation to public services (-1.327,  $p < 0.05$ , or -2.3%), local news in relation to immigration (-1.046,  $p < 0.05$ , or -1.9%) and mental health services (-2.930,  $p < 0.01$ , or -1.7%).

## 9. Discussion

The aim of the study was to empirically assess whether mobile applications aiming to facilitate immigrants' societal integration could be associated with better levels of integration,

health and mental health. We defined m-Integration applications, i.e., an abbreviation of mobile integration applications, as the use of mobile applications to support immigrants' needs in relation to social integration in host countries. We developed a vector consisting of 10 categories of application services, in relation to public services, legislation, employment, city transportation, housing, translation, voice assistants, education, health and mental health, aiming to support immigrants' integration and needs in host countries. We utilized three inventories which have been found to provide high levels of replicability in relation to integration: Ethnosizer (Constant and Zimmermann, 2008), overall health status: EQ-VAS (Priestman and Baum, 1976), and mental health status: CESD-20 (Radloff, 1977). In addition, we screened the actual applications in use, aiming to identify those which were aided by AI and then to empirically evaluate whether these could be positively associated with immigrants' integration and health/mental health. In the literature no known study has attempted to quantify the aforementioned relationships, although a few studies have found that immigrants utilize applications developed for their needs (Marcolino et al., 2018; Andrade and Doolin, 2016).

The study found that having an increasing number of m-Integration applications in use is positively associated with enhanced levels of societal integration, and a good health/mental health status. In this study we hypothesized that m-Integration applications could be associated with increased levels of integration because they facilitate immigrants' needs in relation to access to public services and aid, networking, language learning and employment. All these factors have been found to positively impact on immigrants' integration (Aoki and Santiago, 2018; Clarke and Isphording, 2016; United Nations, 2015; World Bank, 2013; Drydakis, 2013; 2012a). In addition, we argued that since integration policies on health provision could determine health outcomes (World Health Organization, 2018a; Aoki and Santiago, 2018; OECD, 2016; Simon et al., 2015), then m-Integration applications, which include m-Health and m-Mental applications, could be also associated with better health and mental health statuses.

Sen's (1999; 1992; 1985) capability approach was utilized to build the theoretical framework around m-Integration applications. It was hypothesized that m-Integration applications could be considered as providing capability-enhancing freedom for immigrants (St. George, 2017; Gigler, 2015; 2013; Kleine, 2013; Alkire, 2005). We indicated that, if m-Integration applications facilitate immigrants' acquiring of information, communication skills, and reduction of participation barriers to public services, then the utilization of m-Integration applications could enhance their capabilities, human and social capital enabling them to experience increased levels of integration and well-being.

The theoretical considerations were found to be held. It was estimated that immigrants' level of integration was positively associated with a variety of m-Integration applications such as public services, city transportation and maps, translation and voice assistants and mental-health applications. Similarly, health and mental health statuses were found to be positively associated with a few m-Integration applications in relation to public services, news and health. The assigned patterns verified our theoretical predictions suggesting that not only m-Health applications might be associated with better health but also other relevant applications. Policy makers might have an interest to consider the implications of the current study which suggests that M-Integration applications might provide an accessible venue that could facilitate immigrants needs and subsequently could play a critical role in their integration and health/mental health status (Ghahramani and Wang, 2019; Marrie et al., 2013; Johnson and Case, 2012; Kim, 2008).

The study found that AI m-Integration applications in use were positively associated with increased levels of immigrants' level of integration, good health, and mental health. We hypothesized that AI which provides customized search results, peer reviewed e-learning, professional coaching on pronunciation, real-time translations, virtual communication for finding possible explanations and assistance for health conditions might bring qualitative services advantages compared to those applications which are not aided by AI assistants (Bock et al., 2020, Van Roy et al., 2020; European Commission, 2020; Esmailzadeh, 2020; Sharma et al., 2020; AbuJarour et al., 2019; Sim, 2019; Ertel, 2018). The interaction effect analysis indicated that the number of AI m-Integration applications in use and integration level was stronger for women than men. We indicate that AI advantages may create a better match between women's needs and outcomes which could be associated with better functioning.

