I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 15413

M-Health Apps and Physical and Mental Health Outcomes of Sexual Minorities

Nick Drydakis

JULY 2022

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 15413

M-Health Apps and Physical and Mental Health Outcomes of Sexual Minorities

Nick Drydakis
Anglia Ruskin University, University of Cambridge and IZA

JULY 2022

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

M-Health Apps and Physical and Mental Health Outcomes of Sexual Minorities

Given the assigned health inequalities faced by sexual minorities, it is fitting to assess whether m-health could be associated with better health-related outcomes for these sexual minorities. The present study examines associations between m-physical and m-mental health apps and sexual minorities' physical and mental health status in Greece. The study utilized three waves of panel data collected in 2018, 2019, and 2020. The findings indicated associations between the use of m-physical and m-mental health apps and increased physical and mental health status for sexual minorities. The work concludes that m-health could enhance informational capabilities associated with increased levels of physical and mental health for sexual minorities. Indeed, the study found that, during the COVID-19 pandemic, sexual minorities experienced physical and mental health deteriorations. Interestingly, the estimates indicated that the association between the use of m-physical and m-mental health apps and increased mental health status for sexual minorities was stronger during the COVID-19 pandemic than before. The study suggests that tracking health-related information through m-health apps during periods of increased uncertainty could be associated with better health prevention and management. If m-health apps can alleviate adverse physical and mental health symptoms for sexual minorities, their potential should be considered.

JEL Classification: I1, I14, O3

Keywords: m-health, smartphone, apps, physical health, mental health, COVID-19, sexual minorities

Corresponding author:
Nick Drydakis
Centre for Pluralist Economics
Department of Economics and International Business
Anglia Ruskin University
East Road
Cambridge, CB1 1PT
United Kingdom
E-mail: nick.drydakis@aru.ac.uk

1. Introduction

M-health (i.e., mobile health) describes services supported by mobile communication devices, such as smartphones (Weinstein et al., 2014). M-health apps are the enablers of m-health and the drivers of the systems (Weinstein et al., 2014)[1]. M-health apps have become channels through which people can access the internet so as to obtain health information (Wattanapisit et al., 2020; Nie et al., 2020; Mutebi and Devroey, 2018; Lim et al., 2011). M-health apps aim to meet health needs by monitoring health status, providing disease self-management, guides, and action plans (Mosa et al., 2012; World Health Organization, 2011). Through direct and customized communication, m-health apps attempt to support health practices (Drydakis, 2021a; Wattanapisit et al., 2020; Ghahramani and Wang, 2020; World Health Organization, 2011). These apps can also potentially prevent the occurrence of a particular disease through communication, storage of information, and the delivery of messages that can lead to healthy behaviors (Morse et al., 2018; Izahar et al., 2017). Indeed, such apps are associated with better quality of life and chronic disease management, as well as reduced depressive symptoms, blood pressure, weight, hospitalization and deaths (Ghahramani and Wang, 2020; Marcolino et al., 2018; Firth et al., 2017). Studies suggest that m-heath apps might be valuable for patients with low health literacy, patients who perceive themselves as having a stigmatizing condition, and minority population groups (Drydakis, 2021a; Aboueid et al., 2019; Amante et al., 2015; Kim and Xie, 2015).

Sexual minorities experience poorer physical and mental health, consume more substances, including tobacco, alcohol, and drugs, and have unprotected sexual intercourse relative to their heterosexual peers (Meads, 2020; Drydakis and Zimmermann, 2020; Lick et al., 2013; Cochran and May, 2012). This difference is attributed to the negative consequences of sexual minority stigma, which can take several forms, such as social exclusion, discrimination, victimization, and internalized homophobia (Hafeez et al., 2017; Meyer, 2003). Studies have found that sexual minorities utilize m-health apps for a variety of reasons, such as to chat with a healthcare provider as well as to track and receive feedback on their sexual behavior and substance use (Dubov et al., 2021; Craig et al., 2021; Byron, 2019; Shrestha et al., 2019; Ventuneac et al., 2018).

The present study examined the associations between m-physical and m-mental health apps and sexual minorities' physical and mental health status in Greece. Longitudinal data sets covering

[1] In contrast, telemedicine is defined as the provision of medical services at a distance, through video imaging and telecommunication, by a physician (Weinstein et al., 2014). Telehealth is an umbrella term that covers telemedicine and a variety of nonphysician services, including telenursing and telepharmacy (Weinstein et al., 2014).

three years, 2018–2020, were utilized to provide evaluations. Physical health outcomes were captured through the SF-36 General Health dimension and mental health was evaluated through the SF-36 Mental Health dimension (Ware et al., 1994). The study hypothesizes that m-health apps could be envisioned as supporting mechanisms to access health-related services (Wattanapisit et al., 2020; Ghahramani and Wang, 2020; Zheng and Walsham, 2008; Alkire, 2005), thus enhancing informational capabilities that could be associated with increased levels of physical and mental health status (Drydakis, 2021a; Gigler, 2015; Zheng and Walsham, 2008; Heeks, 2002). The study indicates that m-health apps could turn provided information and guidance into learning decisions for value actions for sexual minorities (Sen, 1985; 1999; Gigler, 2015; Heeks, 2002).

In Greece, there exists no literature concerning the association between m-health apps and sexual minorities' physical and mental health outcomes. The Greek state has historically pursued an intolerant approach to sexual orientation civil and human rights issues (Giannou and Ioakimidis, 2020). In Greece, employment studies have found that gay/bisexual men and lesbian/bisexual women encounter lower wages, higher unemployment, and more adverse experiences in the workplace than do their heterosexual peers, thus indicating that the sexual minorities might experience higher financial hardships than heterosexual people (Drydakis, 2009; 2011; 2012a; 2015a, 2019a; 2021b). Moreover, the Greek literature has indicated that homophobia is at the root of biased treatment which is received by sexual minorities in the workplace (Drydakis, 2009; 2019a; 2021c). During the financial crisis, especially between 2012 and 2017, there was an increase in homophobia, verbal abuse, and physical violence against sexual minorities (Sroiter, 2014). In Greece, Giannou and Ioakimidis (2020) reported that sexual minorities and medical care professionals consider homophobia a profound factor when it comes to systematic exclusion and restrictions on access to good-quality healthcare. In the same region, Drydakis (2021d) found that social rejection due to a minority sexual orientation, related to unfair treatment in educational and workplace environments, and/or public/health environments, bore a negative association with physical and mental health. Moreover, it was discovered that periods characterized by worse economic conditions correlated with a decline in sexual minorities' physical and mental health. Furthermore, Drydakis (2022a) also found that social rejection due to a minority sexual orientation was associated with the increased consumption of tobacco, alcohol, and cannabis, as well as unprotected sexual intercourse. The study revealed that there was increased cannabis consumption during periods of deteriorated economic conditions.

In Greece, there is a lack of studies on m-health apps and sexual minorities' health-related outcomes – something which the present study aims to address by contributing to the literature. The 2019 Eurobarometer survey indicated that Greece is more homophobic compared to the EU-28 average (Eurobarometer, 2019). Moreover, in Greece health inequalities between sexual majorities

and minorities seem to be prevalent (Drydakis, 2021d). Hence, there is an interest in assessing factors that might positively impact on sexual minorities' health-related performance.