Based on the study's statistics it was found that 32.2% of the study's population did not own a smartphone. The study found also that among those owned a smartphone 42.3% were not to utilized any of the 10 m-Integration application services. One might argue, that smartphones and m-Integration application usage may not be the technological panacea for all immigrant populations. Moreover, the estimates indicated that the association between the number of m-Integration applications in use and the reduction of adverse mental health symptoms was estimated to be stronger for men than for women. Additional regression outcomes indicate that women experienced 27.8% less chances of owning of smartphone than men<sup>5</sup>, and 33.1% less chances to use m-

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<sup>5</sup> In this study, random effect estimates indicated that the determinants of smartphone ownership are being of a young age (0.054,  $p < 0.10$ , or 0.3%), being a man (4.581,  $p < 0.01$ , or 27.8%), having higher or vocational education (1.674,  $p < 0.10$ , or 10.1%), being a European citizen (2.328,  $p < 0.01$ ,

Integration applications than men<sup>6</sup>. The assigned patterns are in-line with international outcomes. Women are regularly behind men in their use of technology, the internet, and ownership and usage of smartphones (Ameen et al. 2018; Ameen and Willis, 2016). They are less aware of mobile applications' benefits due to their lived socioeconomic and cultural conditions. Based on the unified theory of acceptance and use of technology (Venkatesh et al., 2012) gender moderates technology's usage, with men exhibiting a greater tendency to seek novelty, motivation and innovativeness, which might affect socioeconomic outcomes (Ameen et al. 2018). It is indicating that achieving gender equality in smartphone adoption would benefit women's societal role, empowerment, education, employment and entrepreneurship, their families' income, the mobile industry and countries' growth (Ameen et al., 2018; Ameen and Willis, 2019).

Although owning a smartphone and using technology can be helpful it can also be a barrier if there is a low level of digital literacy, language and communication constraints, limited resources, weak desires to catch up with technology and integration applications or adverse socioeconomic and infrastructure conditions in the local area (Opas and McMurray, 2015; O'Mara et al., 2012; Smith et al., 2011). This would be leading to social exclusion and underdevelopment (Gigler, 2015; Johnstone, 2012; Caidi et al., 2010; Sen, 1985). In this study, it was found that older and less educated people did not own a smartphone, as well as, the use of M-Integration applications was lower for less educated people. These patterns might relate to the 'digital divide' and 'second level of digital divide' framework (Gallup, 2018; Van Deursen and Van Dijk, 2011; Ono and Zavodny, 2007; Van Dijk, 2006). In the former case the gap between those who do not have physical access to technology and those who do have physical access to technology is considered. In the latter case, i.e. the 'second level digital divide', the gap between those who have physical access to technology but do not use it and those who have physical access to technology and utilize it is considered.

The reasons for digital illiteracy, its consequences for individuals' development and inclusion, ways to address digital illiteracy, and the returning benefits of using ICTs have formed

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or 14.1%), being employed (1.232,  $p < 0.05$ , or 7.4%), and having a longer stay in Greece (0.597,  $p < 0.10$ , or 3.6%). Moreover, random effect estimates indicated a positive association between owning a smartphone and integration (0.561,  $p < 0.01$ , or 15.4%) and health status (4.532,  $p < 0.01$ , or 4.7%). In addition, there was found a negative association between owning a smartphone and adverse mental health status (-2.247,  $p < 0.01$ , or -9.8%).

<sup>6</sup> In this study, random effect estimates indicated that the determinants of using m-Integration applications are being a man (0.754,  $p < 0.05$ , or 33.1%), having higher or vocational education (0.976,  $p < 0.05$ , or 7.4%), and having a longer stay in Greece (0.172,  $p < 0.05$ , or 29.2%).

the 'third level of digital divide' (St. George, 2017; Van Deursen and Van Dijk, 2014; Pedrozo, 2013; Palfrey and Gasser, 2008). It has been indicating that for immigrants the digital infrastructure is as important as the physical infrastructures of roads, railways, sea crossings and borders (Gillespie et al., 2016). Mobile phones and m-Integration applications seem to guarantee key human rights such as the right of information, the right to the family life, the right to work and education, the right to cultural identity maintenance, and the right to mental health (Mancini et al., 2019). The United Nations advocate working with mobile network operators, governments, and regulators to improve access by improving network coverage, deliver low-cost refugee-specific products and connectivity and identify digital literacy as key channel to providing training on how immigrant populations to use mobile phones and applications (UNHCR, 2016).

The importance of access to technology and digital literacy has received attention and the current study's outcomes might provide insights to policymakers (OECD, 2017; 2016; UNHCR, 2016; Van Deursen and Van Dijk, 2014; Pedrozo, 2013; Palfrey and Gasser, 2008). The notion of an information society is converging with that of a proactive and inclusive society where access to and use of technology, along with what immigrants are actually able to do and achieve with technology, should be seen as a further tool for fostering immigration policies for individuals' and economies' benefits (Bradley et al., 2017; Lloyd et al., 2013; Notley, 2009; Zheng and Walsham, 2008; Panagakos and Horst, 2006; Notley, 2009; Wilding, 2009). We indicate that mobile technologies and m-Integration applications should be envisioned as a channel to integrate immigrant population groups in new societies (Mancini et al., 2019). The World Health Organization (WHO, 2018b) recommended the use of digital health in improving health services, particularly for vulnerable populations. It urged Member States to prioritize the development and greater use of digital technologies in health as a means of advancing sustainable development and boosting health coverage (WHO, 2018b).

Bock et al. (2020) proposed the developed a global, cloud-based computer system with a full suite of applications, designed with input from immigrants to assist governments and NGOs in managing the influx of newcomers, while also supporting the capacities of these people to help each other. As immigrants gain information access about the functioning of the new environment and invest in human and social capital in the host culture, their labour market outcomes, income and wellbeing could be increased (Giannoni et al., 2016; Simon et al., 2015; Malmusi, 2015; Drydakis, 2012a; 2013). Then, the more integrated immigrants are in a host country, the higher their net economic and fiscal contribution to the host economy will be (Drydakis, 2013). In addition, integrated immigrants may be important for the attitudes of the natives toward newcomers (Drydakis, 2012a).

The study patterns presented should not be treated as representative. The data gathering took place only in the capital city of Greece. The capital city might attract immigrants with certain characteristics i.e. better educated with higher income. New studies focusing on more regions are needed. Studies comparing international experiences could also help to evaluate whether comparable patterns are observed in regions where immigrants are characterized by different characteristics i.e. countries attracting better educated immigrants. We expect that the assigned patterns were driven by immigrants' demographic characteristics. The sample observations were made of immigrants with limited knowledge of the language enrolled in free language programmes. They also had unknown legal status and experienced low employment rates, with low human capital and a high proportion of refugees. Whether the study's patterns could be verified in regions attracting better-educated immigrants, experiencing higher employment levels and enrolling in language programmes with tuition fees requires evaluation. In addition, the immigrants in this study were actively integrating into society by enrolling in language programmes. One might expect different patterns if immigrants were not active in language learning.

We might expect that the macroeconomic environment would drive the patterns. The sample produced data on immigrants living in a country experiencing a massive economic recession (Drydakis, 2015a). Better developed economies might attract better educated immigrants, as well as, provide better employment opportunities which could boost immigrants' income, societal integration and well-being. New studies are needed to offer firm evaluations. In this study we did not evaluate demographic differences within immigrants in terms of mobile phone ownership, actual need and usage, as well as, m-Integration applications usage. Whether continent of origin, years of age, employment status and level of education might be associated with smartphone ownership and m-Integration applications' payoffs needs examination. Similarly, in this study we did not collect information in relation to immigrants who were granted asylum or were seeking such a status. Whether immigrants belonging in this category (i.e., looking for international protection) experience different payoffs requires investigation.

Finally, as we have highlighted throughout the study, although panel data has been utilized and information in relation to human capital and employment status has been included the assigned patterns should be treated as associations and not as causal patterns. It might be difficult to minimize and exclude endogenous relationships between ICTs and immigrants' integration and the public's health/mental health status. Further studies are needed to capture unexamined heterogeneities, such as personality traits, societal discrimination, immigrants' early trauma, cultural shock and integration stress, and offer better-informed estimates.