Moreover, this study is among the first to assess the effects which m-physical and m-health apps have on both physical and mental health status for sexual minorities, so as to provide comprehensive empirical patterns. Given the strong link between physical and mental health (Ohrnberger et al., 2017; Doherty and Gaughran, 2014), it is of interest to assess whether m-physical health apps might be associated not only with better physical health, but also with better mental health for sexual minorities. The latter outcome could unravel m-health apps' multiple potential uses.

In addition, the current study utilizes panel data – not a common feature in sexual orientation epidemiological studies – which might make it possible to offer better-informed estimates by reducing unobserved heterogeneity (Wooldridge, 2010).

Furthermore, in the present study the actual number of observations of sexual minorities utilizing m-health apps is higher than in the majority of studies examining relevant patterns (Hightow et al., 2015; Dubov et al., 2021; Craig et al., 2015; Gannon et al., 2020; Garg et al., 2020). Such a feature might enhance the accuracy of the estimates.

Importantly, the third wave of the present data set contains information collected during the COVID-19 pandemic. That period (i.e., April-June 2020[2]) saw Greece's first nationwide lockdown, designed to prevent further spread of the COVID-19 pandemic. This information makes it possible to examine whether m-physical and m-mental health apps could be associated with better physical and mental health outcomes for sexual minorities during a period when sexual minorities were disproportionately affected by the COVID-19 pandemic (Drabble and Eliason, 2021; Phillips, 2021; Barrientos et al., 2021). Sexual minorities experience social disadvantages and mental health disparities, which have been exacerbated by COVID-19 pandemic trauma and social isolation measures (Barrientos et al., 2021; Drabble and Eliason, 2021; Fish et al., 2020; Gonzales et al., 2020).

The present study shall evaluate factors that could reduce adverse health-related outcomes during challenging periods. Assessing whether m-health is associated with better health-oriented outcomes for minority population groups should be of interest to policymakers and the general public (Drabble and Eliason, 2021; Phillips, 2021).

[2] In March 2020, all residents in Greece were asked to limit non-essential movement. Starting from May 2020, Greece began to gradually lift restrictions on movement and to restart business activity. However, in November 2020, the country put in place new measures and restrictions on movement and business activity.

2. Theoretical framework

2.1 M-health and outcomes

Smartphones and m-physical and m-mental health provision constitute a new technological revolution, providing the basis for one of the greatest expansions of human capabilities in known history (Drydakis, 2021a; Smith et al., 2011). It is suggested that m-physical and m-mental health apps could be considered supporting mechanisms which can be used to access health-related services (Alkire, 2005). Based on the capability approach framework (Sen, 1985; 1999), m-physical and m-health apps may boost health-oriented indicators by increasing people's capability to find health-related information and acquire knowledge in a process designed to boost their ability to address health concerns and make informed decisions (Drydakis, 2021a; Zheng and Walsham, 2008).

M-physical health apps aim to achieve health goals through tools, action plans, and healthy lifestyle guides (Drydakis, 2021a; World Health Organization, 2011). Researching health-related information on the internet has become common practice among the general public (Beck et al., 2014; World Health Organization, 2011). M-physical health apps are appropriate channels for accessing the internet in order to obtain health information (Drydakis, 2021a; Lim et al., 2011), with smartphones playing an important role in patient health education, disease self-management, and remote monitoring of patients (Ghahramani and Wang, 2020; Wattanapisit et al., 2020; Mosa et al., 2012). There are positive associations between m-physical health apps in chronic disease management and improved heart failure symptoms, reduced blood pressure in hypertensive patients, reduced weight in overweight and obese patients, and reduced deaths and hospitalization (Marcolino et al., 2018).

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). M-physical health apps have the potential to replace certain practices, such as taking medical histories and making a diagnosis, performing particular kinds of physical examinations, supporting disease-specific care, and health promotion (Wattanapisit et al., 2020). In Belgium, Mutebi and Devroey (2018) estimated that 41% of their study's participants used m-physical health apps for general health check-ups and 18% for follow-up of chronic illnesses. In the US, Bauer et al. (2014) estimated that 35.5% of smartphone patients sought physical health information from their smartphones, 22.0% accessed an m-health app, and 20.8% tracked or managed health conditions via mobile devices. Touchscreen-based apps aid users with low health literacy in achieving an understanding of, and education on, medical treatments (Kim and Xie, 2015). M-physical health apps can positively impact patients who are less inclined to engage with traditional health services and those who do not have access to healthcare services and perceive

themselves as having a stigmatizing condition, reducing the burden of diseases which are linked to poverty (Aboueid et al., 2019, Amante et al., 2015; Hamine et al., 2015; Carter et al., 2015).

Mobile technology also 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). There are emotional and psychological support m-mental health apps that provide evidence-based health information and education with varying levels of health literacy (Nie et al., 2020; Goodwin et al., 2016). M-mental health apps also cover many stages of clinical care provision, such as crisis intervention, prevention, diagnosis, primary treatment, supplementing in-person therapy, and post-treatment condition management (Price et al., 2014).

M-mental health apps allow for so-called 'anywhere, anytime' access and they may reduce the stigma associated with seeking face-to-face consultation (Jones and Moffitt, 2016). Indeed, a past study found that m-mental health apps designed to alleviate symptoms and allow for self-management of depression reduced patients' depressive symptoms (Firth et al., 2017). In addition, m-mental health apps for treating symptoms of schizophrenia can have broad-ranging clinical benefits (Firth et al., 2017). M-mental health apps can reach population groups that might otherwise not have access to mental health care (Dahl and Boulos, 2013; Cahill et al., 2007) and are beneficial for adolescents (Gindidis et al., 2019).

2.2 M-health and sexual minorities

One of the most notable advantages of m-health apps is the access to healthcare services which they provide for marginalized populations (Drydakis, 2021a). Sexual minorities, due to adverse lived experiences, are disproportionally affected by a wide range of health and mental health risks (Drydakis, 2021d) and experience barriers and discrimination in healthcare settings (Meads, 2020). M-health can address some of these barriers by, for instance, offering sexual minorities private and flexible ways to access specialized information and services, thus reducing the risk of biased treatments. For sexual minorities, m-health can help promote interventions for HIV prevention, facilitate HPV vaccination, reduce sexual activities without condom use, reduce depression symptoms, and increase self-esteem and coping strategies (Craig et al., 2021; Fontenot et al., 2020; Nelson et al., 2020; Shrestha et al., 2019).

The empirical literature related to sexual minorities indicates a positive association between the use of m-physical health apps and access to critical information and services (Shrestha et al., 2019; Ventuneac et al., 2018). A systematic evaluation suggested that mobile apps for pre-exposure prophylaxis (PrEP) demonstrate some promise as potential avenues for increasing PrEP uptake and adherence among persons at risk of HIV infection (Sharpe and Kamara, 2018). A literature review

on m-health interventions for HIV prevention and treatment among gay, bisexual, and other men who have sex with men indicated that the m-health approach is feasible and acceptable, and evidence of efficacy exists (Nelson et al., 2020).

In the US, gay, bisexual, and other men who have sex with men reported interest in one or more sexual m-health app feature, including those used to find LGBTIQ+-friendly providers, receive lab results, schedule appointment reminders, chat with a healthcare provider, receive medication reminder alerts, and track and receive feedback on their sexual behavior and substance use (Ventuneac et al., 2018). Moreover, in Boston, Massachusetts, it was found that young men who have sex with men utilized an m-health app to facilitate HPV vaccination, thereby helping youth with m-health interventions to create action plans to facilitate healthy behaviors (Fontenot et al., 2020). In Chicago, Illinois, and in New York, it was estimated that, for male youth sexual minorities pursuing empowerment, education and prevention around sexuality, mobile apps would be informative and usable for their sexual health education and HIV prevention needs (Gannon et al., 2020). Moreover, in Indonesia it was found that a peer-customized mobile app based on the principle of self-learning for improving HIV prevention knowledge and access to health services among men who have sex with men and trans women was associated with increased HIV-related knowledge, uptake of HIV testing, and self-esteem, as well as a reduction in sexual activities without condom use (Garg et al., 2020). In Malaysia, most men who have sex with men and own a smartphone have used m-health apps to seek sexual health information (Shrestha et al., 2019).

Regarding the use of m-mental health apps, in Australia, LGBTIQ+ young people (aged 16–25) highlighted the potential value of m-health apps (Byron, 2019). In Toronto, Canada, young LGBTIQ+ people who used digital computer-based m-health interventions reported significantly reduced depression symptoms and improved stress appraisal and coping skills (Craig et al., 2021). In the US, a mobile phone online intervention for young black men who have sex with men and black trans women resulted in decreased social isolation and depression symptoms (Hightow-Weidman et al., 2015). In Los Angeles, interventions designed for trans people tracked their mood, connected them to the community, and allowed them to access local resources, thus supporting the acceptability and usability of m-health interventions to predict and improve the rates of suicidal ideation among trans people (Dubov et al., 2021).

2.3 Hypotheses

Given the presented theoretical and empirical patterns, the current study indicates that sexual minorities might find comfort in utilizing m-physical and m-health apps. Such technology may improve patient–provider communication and assist in disease prevention, disease

management, 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). It might be the case that m-physical and m-mental health apps could turn provided services into learning decisions for value actions (Gigler, 2015; Heeks, 2002). Subsequently, enhanced informational capabilities might be associated with increased levels of physical and mental health (Gigler, 2015; Zheng and Walsham, 2008; Heeks, 2002).

Given the presented theoretical and empirical considerations and the strong link between physical and mental health (Ohrnberger et al., 2017; Doherty and Gaughran, 2014), the present study proposes the following set of predictions:

Hypothesis 1i. M-physical health apps might be associated with increased physical health status for sexual minorities.

Hypothesis 1ii. M-physical health apps might be associated with increased mental health status for sexual minorities.

Hypothesis 2i. M-mental health apps might be associated with increased physical health status for sexual minorities.

Hypothesis 2ii. M-mental health apps might be associated with increased mental health status for sexual minorities.

3. Data collection, variables, and estimation strategy

3.1 Data collection

The study utilized panel data consisting of information collected during the years 2018, 2019, and 2020. In 2018, the research team approached LGBTIQ+ unions and NGOs working on sexual minorities' rights to gather information on the scheduled events before the annual LGBTIQ+ pride, which takes place in the capital city of Greece (Athens) every June. The events held during the pride preparation, as well as those which take place during the pride week itself, are attended by thousands of people, with features including round-table talks and workshops, lectures, film screenings, and artistic and cultural exhibitions. The events provide an opportunity for researchers to recruit LGBTIQ+ people for surveys and to collect data (Sidiropoulou et al., 2020; Drydakis, 2019b).

The research team attended the events between April and June 2018, distributing participation forms with assistance from the organizers. At each event, the research team informed the public that university research was being conducted, providing information regarding the study's aim, i.e., to research health outcomes for non-heterosexual people; at this point, the participation forms were distributed. The team invited non-heterosexual people to participate in the survey: '*You are invited to participate in the current university survey if you self-identify as non-*

heterosexual, that is, you self-identify as a gay, lesbian, bisexual, queer, etc. This survey aims to capture health-oriented behaviors and patterns of non-heterosexual people.'

The participation forms provided the contact information of the research team as well as the study's aim, namely to collect longitudinal information on non-heterosexual people's demographic characteristics, habits, and health-related outcomes. Potential participants were asked to provide an email address to which the e-questionnaire could be forwarded, allowing them to complete the survey. The participants were informed that those who completed the survey would be re-approached in the future to provide follow-up information. The first data collection session took place between April and August 2018, with two emails sent to participants reminding them to undertake the survey. Two follow-up data collection sessions were conducted in 2019 and 2020 between April and August, with those participants who had provided information in the first wave re-approached. Similar to the first data collection session, up to two reminder emails were sent to participants asking them to consider the follow-up study.

Between April and June 2018, the research team gathered 268 participation forms, through which individuals had confirmed their participation, verified their self-identified non-heterosexual status, and provided an email address. E-questionnaires were forwarded to the provided email addresses and 223 individuals completed the survey. In 2019, the follow-up data collection session obtained 187 responses, while this figure was 165 responses in 2020. The 2018–2020 panel sample consisted of 575 observations. The consent form highlighted that the email addresses of the participants would only be utilized for follow-up surveys, while it also provided information on how participants could raise concerns, ask for clarification, and/or complain to the university's Ethics Committee. No complaints were received by the research team.

3.2 Variables

The e-questionnaires collected information regarding basic demographics (gender, gender identity, age, education, economic condition, and employment status). Economic condition was measured through a 5-point Likert scale. The e-questionnaires contained dichotomous items (yes/no) regarding smartphone ownership and whether smartphone owners use m-physical and m-mental health apps (Weinstein et al., 2014): 'are you a smartphone owner?', '*if you are a smartphone owner, have you used in the last year mobile applications on physical health and fitness to receive physical health care and fitness services, to facilitate your needs and interests, to find information and access educational materials for training and coaching purposes, to track your own activities and perform self-assessment, etc.?*' and '*if you are a smartphone owner, have you used in the last year mobile applications on mental health to receive psychological care, to*

facilitate your needs and interests, to find information and access educational materials for training and coaching purposes, to track your own activities and perform self-assessment, etc.?'

To measure physical health status, the 36-Item Short Form Health Survey's General/Physical Heath dimension (SF-36 GH) was utilized; indeed, this is the most widely used measure of health-related quality of life in population-based studies (Ware et al., 1994; Ware, 2000) and has been validated in Greece (Kontodimopoulos et al., 2008; Pappa et al., 2005). The SF-36 GH dimension measures perceived physical health status by utilizing five items which assess whether people believe they are 'in good health, are getting sick a little easier than other people, and are expecting their health to get worse' (Ware, 2000). Following the developers of the inventory, the SF-36 GH dimension was standardized to a T-score using the standard SF-36 scoring algorithms (Ware et al., 2004), ranging between 0 and 100, with higher values reflecting better-perceived physical health; indeed, this tool provides valid and reliable patterns (Ware, 2000).