## 10. Conclusion

In this study using panel data on immigrant populations from European, Asian and African countries for the period 2018-2019 we found that having an increasing number of mobile applications in use aiming to facilitate immigrants' societal integration (m-Integration) is positively associated with enhanced levels of integration (Ethnosizer), good health (EQ-VAS), and a better mental health status (CESD-20). The outcomes indicated that immigrants' level of integration was positively associated with a variety of m-Integration applications such as public services, city transportation and maps, translation and voice assistants and mental health. Also, health and mental health status were found to be positively associated with a few m-Integration applications, in relation to public services and local news, and health applications. Moreover, the study estimated that m-Integration applications of AI were positively associated with increased levels of immigrant integration and a good health/mental health status. We evaluated that m-Integration applications could provide an accessible venue that could facilitate immigrants customized online information and services which subsequently might play a critical role in their integration and well-being. In addition, AI m-Integration applications might create a better match between immigrants' needs and outcomes, something associated with better functioning. It may be the case that AI features such as accuracy of search results, peer reviewed e-learning, professional coaching on pronunciation, real-time translations and virtual communication for finding possible explanations for health conditions could be associated with better-quality services facilitating immigrants' needs. The study concluded by indicating that the notion of an information society should be converging with that of a proactive and inclusive society where access to and use of technology and what immigrants are actually able to do and achieve with technology should be seen as a further tool for fostering their integration strategies for positive outcomes at individual and society levels. This is the first known study to introduce the term 'm-Integration' and quantify associations between mobile applications, integration and health and mental health for immigrants and assess AI's role in enhancing the aforementioned relationships.

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**Table 1. Descriptive statistics. Total sample**

	Panel I 2018 year	Panel II 2019 year	Panel III 2018 and 2019 years
Men (%)	65.50 (0.47)	65.36 (0.47)	65.44 (0.47)
Age (c.)	31.44 (7.98)	31.87 (8.00)	31.64 (7.99)
Higher or vocational education (%)	9.40 (0.29)	10.11 (0.30)	9.74 (0.29)
Non-refugees <sup>^</sup> (%)	62.02 (0.48)	68.09 (0.46)	64.88 (0.47)
Years of immigration in Greece (c.)	2.60 (1.47)	2.94 (1.53)	2.76 (1.51)
Continent of origin: Africa (%)	19.51 (0.39)	19.45 (0.39)	19.48 (0.39)
Continent of origin: Asia (%)	54.70 (0.49)	55.25 (0.49)	54.96 (0.49)
Continent of origin: Europe (%)	25.78 (0.43)	25.29 (0.43)	25.55 (0.43)
Employed <sup>^^</sup> (%)	61.32 (0.48)	69.26 (0.46)	65.07 (0.47)
Smartphone owners <sup>^^^</sup> (%)	66.89 (0.47)	68.87 (0.46)	67.83 (0.46)
Average number of m-Integration applications in use (including the 'no' option) (c.)	1.01 (1.69)	1.24 (1.78)	1.16 (1.73)
Average number of m-Integration applications in use (excluding the 'no' option) (c.)	2.98 (1.47)	2.98 (1.56)	2.98 (1.51)
Average number of Artificial Intelligence m-Integration applications in use (including the 'no' option) (c.)	1.86 (1.06)	2.02 (0.97)	1.94 (1.02)
Average number of Artificial Intelligence m-Integration applications in use (excluding the 'no' option) (c.)	1.98 (0.99)	2.13 (0.88)	2.05 (0.94)
Integration index (Ethnosizer) (c.)	2.43 (0.65)	2.47 (0.67)	2.45 (0.66)
Health status (EQ-VAS) (c.)	64.53 (7.98)	65.55 (7.98)	65.01 (7.99)
Adverse mental health symptoms (CESD-20) (c.)	15.98 (5.44)	14.80 (5.46)	15.43 (5.48)
Observations	287	257	544

Notes: (<sup>^</sup>) The reference category is refugees. (<sup>^^</sup>) The reference category is unemployed and inactive people. (<sup>^^^</sup>) The reference category is non-smartphone owners. Standard deviations are in parentheses.



**Table 2. Descriptive statistics. Smartphone owners**

	Panel I 2018 year	Panel II 2019 year	Panel III 2018 and 2019 years
Average integration index (Ethnosizer) (c.)	2.66 (0.51)	2.71 (0.54)	2.69 (0.52)
-No application in use	2.53 (0.56)	2.61 (0.51)	2.57 (0.54)
-Two applications in use	2.60 (0.56)	2.59 (0.61)	2.59 (0.58)
-Four applications in use	2.92 (0.27)	2.85 (0.36)	2.88 (0.32)
Average health status (EQ-VAS) (c.)	67.37 (7.23)	67.89 (7.51)	67.62 (7.36)
-No application in use	63.60 (5.60)	64.40 (5.80)	63.96 (5.68)
-Two applications in use	66.40 (3.32)	67.34 (4.17)	66.88 (3.78)
-Four applications in use	74.38 (6.43)	73.21 (6.06)	73.77 (6.15)
Average adverse mental health symptoms (CESD-20) (c.)	14.60 (5.76)	13.58 (5.56)	14.11 (5.68)
-No application in use	17.08 (3.80)	15.58 (4.15)	16.41 (4.01)
-Two applications in use	16.26 (5.10)	14.09 (4.58)	15.14 (4.92)
-Four applications in use	9.07 (3.92)	9.28 (4.96)	9.18 (4.41)

Notes: *Standard deviations are in parentheses.*

**Table 3. Correlation matrix. Smartphone owners**

	Number of m-Integration applications in use	Integration index (Ethnosizer)	Health status (EQ-VAS)	Adverse mental health (CESD-20)	Men	Age	Higher or vocational education	Non- refugees ^	Years of immigration in Greece	Employed ^^
Number of m-Integration applications in use	1									
Integration index (Ethnosizer)	0.32 (0.00)*	1								
Health status (EQ-VAS)	0.69 (0.00)*	0.48 (0.00)*	1							
Adverse mental health (CESD-20)	-0.61 (0.00)*	-0.36 (0.00)*	-0.79 (0.00)*	1						
Men	0.18 (0.00)*	0.08 (0.11)	0.26 (0.00)*	-0.30 (0.00)*	1					
Age	-0.01 (0.72)	0.15 (0.00)*	0.10 (0.04)**	-0.17 (0.00)*	-0.09 (0.05)***	1				
Higher or vocational education	0.23 (0.00)*	0.12 (0.01)**	0.27 (0.00)*	-0.30 (0.00)*	0.06 (0.18)	0.15 (0.00)*	1			
Non-refugees^	0.29 (0.00)*	0.20 (0.00)*	0.48 (0.00)*	-0.45 (0.00)*	0.02 (0.64)	0.14 (0.00)*	0.10 (0.03)**	1		
Years of immigration in Greece	0.34 (0.00)*	0.14 (0.00)*	0.43 (0.00)*	-0.44 (0.00)*	-0.02 (0.58)	0.23 (0.00)*	0.43 (0.00)*	0.56 (0.00)*	1	
Employed^^	0.24 (0.00)*	0.17 (0.00)*	0.41 (0.00)*	-0.32 (0.00)*	0.01 (0.73)*	0.19 (0.00)*	0.17 (0.00)*	0.34 (0.00)*	0.29 (0.00)*	1

Notes: P-values are in parentheses. (^) The reference category is refugees. (^^) The reference category is unemployed and inactive people. (\*) Statistically significant at the 1% level. (\*\*) Statistically significant at the 5% level. (\*\*\*) Statistically significant at the 10% level.