The 36-Item Short Form Health Survey's Mental Health dimension (SF-36 MH), which has been validated in Greek contexts (Pappa et al., 2005; Anagnostopoulos et al., 2005), was utilized to assess perceived mental health status in the past four weeks (Ware et al., 1993; Ware et al., 1994; Ware, 2000) via five items which assess whether people believe that they 'feel happy, calm, and peaceful' (Ware, 2000). The SF-36 Mental Health dimension was standardized using the standard SF-36 scoring algorithms, with values between 0 and 100; higher scores reflect better-perceived mental health (Ware, 2004).

3.3 Estimation strategy

Since individuals who do not own a smartphone cannot use smartphone apps, the sample is restricted to smartphone owners (Drydakis, 2021a). This strategy aims to reduce selection issues related to the digital divide and physical and mental health outcomes (Drydakis, 2021a). It is indicated that, if people do not own a smartphone, this may be linked to key physical and mental health determinants, such as age, economic condition, and human and digital capital (Drydakis, 2021a).

Breusch-Pagan LM-tests and Hausman tests were conducted, finding that random effects rather than pooled and fixed effects models better fit the data (Morgan, 2013; Wooldridge, 2010). Apart from the usual coefficients, the study reports marginal effects, measuring the instantaneous rate of change (Morgan, 2013). The empirical specification evaluates the marginal effects at the mean of each continuous covariate (Wooldridge, 2010). The marginal effects of the dichotomic variables are calculated as the discrete change in the prediction equation as the covariate changes from 0 to 1 (Wooldridge, 2010).

Four models are offered in both health-related measurements (SF-36 GH dimension, SF-36 MH dimension). Model 1 captures the use of m-physical and m-mental health apps through two dummy variables. In addition, it captures time heterogeneity through a dummy variable controlling for 2020 (versus 2018–2019). Additional variables were added to Model II, such as individuals' gender, gender identity, and age. In addition, Model III contains information on higher education, unemployment, and inactivity status, while Model IV includes information on economic condition. A statistically significant positive m-physical and m-mental health apps estimate will indicate a positive association between m-physical and m-mental health apps and physical and mental health status. A negative 2020 time period estimate will indicate that, in 2020, individuals experienced deteriorated physical and mental health statuses compared to the 2018–2019 period. If the three covariates remain statistically significant in Models II, III, and IV, where more covariates are included, then these features might indicate that the empirical specification is not sensitive to some unobserved factors related to the use of mobile apps and time (Clarke, 2005). Multicollinearity tests were conducted to assess whether the simultaneous inclusion of the aforementioned variables was recommended (Belsley, 1991).

To examine jointed patterns, new models are offered. The variables capturing the use of m-physical and m-mental health apps are added to form a new variable that reflects jointed patterns. The new variable, entitled 'Use of m-physical and m-mental health apps,' ranges from 0 (no use of m-physical and m-mental health apps) to 2 (use of both m-physical and m-mental health apps). The new variable captures critical patterns related to the simultaneous usage of m-health apps addressing the complexity and dimensions of mobile apps usage. Moreover, including the time period variable enables the estimation of an interaction effect between the use of m-physical and m-mental health apps and time period (i.e., *use of m-physical and m-mental health apps × 2020 period*). The interaction effects enable examination of whether the use of m-physical and m-mental health apps is associated with better physical and mental health status in 2020 than in 2018–2019. A statistically significant positive interaction effect will indicate that the association between the use of m-physical and m-mental health apps and physical and mental health status was stronger in 2020 than in 2018–2019.

The study offers a robustness evaluation by presenting a variety of empirical specifications: pooled OLS and fixed effects estimates reporting robust standard errors. The study indicates that, given the longitudinal nature of the data, panel specifications shall be more appropriate than cross-sectional specifications (Wooldridge, 2010), omitted factors may be correlated with key predictors in random effects models (Vaisey and Miles, 2017), and fixed effects models could remove omitted variable bias (Vaisey and Miles, 2017).

4. Descriptive statistics

Table 1 offers the descriptive statistics, panel I presents information collected in 2018, panel II contains the data collected in 2019, and panel III displays the information collected in 2020, with the pooled data presented in panel IV. Regarding the pooled data, on average, 64.1% were men and 91.4% were cis-gender, with a mean age of 33.3 years. In addition, 34.2% held a higher education degree and the unemployment rate was 26.9%.

Moreover, 94.2% of the study participants were smartphone owners, 25.5% utilized m-physical health apps, and 19.7% employed m-mental apps. In 2018, 18.7% reported using m-physical health apps, increasing to 34.1% in 2020 (x^2=55.0, p<0.01). In 2018, 12.9% were using m-mental health apps, increasing to 27.8% in 2020 (x^2=46.8, p<0.01).

Furthermore, in 2018, the physical health (SF-36 GH) score was 67.0, decreasing to 65.8 in 2020 (t=1.94, p<0.10). In 2018, the mental health (SF-36 MH) score was 68.3, decreasing to 66.7 in 2020 (t=3.06, p<0.01).

[Table 1]

Table 2 presents a 4x4 correlation matrix, showing a positive correlation between the physical health (SF-36 GH) and the mental health (SF-36 MH) (r=0.88, p<0.01). There were positive correlations between m-physical health apps in use and physical health (SF-36 GH) (r=0.41, p<0.01), and mental health (SF-36 MH) (r=0.33, p<0.01), as well as between m-mental health apps in use and physical health (SF-36 GH) (r=0.33, p<0.01), and mental health (SF-36 MH) (r=0.32, p<0.01).

[Table 2]

5. Estimates

5.1 Physical health: SF-36 GH

Table 3 presents the physical health (SF-36 GH) estimates. In Model I, it is observed that m-physical and m-mental health apps are associated with better physical health (5.256, p<0.01, or 2.0%; and 1.880, p<0.10, or 0.5%, respectively). Given the outcomes, hypotheses 1i and 2i can be accepted. The difference between the two coefficients is statistically significant (x^2=39.57, p<0.01). Moreover, the 2020 period is associated with deteriorated physical health compared to 2018 and 2019 (-1.842, p<0.01, or -0.8%).

[Table 3]

In Model II, which includes information on sex, gender identity, and age, the magnitude of the m-physical health apps coefficient declines but is still statistically significant (5.191, p<0.01, or 1.9%), while the m-mental health apps coefficient increases slightly (2.053, p<0.05, or 0.6%), with a statistically significant difference between the two coefficients (x^2=43.26, p<0.10). Men

experience better physical health than do women (5.815, p<0.01, or 5.5%), while older people experience poorer physical health (-27.310, p<0.01, or -12.7%), and there is a deterioration in physical health in 2020 (-0.893, p<0.10, or -0.3%).

In Model III, which includes additional information on higher education, unemployment, and inactivity status, the m-mental health apps coefficient becomes statistically insignificant (1.345, p>0.10 or 0.3%), with the estimates indicating positive associations between m-physical health apps and physical health (5.654, p<0.01, or 2.1%), men (4.691, p<0.01, or 4.5%), and higher education (2.010, p<0.10, or 1.0%). There are negative associations between physical health and age (-23.098, p<0.01 or -10.7%), unemployment (-7.410, p<0.01 or -2.9%), and the year 2020 (-0.924, p<0.10 or -0.4%).