**Table 4. Correlation matrix. Smartphone owners using m-Integration applications**

	Number of Artificial Intelligence m-Integration applications in use	Integration index (Ethnosizer)	Health status (EQ-VAS)	Adverse mental health (CESD-20)	Men	Age	Higher or vocational education	Non-refugees <sup>^</sup>	Years of immigration in Greece	Employed <sup>^^</sup>
Number of Artificial Intelligence m-Integration applications in use	1									
Integration index (Ethnosizer)	0.28 (0.00)*	1								
Health status (EQ-VAS)	0.58 (0.00)*	0.46 (0.00)*	1							
Adverse mental health (CESD-20)	-0.50 (0.00)*	-0.35 (0.00)*	-0.81 (0.00)*	1						
Men	0.15 (0.02)**	0.04 (0.48)	0.30 (0.00)*	-0.36 (0.00)*	1					
Age	-0.07 (0.24)	0.14 (0.03)**	0.13 (0.04)**	-0.20 (0.00)*	-0.09 (0.16)	1				
Higher or vocational education	0.15 (0.02)**	0.16 (0.01)**	0.25 (0.00)*	-0.32 (0.00)*	0.06 (0.53)	0.14 (0.02)**	1			
Non-refugees <sup>^</sup>	0.35 (0.00)*	0.34 (0.00)*	0.53 (0.00)*	-0.51 (0.00)*	0.03 (0.63)	0.21 (0.00)*	0.15 (0.02)**	1		
Years of immigration in Greece	0.29 (0.00)*	0.16 (0.01)**	0.41 (0.00)*	-0.44 (0.00)*	-0.00 (0.95)	0.31 (0.00)*	0.50 (0.00)*	0.55 (0.00)*	1	
Employed <sup>^^</sup>	0.23 (0.00)*	0.33 (0.00)*	0.50 (0.00)*	-0.42 (0.00)*	0.00 (0.94)	0.29 (0.00)*	0.20 (0.00)*	0.31 (0.00)*	0.27 (0.00)*	1

Notes: P-values are in parentheses. (^) The reference category is refugees. (^^) The reference category is unemployed and inactive people. (\*) Statistically significant at the 1% level. (\*\*) Statistically significant at the 5% level.

**Table 5. Integration (Ethnosizer) estimates**

	Model I Smartphone owners	Model II Smartphone owners using m-Integration applications
Number of m-Integration applications in use	0.108 (0.017)*	-
Number of Artificial Intelligence m-Integration applications in use	-	0.038 (0.021)***
2018 period <sup>^</sup>	-0.041 (0.017)**	-0.030 (0.024)
Men	0.047 (0.088)	0.038 (0.108)
Age	0.012 (0.004)**	0.008 (0.006)
Higher or vocational education	0.042 (0.113)	0.113 (0.126)
Non-refugees <sup>^^</sup>	0.026 (0.064)	0.191 (0.094)**
Years of immigration in Greece	-0.041 (0.023)	-0.035 (0.030)
Continent of origin: Europe <sup>#</sup>	0.085 (0.106)	-0.003 (0.136)
Continent of origin: Asia <sup>#</sup>	-0.093 (0.095)	-0.108 (0.119)
Employed <sup>##</sup>	0.001 (0.046)	0.088 (0.057)
School controls	Yes	Yes
Observations	369	213
Wald $\chi^2$	72.22	34.53
Prob> $\chi^2$	0.000	0.000

Notes: Random effect estimates. (<sup>^</sup>) The reference category is the 2019 period. (<sup>^^</sup>) The reference category is refugees. (<sup>#</sup>) The reference category is Africa. (<sup>##</sup>) The reference category is unemployed and inactive people. Standard-errors are in parenthesis. (\*) Statistically significant at the 1% level. (\*\*) Statistically significant at the 5% level. (\*\*\*) Statistically significant at the 10% level.

**Table 6. Health status (EQ-VAS) estimates**

	Model I Smartphone owners	Model II Smartphone owners using m-Integration applications
Number of m-Integration applications in use	2.118 (0.161)*	-
Number of Artificial Intelligence m-Integration applications in use	-	1.934 (0.304)*
2018 period <sup>^</sup>	0.232 (0.277)	0.649 (0.368)
Men	3.198 (0.710)*	4.946 (1.000)*
Age	-0.013 (0.040)	-0.022 (0.058)
Higher or vocational education	1.030 (0.933)	0.598 (1.192)
Non-refugees <sup>^^</sup>	3.321 (0.718)*	4.303 (1.054)*
Years of immigration in Greece	0.155 (0.242)	0.527 (0.330)
Continent of origin: Europe <sup>#</sup>	0.749 (0.851)	0.095 (1.250)
Continent of origin: Asia <sup>#</sup>	-1.420 (0.761)***	-2.207 (1.093)**
Employed <sup>##</sup>	3.423 (0.562)*	4.965 (0.747)*
School controls	Yes	Yes
Observations	369	213
Wald $\chi^2$	513.99	255.10
Prob> $\chi^2$	0.000	0.000

Notes: Random effect estimates. (<sup>^</sup>) The reference category is the 2019 period. (<sup>^^</sup>) The reference category is refugees. (<sup>#</sup>) The reference category is Africa. (<sup>##</sup>) The reference category is unemployed and inactive people. Standard-errors are in parenthesis. (\*) Statistically significant at the 1% level. (\*\*) Statistically significant at the 5% level. (\*\*\*) Statistically significant at the 10% level.