In Model IV, which includes information on economic condition, there is a positive association between m-physical health apps and physical health (5.773, p<0.01, or 2.2%), economic condition (3.910, p<0.01, or 16.5%), and men (3.534, p<0.01, or 3.3%), with negative associations between physical health and age (-18.778, p<0.01 or -8.7%), unemployment (-5.297, p<0.01 or -2.1%), and the year 2020 (-1.061, p<0.05 or -0.4%)[3].

5.2 Mental health: SF-36 MH

Table 4 presents the mental health (SF-36 MH) estimates. Model I shows that m-physical and m-mental health apps are associated with better mental health (4.341, p<0.01, or 1.6%; and 3.098, p<0.01, or 0.9%, respectively). Hypotheses 1ii and 2ii can thus be accepted. The difference between the two coefficients is statistically significant (x^2=43.22, p<0.01). Moreover, the 2020 period is associated with a decline in mental health (-2.425, p<0.01, or -1.0%).

By including socio-demographic information, Model II illustrates that m-physical and m-mental health apps are associated with better mental health (4.281, p<0.01, or 1.6%; and 3.268, p<0.01, or 0.9%, respectively). The difference between the two coefficients is statistically significant (x^2=47.56, p<0.01). The 2020 period is associated with poorer mental health (-1.355,

[3] The estimates indicate that higher education and employment are associated with better health, suggesting that status characteristics should be linked to higher income and well-being. Relevant patterns, in relation to income and physical and mental health, are observed in the international literature (Drydakis, 2021e; 2015b; Kawachi and Beckman, 2000). Moreover, the estimates indicate that men and cis-gender people experience better physical health than do women and trans-gender people, similar to reports in the international literature (Drydakis, 2021d). Physical and mental health inequalities might be explained by factors such as higher unemployment, poverty, debt, and sex discrimination (Drydakis, 2015b; 2016a; 2020a).

p<0.01, or -0.5%). There are positive associations between mental health and men (6.684, p<0.01, or 6.3%), and cis-gender people (5.529, p<0.10, or 7.4%), with negative associations between mental health and age (-31.405, p<0.01, or -14.3%).

Similarly, Model III continues to indicate that m-physical and m-mental health apps are associated with better mental health (4.474, p<0.01, or 1.6%; and 2.617, p<0.01, or 0.7%, respectively). The difference between the two coefficients is statistically significant (x^2=43.76, p<0.01). The 2020 period is associated with poorer mental health (-1.275, p<0.01, or -0.5%). There are positive associations between mental health and men (5.550, p<0.01, or 5.2%), and cis-gender people (5.025, p<0.10, or 6.7%), with negative associations between mental health and age (-29.340, p<0.01, or -13.4%), unemployment (-6.100, p<0.01 or -2.3%), and inactivity (-4.088, p<0.05, or -0.4%).

[Table 4]

In the full informative model i.e., Model IV, there are positive associations between m-physical and m-mental health apps and mental health (4.651, p<0.01, or 1.7%; and 2.372, p<0.01, or 0.6%, respectively). The difference between the two coefficients is statistically significant (x^2=46.45, p<0.01). There are positive associations between mental health and economic condition (3.415, p<0.01, or 14.2%), and men (4.422, p<0.01, or 4.1%), with negative associations between mental health and age (-25.551, p<0.01, or -11.6%), unemployment (-4.723, p<0.01 or -1.8%), inactivity (-3.804, p<0.05, or -0.3%), and the year 2020 (-1.387, p<0.01, or -0.5%).

5.3 Jointed associations and interactions

In Table 5, the m-physical and m-mental health apps variables are added to form a new variable that captures jointed patterns. In Model I, it is estimated that using both m-physical and m-mental health apps is associated with better physical health (3.114, p<0.01, or 2.1%). Interacting the use of m-physical and m-mental health apps with the year 2020, the difference estimate indicates a statistically insignificant coefficient (1.079, p>0.10 or 0.2%).

[Table 5]

Model II shows that using both m-physical and m-mental health apps is associated with better mental health (1.729, p<0.01, or 1.1%). The interaction between the use of m-physical and m-mental health apps and the year 2020 indicates a positive outcome (3.352, p<0.01, or 0.8%). The pattern suggests that the use of m-physical and m-mental health apps might be associated with increased mental health status in 2020 compared to 2018–2019.

5.4 Robustness tests

Table 6 offers robustness specifications and reports robust standard errors. Models I–III present physical health (SF-36 GH) estimates. Model I offers random effects estimates, showing that m-physical health apps are associated with better physical health (5.773, $p<0.01$, or 2.2%). Model II presents pooled OLS estimates, showing that m-physical and m-mental health apps are associated with better physical health (8.609, $p<0.01$, or 3.3%; and 5.520, $p<0.01$, or 1.6%, respectively). Model III offers fixed effects estimates, illustrating that m-physical health apps are associated with better physical health (3.852, $p<0.01$, or 1.4%).

[Table 6]

Models IV–VI offer mental health (SF-36 MH) estimates. The random effects estimates in Model IV demonstrate that m-physical and m-mental health apps are associated with better mental health (4.651, $p<0.01$, or 1.7%; and 2.372, $p<0.01$, or 0.6%, respectively). Similarly, the pooled OLS estimates in Model V show that m-physical and m-mental health apps are associated with better mental health (6.486, $p<0.01$, or 2.4%; and 6.241, $p<0.01$, or 1.8%, respectively). Model VI offers the fixed effects estimates showing that m-physical health apps are associated with better mental health (3.907, $p<0.01$, or 1.4%).

Taken together, the estimates in Table 6 suggest that the outcomes presented in Tables 3 and 4 hold for the different empirical specifications.

6. Discussion and conclusions

6.1 Outcomes' evaluation

This study examined associations between m-physical and m-mental health apps in use and sexual minorities' physical and mental health status in Greece. The study offered new insights into the subject matters, employing panel data sets for the period spanning 2018–2020. It was hypothesized that m-physical and m-mental health apps could enhance informational capabilities by encouraging sexual minorities to engage in more informed actions, associated with better physical and mental health status (Sen, 1985; 1999). M-health might provide an accessible venue information platform, creating a better match between sexual minorities' needs and better health functioning (Drydakis, 2021a). M-health's instantaneous information access, and direct interactions between the user and the health provider, may allow for faster transfer of valued information for action, thus boosting users' health literacy and allowing them to achieve an understanding of, and education on, health issues (Drydakis, 2021a).

The lack of healthcare providers' awareness of, and sensitivity to, sexual minorities' needs has been identified as a factor exaggerating health inequalities against the relevant community (Meads, 2020). The study's outcomes indicated that sexual minorities who utilize m-physical and m-mental health apps experienced better physical and mental health, thus meaning that these apps

could be considered supporting mechanisms which make it possible to access health-related services which can boost users' ability to address health questions, issues and concerns and make informed decisions (Drydakis, 2021a; Gigler, 2015; Zheng and Walsham, 2008; Alkire, 2005). The international literature has found that minority population groups might utilize m-health apps to reduce the stressors associated with having to interact with traditional health services in the presence of a stigmatizing condition (Aboueid et al., 2019, Amante et al., 2015; Hamine et al., 2015; Carter et al., 2015). Hence, m-health might play a critical role in individuals' health education, health and disease self-management, and health promotion (Wattanapisit et al., 2020; Dubov et al., 2021; Nie et al., 2020; Nelson et al., 2020; Bennion et al., 2019; Sharpe and Kamara, 2018; Chandrashekar, 2018; Mosa et al., 2012; Lim et al., 2011). Especially, this might be the case in Greece, where homophobia is a profound factor when it comes to systematic exclusion and restrictions on access to good-quality healthcare for the sexual minority community (Giannou and Ioakimidis, 2020).

The study found that, in 2020, sexual minorities experienced poorer physical and mental health compared to 2018–2019. In the general population, COVID-19 has brought about new physical and psychological health risks, isolation, and loneliness, as well as economic vulnerability (Pardhan and Drydakis, 2021; Bradbury-Jones and Isham, 2020). Moreover, marginalized communities, including sexual minorities, may have been disproportionally affected by the COVID-19 pandemic in terms of deteriorated well-being (Phillips, 2021; Salerno et al., 2020), as they might have had to quarantine with often unaccepting or abusive families (Phillips, 2021). If that is the case, one might expect an increase in adverse experiences due to interactions with people who do not affirm sexual minorities' identity, which might in turn be associated with long-term consequences for their physical and mental health. International studies evaluated the adverse psychosocial effects of the COVID-19 pandemic on sexual minorities, indicating that these psychosocial impacts may exaggerate the existing vulnerability of this population, whose members have been subjected to the different effects of sexual and gender prejudice (Phillips, 2021; Barrientos et al., 2021; Fish et al., 2020; Gonzales et al., 2020). In Europe and South America, depression and anxiety were higher among younger sexual minorities, those not working, and those who reported feeling more emotionally affected by the pandemic, uncomfortable at home, or isolated from non-LGBTIQ+ friends (Drabble and Eliason, 2021).

The study found that, in 2020, i.e., during the COVID-19 pandemic, the use of m-physical and m-mental health apps provided higher returns to good mental health than before the COVID-19 pandemic (in 2018–2019). It might be the case that, during the COVID-19 period, when there was an increased need for physical and mental health information, disease prevention and management, utilization of m-health apps was more needed than before the COVID-19 pandemic. The present

study indicates that tracking health information during periods of increased uncertainty could be associated with enhanced extraction of health information, health prevention, disease management, and healthy coping strategies. During the COVID-19 pandemic, which saw lockdowns (designed to save lives) and schedules disrupted, as well as medical and psychological care curtailed, m-health apps might have provided useful health-related services. Indeed, a meta-review of 83 studies indicated that there was good evidence on the usability, safety, acceptance/satisfaction, and effectiveness of m-health apps to mitigate the negative impact of the COVID-19 pandemic on public mental health (Rauschenberg et al., 2021). During the pandemic, governments and tech companies developed m-health apps to keep the population informed and help manage the crisis (Rauschenberg et al., 2021; Torous and Keshavan, 2020; WHO, 2020).

If m-health apps can alleviate depression symptoms, then their potential during periods of unprecedented stress should be considered (Rauschenberg et al., 2021; Nie et al., 2020; Firth et al., 2017). The notion of an information society is converging with that of an inclusive society where access to, and use of, technology should be considered as a potential tool for fostering inclusive policies for minorities' well-being and progression (Drydakis, 2021a). Apart from mobile opportunities, actions to reduce stigma and exclusions against sexual minorities in families, schools, workplaces, and services should be considered, which in turn could reduce the factors which negatively affect sexual minorities' well-being and development (Bozani et al., 2020; Sidiropoulou, et al., 2020; Drydakis, 2019a).

6.2 Limitations and future research

The study's estimates should not be interpreted as representative for several reasons. A key weakness of this study is the small sample size. The sample size might impact on the generalization of the research outcomes. Moreover, the data collection was conducted in the capital city of Greece, and sexual orientation minorities might experience a higher level of homophobia in rural areas (Drydakis, 2012a). Moreover, in rural areas, the use of m-health technology might be less common, and so there is a need for future research on how regions moderate the use of m-health and health outcomes.

The sample consisted of data collected during a period in which the country experienced a massive economic recession (Drydakis, 2015b; 2016a), and so the patterns might be different in better-developed economies; thus, further studies are needed to offer firm evaluations. Moreover, the data were collected from sexual minorities who participated in community gatherings and events, and so the physical and mental health profiles of those not participating in relevant events are unknown. Comparable concerns hold for the degree of sexual orientation openness. It might be the case that, at LGBTIQ+ events, closed LGB people might not participate and closed sexual

minorities might not experience social exclusions and discrimination, but rather stress related to sexual orientation concealment (Drydakis, 2015a). A future study assessing the physical and mental health status of sexual minorities based on an openness status and whether they utilize m-health should generate new insights.

In this study, information on different sexual minority groups was not collected, and so a future study examining whether the main patterns hold for gays/lesbians, bisexuals, queers, questioning, pansexuals, and asexuals would be informative. Furthermore, heterosexuals were not recruited, and thus it would be interesting to assess whether m-health is more strongly (or weakly) associated with heterosexuals' physical and mental health status. Health inequalities in relation to mobile technology might shed light on interesting patterns, as well as the interactions between sexual orientation and gender identity (Drydakis, 2020) and trans people's experiences compared to those of cis-gender people (Drydakis, 2016b; 2017a; b).

The study did not gather information on certain health conditions and corresponding m-health apps. A new systematic study should quantify the associations between (i) telemedicine and health outcomes, and (ii) telehealth and health outcomes (Weinstein et al., 2014). In the current study, information on the frequency and duration of the m-physical and m-mental health apps was not available. Future studies should collect such information to evaluate further dimensions of m-health apps usage.

Although the study utilized panel data, the assigned patterns should not be treated as causal effects but as associations. In the literature, it is difficult to minimize and exclude endogenous relationships between better physical and mental health status and usage of information and communication technologies (Drydakis, 2021a). Similarly, information in relation to personality characteristics, history of victimization, and chronic health conditions was missing (Sidiropoulou et al., 2020; Drydakis, 2019b; Drydakis et al., 2018); thus, a future study should collect critical information for better-informed evaluations. Moreover, the role of the digital divide (Drydakis, 2022b) within sexual minorities and its impact on m-health utilization shall inform new studies.

6.3 Conclusions

The present study found associations between the use of m-physical and m-mental health apps and good physical and mental health status for sexual minorities in Greece, during the period spanning 2018-2020. The outcomes indicated that the association between the use of m-physical and m-mental health apps and good mental health status was stronger during the COVID-19 pandemic than before. The study suggested that, if m-health apps can alleviate adverse physical and mental health symptoms for sexual minorities, their potential should be considered.

References

Aboueid, S., Liu, R. H., Desta, B. N., Chaurasia, A., & Ebrahim, S. (2019). The Use of Artificially Intelligent Self-Diagnosing Digital Platforms by the General Public: Scoping Review. *JMIR Medical Informatics*, 7(2): 1-10.