**Table 7. Adverse mental health status (CESD-20) estimates**

	Model I Smartphone owners	Model II Smartphone owners using m-Integration applications
Number of m-Integration applications in use	-1.181 (0.149)*	-
Number of Artificial Intelligence m-Integration applications in use	-	-1.042 (0.278)*
2018 period <sup>^</sup>	0.469 (0.240)**	-0.007 (0.333)
Men	-2.858 (0.664)*	-4.559 (0.947)*
Age	-0.073 (0.037)**	-0.061 (0.055)
Higher or vocational education	-1.383 (0.870)	-1.579 (1.128)
Non-refugees <sup>^^</sup>	-2.073 (0.655)*	-3.377 (0.986)*
Years of immigration in Greece	-0.429 (0.222)***	-0.566 (0.310)**
Continent of origin: Europe <sup>#</sup>	0.816 (0.796)	0.363 (1.184)
Continent of origin: Asia <sup>#</sup>	1.215 (0.712)	1.286 (1.036)
Employed <sup>##</sup>	-1.763 (0.509)*	-3.323 (0.690)*
School controls	Yes	Yes
Observations	369	213
Wald $\chi^2$	295.79	181.87
Prob> $\chi^2$	0.000	0.000

Notes: Random effect estimates. (<sup>^</sup>) The reference category is the 2019 period. (<sup>^^</sup>) The reference category is refugees. (<sup>#</sup>) The reference category is Africa. (<sup>##</sup>) The reference category is unemployed and inactive people. Standard-errors are in parenthesis. (\*) Statistically significant at the 1% level. (\*\*) Statistically significant at the 5% level. (\*\*\*) Statistically significant at the 10% level.

**Table 8. Interaction effect analysis; Gender**

	Panel A Integration (Ethnosizer)	Panel B Health status (EQ-VAS)	Panel C Adverse mental health status (CESD-20)
Model I. Smartphone owners			
Number of m-Integration applications in use x men	-0.029 (0.042)	0.288 (0.441)	-0.930 (0.401)**
Model II. Smartphone owners using m-Integration applications			
Number of Artificial Intelligence m-Integration applications in use x men	-0.138 (0.058)**	-0.495 (0.821)	-0.900 (0.755)

*Notes: Each regression controls for gender, age, higher or vocational education, non-refugee status, years of immigration in Greece, continents of origin, employment, period of data gathering and school effects. Standard-errors are in parenthesis. (\*\*) Statistically significant at the 5%.*

**Table 9. M-Integration applications in use estimates**

	Panel A Integration (Ethnosizer)	Panel B Health status (EQ-VAS)	Panel C Adverse mental health status (CESD-20)
Public services	0.070 (0.038)***	2.126 (0.551)*	-1.327 (0.480)**
Local news in relation to immigration	0.095 (0.038)**	2.417 (0.529)*	-1.046 (0.462)**
Legal services	0.032 (0.044)	2.221 (0.646)*	-1.198 (0.560)**
Housing and accommodation services	0.055 (0.044)	1.665 (0.661)**	-1.250 (0.572)**
Employment and access to jobs services	0.068 (0.048)	2.500 (0.711)*	-1.659 (0.617)*
City transportation and maps services	0.091 (0.050)**	1.547 (0.730)**	-0.402 (0.636)
Languages education	0.056 (0.051)	1.938 (0.730)*	-1.987 (0.636)*
Translation and voice assistants	0.204 (0.041)*	1.142 (0.550)**	-0.611 (0.485)
Medical services	0.029 (0.049)	3.213 (0.701)*	-0.954 (0.612)
Mental health services	0.119 (0.052)**	2.565 (0.734)*	-2.930 (0.640)*
Observations	369	369	369
Wald $\chi^2$	76.83	512.93	313.27
Prob> $\chi^2$	0.000	0.000	0.000

*Notes: Observations on smartphone owners. Each regression controls for gender, age, higher or vocational education, non-refugee status, years of immigration in Greece, continents of origin, employment, period of data gathering and school effects. Standard-errors are in parenthesis. (\*) Statistically significant at the 1%. (\*\*) Statistically significant at the 5%. (\*\*\*) Statistically significant at the 10% level.*



## Appendix

### Descriptive statistics. M-Integration applications in use

	Panel I 2018 year	Panel II 2019 year	Panel III 2018 and 2019 years
Proportions of m-Integration applications in use			
No application in use (%)	44.79 (0.35)	39.54 (0.36)	42.27 (0.25)
One application in use (%)	7.81 (0.01)	9.6 (0.02)	8.67 (0.01)
Two applications in use (%)	15.62 (0.02)	18.0 (0.02)	16.8 (0.01)
Three applications in use (%)	16.14 (0.02)	14.68 (0.02)	15.44 (0.01)
Four applications in use (%)	6.77 (0.01)	7.9 (0.02)	7.31 (0.01)
Five applications in use (%)	3.64 (0.01)	3.38 (0.01)	3.52 (0.01)
Six applications in use (%)	4.68 (0.01)	5.64 (0.01)	5.14 (0.01)
Seven applications in use (%)	0.52 (0.01)	1.12 (0.01)	0.81 (0.01)
Eight applications in use (%)	0	0	0
Nine applications in use (%)	0	0	0
Ten applications in use (%)	0	0	0
Observations	192	177	369
Types of m-Integration applications in use*			
Public services (%)	19.79 (0.39)	29.94 (0.45)	24.66 (0.43)
Local news in relation to immigration (%)	23.43 (0.42)	28.81 (0.45)	26.01 (0.43)
Legal services (%)	12.50 (0.33)	11.29 (0.31)	11.92 (0.32)
Housing and accommodation services (%)	10.41 (0.30)	10.16 (0.30)	10.29 (0.30)
Employment and access to jobs services (%)	10.93 (0.31)	6.77 (0.25)	8.94 (0.28)
City transportation and maps services (%)	9.37 (0.29)	8.47 (0.27)	8.94 (0.28)
Languages education (%)	9.89 (0.29)	8.47 (0.27)	9.21 (0.28)
Translation and voice assistants (%)	50.52 (0.50)	55.93 (0.49)	53.11 (0.49)
Medical services (%)	10.41 (0.30)	13.55 (0.34)	11.92 (0.32)
Mental health services (%)	7.81 (0.26)	9.03 (0.28)	8.40 (0.27)
Observations	192	177	369
Types of Artificial Intelligence m-Integration applications in use*			
Public services (%)	47.36 (0.50) obs.38	51.85 (0.50) obs.54	50.00 (0.50) obs.92
Local news in relation to immigration (%)	57.77 (0.49) obs.45	56.86 (0.50) obs.51	57.29 (0.49) obs.96
Legal services (%)	75.0 (0.44) obs.24	57.14 (0.50) obs.21	66.66 (0.47) obs.45
Housing and accommodation services (%)	50.0 (0.51) obs.20	66.66 (0.48) obs.18	57.89 (0.50) obs.38
Employment and access to jobs services (%)	38.09 (0.49) obs. 21	69.23 (0.48) obs.13	50.00 (0.50) obs.34
City transportation and maps services (%)	38.88 (0.50) obs.18	66.66 (0.48) obs.15	51.51 (0.50) obs.33
Languages education (%)	47.36 (0.51) obs.19	47.05 (0.51) obs.17	47.22 (0.50) obs.36
Translation and voice assistants (%)	71.13 (0.45) obs.97	71.42 (0.45) obs.98	71.28 (0.45) obs.195
Medical services (%)	55.00 (0.51) obs.20	70.37 (0.46) obs.27	63.82 (0.48) obs.47
Mental health services (%)	53.00 (0.51) obs.15	52.94 (0.51) obs.17	53.12 (0.50) obs.32
Total (%)	58.04 (0.44) obs.317	62.22(0.48) obs.331	60.18 (0.48) obs.648

Notes: (\*) Multiple answers are allowed in this category. Standard deviations are in parentheses.