Alkire, S. (2005). Why the Capability Approach? *Journal of Human Development*, 6(1): 115-135.

Amante, D. J., Hogan, T. P., Pagoto, S. L., English, T. M, & Lapane, K. L. (2015). Access to Care and Use of the Internet to Search for Health Information: Results from the US National Health Interview Survey. *Journal of Medical Internet Research*, 17(4): 1-10.

Anagnostopoulos, F., Niakas, D., & Pappa, E. (2005). Construct Validation of the Greek SF-36 Health Survey. *Quality Life Research*, 5(8): 1959–1965.

Anthes, E. (2016). Mental Health: There's an App for That. *Nature*, 532(20-3): 1-4.

Barrientos, J., Guzmán-González, M., Urzúa, A., & Ulloa, F. (2021). Psychosocial Impact of COVID-19 Pandemic on LGBT People in Chile. *Sexologies*, 30(1): e35-e41.

Bauer, A. M., Rue, T., Keppel, G. A., Cole, A. M., Baldwin, L-M., & Katon, W. (2014). Use of Mobile Health (mHealth) Tools by Primary Care Patients in the WWAMI Region Practice and Research Network (WPRN). *Journal of the American Board of Family Medicine*, 27(6):780–788.

Beck, F., Richard, J. B., Nguyen-Thanh, V., Montagni, I., Parizot, I., & Renahy, E. (2014). Use of the Internet as a Health Information Resource among French Young Adults: Results from a Nationally Representative Survey. *Journal of Medical Internet Research*, 16(5): 1-13.

Belsley D. (1991). Conditioning Diagnostics: Collinearity and Weak Data in Regression. New York: Wiley.

Bennion, M., Hardy, G., Moore, R., Kellett, S., & Millings, A. (2019). E-therapies in England for Stress, Anxiety or Depression: How Are Apps Developed? A Survey of NHS E-Therapy Developers. *BMJ Health and Care Informatics*, 26(1): 1-9.

Bozani, V., Drydakis, N., Sidiropoulou, K., Harvey, B., & Paraskevopoulou, A. (2020). Workplace Positive Actions, Trans People's Self-Esteem and Human Resources' Evaluations. *International Journal of Manpower*, 41(6): 809-831.

Bradbury-Jones C., & Isham, L. (2020). The Pandemic Paradox: The Consequences of COVID-19 on Domestic Violence. *Journal of Clinical Nursing*, 29(13-14): 2047-2049.

Byron, P. (2019). 'Apps Are Cool but Generally Pretty Pointless': LGBTIQ+ Young People's Mental Health App Ambivalence. *Media International Australia*. 171(1): 51-65.

Cahill, S., Macijauskiene, J., Nygård, A., Faulkner, J., & Hagen, I. (2007). Technology in Dementia Care. *Technology and Disability*, 19(2):55-60.

Carter, A., Liddle, J., Hall, W., & Chenery, H. (2015). Mobile Phones in Research and Treatment: Ethical Guidelines and Future Directions. *JMIR Mhealth and Uhealth*, 3(4): 1-8.

Chandrashekar, P. (2018). Do Mental Health Mobile Apps Work: Evidence and Recommendations for Designing High-Efficacy Mental Health Mobile apps. *mHealth*, 4(6): 1-4.

Clarke, K. A. (2005). The Phantom Menace: Omitted Variable Bias in Econometric Research. *Conflict Management and Peace Science*, 22(4): 341–352.

Cochran, S. D., & Mays, V. M. (2012). Risk of Breast Cancer Mortality Among Women Cohabiting With Same Sex Partners: Findings from the National Health Interview Survey 1997-2003. *Journal of Women's Health*, 21(5): 528-533.

Craig, S. L., McInroy, L. B., McCready, L. T., Di Cesare, D. M., & Pettaway, L. D. (2015). Connecting Without Fear: Clinical Implications of the Consumption of Information and Communication Technologies by Sexual Minority Youth and Young Adults. *Clinical Social Work Journal*, 43(2): 159–168.

Craig, S. L., Leung, V.W.Y., Pascoe, R., Pang, N., Iacono, G., Austin, A., & Dillon, F. (2021). AFFIRM Online: Utilising an Affirmative Cognitive–Behavioural Digital Intervention to Improve Mental Health, Access, and Engagement among LGBTQA+ Youth and Young Adults. *International Journal of Environmental Research and Public Health*, 18: 1541.

Dahl, T., & Boulos, M. (2013). Robots in Health and Social Care: A Complementary Technology to Home Care and Telehealth Care? *Robotics*, 30(1):1-21.
Drabble, A. L., & Eliason, J. M. (2021). Introduction to Special Issue: Impacts of the COVID-19 Pandemic on LGBTQ+ Health and Well-Being. *Journal of Homosexuality,* 68:4, pages 545-559.
Doherty, A. M., & Gaughran, F. (2014). The Interface of Physical and Mental Health. *Social Psychiatry and Psychiatric Epidemiology*, 49: 673–682.
Drydakis, N. (2009). Sexual Orientation Discrimination in the Labour Market. *Labour Economics*, 16(4): 364-372.
Drydakis, N. (2011). Women's Sexual Orientation and Labor Market Outcomes in Greece. *Feminist Economics*, 11(1):89-117.
Drydakis, N. (2012a). Sexual Orientation and Labour Relations New Evidence from Athens, Greece. *Applied Economics*, 44(20): 2653-2665.
Drydakis, N. (2015a). Effect of Sexual Orientation on Job Satisfaction: Evidence from Greece. *Industrial Relations: A Journal of Economy and Society*, 54(1): 162-187.
Drydakis, N. (2015b). The Effect of Unemployment on Self-reported Health and Mental Health in Greece from 2008 to 2013: A Longitudinal Study Before and During the Financial Crisis. *Social Science and Medicine*, 128(March): 43-51.
Drydakis, N. (2016a). The Relationship Between Recessions and Health. IZA World of Labor No. 283. Bonn: IZA World of Labor.
Drydakis, N. (2016b). Transgenderism, Sex Reassignment Surgery and Employees' Job-Satisfaction, in T. Köllen (Ed.), *Sexual Orientation and Transgender Issues in Organizations Global Perspectives on LGBT Workforce Diversity* (pp. 83-99). New York: Springer Publishing.
Drydakis, N. (2017a). Trans Employees, Transitioning, and Job Satisfaction. *Journal of Vocational Behavior*, 78:1-16.
Drydakis, N. (2017b). Trans People, Well-Being, and Labor Market Outcomes. IZA World of Labor 2017 No. 386. Bonn: IZA World of Labor.
Drydakis, N., Sidiropoulou, K., Patnaik. S., Selmanovic, S., & Bozani, V. (2018). Masculine vs Feminine Personality Traits and Women's Employment Outcomes in Britain: A Field Experiment. *International Journal of Manpower*, 39(4): 621-630.
Drydakis, N. (2019a). *Sexual Orientation and Labor Market Outcomes*. IZA World of Labor No 111.v2. Bonn: IZA World of Labor.
Drydakis, N. (2019b). School-Age Bullying, Workplace Bullying and Job Satisfaction: Experiences of LGB People in Britain. *Manchester School*, 87(4): 455-488.
Drydakis, N., & Zimmermann, K. F. (2020). Sexual Orientation, Gender Identity and Labour Market Outcomes: New Patterns and Insights. *International Journal of Manpower,* 41(6): 621-628.
Drydakis, N. (2020). Trans People, Transitioning, Mental Health, Life and Job Satisfaction in K. F. Zimmermann (Eds), *Handbook of Labor, Human Recourses and Population Economics*. New York: Springer.
Drydakis, N. (2021a). Mobile Applications Aiming to Facilitate Immigrants' Societal Integration and Overall Level of Integration, Health and Mental Health. Does Artificial Intelligence Enhance Outcomes? *Computers in Human Behavior*, 117(April): 106661.
Drydakis, N. (2021b). Sexual Orientation and Earnings: A Meta-Analysis 2012–2020. *Journal of Population Economics*, 35: 409-440.
Drydakis, N. (2021c, on-line first). Sexual orientation discrimination in the labor market against gay men. *Review of Economics of the Household*.
Drydakis, N. (2021d, on-line first). Social Rejection, Family Acceptance, Economic Recession, and Physical and Mental Health of Sexual Minorities. *Sexuality Research and Social Policy*.
Drydakis, N. (2021e, on-line first). Sex workers' self-reported physical and mental health in Greece. A repeated cross-sectional study in 2009, 2013 and 2019. *Culture, Health and Sexuality*.

Drydakis, N. (2022a, on-line first). The Perceived Social Rejection of Sexual Minorities: Substance Use and Unprotected Sexual Intercourse. *Drug and Alcohol Review*.
Drydakis, N. (2022b). Improving Entrepreneurs' Digital Skills and Firms' Digital Competencies through Business Apps Training: A Study of Small Firms. *Sustainability*, 14(8); 4417.
Dubov, A., Fraenkel, L., Goldstein, Z., Arroyo, H., McKellar, D., & Shoptaw, S. (2021). Development of a Smartphone App to Predict and Improve the Rates of Suicidal Ideation Among Transgender Persons (TransLife): Qualitative Study. *Journal of Medical Internet Research*, 23(3): e24023.
Eurobarometer (2019). *Special Eurobarometer 493*. *Discrimination in the European Union: The Social Acceptance of LGBTI People in the EU*. Brussels: European Commission.
Firth, J., Torous. J., Nicholas, J., Carney, R., Rosenbaum, S., & Sarris, J. (2017). Can Smartphone Mental h\Health Interventions Reduce Symptoms of Anxiety? A Metaanalysis of Randomized Controlled Trials. *Journal of Affecting Disorders*, 218(August): 15-22.
Fish, J. N., McInroy, B. L., Paceley, S. M., Williams, N. D., Henderson, S., Levine, S. D., & Edsall, N. R. (2020). "I'm Kinda Stuck at Home with Unsupportive Parents Right Now": LGBTQ Youths' Experiences With COVID-19 and the Importance of Online Support. Journal of Adolescent Health, 67(3): 450-452.
Fontenot, H. B., White, B. P., Rosenberger, J. G., Lacasse, H., Rutirasiri, C., Mayer, K. H., & Zimet, G. (2020). Mobile App Strategy to Facilitate Human Papillomavirus Vaccination Among Young Men Who Have Sex with Men: Pilot Intervention Study. *Journal of Medical Internet Research*, 22(11): e22878.
Gajecki, M., Berman, A. H., Sinadinovic, K., Rosendahl, I., & Andersson, C. (2014). Mobile Phone Brief Intervention Applications for Risky Alcohol Use Among University Students: A Randomized Controlled Study. *Addiction Science and Clinical Practice*, 9(11): 1-12.
Gannon, B., Davis, R., Kuhns, L. M., Rodriguez, R. G., Garofalo, R., & Schnall, R. (2020). A Mobile Sexual Health App on Empowerment, Education, and Prevention for Young Adult Men (MyPEEPS Mobile): Acceptability and Usability Evaluation. *JMIR Formative Research*, 4(4): e17901.
Garg, P. R., Uppal, L., Mehra, S., & Mehra, D. (2020). Mobile Health App for Self-Learning on HIV Prevention Knowledge and Services Among a Young Indonesian Key Population: Cohort Study. *JMIR Mhealth and Uhealth*, 8(9):e17646.
Ghahramani, F., & Wang, J. (2020). Impact of Smartphones on Quality of Life: A Health Information Behavior Perspective. *Information Systems Frontier*. 22: 1275–1290.
Giannou, D., & Ioakimidis, V. (2020). Neither Invisible nor Abnormal! Exploring the Invisibility and Pathologisation of LGBT People in the Greek National Health System. *Critical Social Policy,* 40(3): 370-388.
Gigler, B. S. (2015). *Development as Freedom in a Digital Age: Experiences from the Rural Poor in Bolivia*. Washington DC: World Bank.
Gindidis, S., Stewart, S., & Roodenburg, J. (2019). A Systematic Scoping Review of Adolescent Mental Health Treatment Using Mobile Apps. *Advances in Mental Health*, 17(2): 161-177.
Gonzales, G., Loret de Mola, E., Gavulic, K. A., McKay, T., & Purcell, C. (2020). Mental Health Needs Among Lesbian, Gay, Bisexual, and Transgender College Students During the COVID-19 Pandemic. *Journal of Adolescent Health*, 67(5): 645-648.
Goodwin, J., Cummins, J., Behan, L., & O'Brien, S. M. (2016). Development of a Mental Health Smartphone App: Perspectives of Mental Health Service Users. *Journal of Mental Health*, 25(5): 434–440.
Hafeez, H., Zeshan, M., Tahir, M. A., Jahan, N., & Naveed, S. (2017). Health Care Disparities Among Lesbian, Gay, Bisexual, and Transgender Youth: A Literature Review. *Cureus*, 9(4): e1184.
Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B. B., & Ginsburg, A. S. (2015). Impact of mHealth Chronic Disease Management on Treatment Adherence and Patient Outcomes: A Systematic Review. *Journal of Medical Internet Research*, 17(2): 1-15.

Heeks, R. (2002). I-Development not E-Development: Special Issue on ICTs and Development. *Journal of International Development*, 14(1): 1-11.

Hightow-Weidman, L. B., Muessig, K. E., Pike, E. C., LeGrand, S., Baltierra, N., Rucker, A. J., & Wilson, P. (2015). HealthMpowerment Org: Building Community Through A Mobile-Optimized, Online Health Promotion Intervention. *Health Education and Behavio*r, 42(4): 493–499.

Izahar, S., Lean, Q. Y., Hameed, M. A., Murugiah, M. K., Patel, R. P., Al-Worafi, M. Y., Wong, T. W., & Ming, L. C. (2017). Content Analysis of Mobile Health Applications on Diabetes Mellitus. *Front Endocrinol*, 8: 318.

Jones, N., & Moffitt, M. (2016). Ethical Guidelines for Mobile App Development Within Health and Mental Health Fields. *Professional Psychology: Research and Practice*, 47(2): 155–162.

Kawachi, I., & Beckman, L. (2000). *Social Epidemiology*. New York: Oxford University Press.

Kim, H., & Xie, B. (2015). Health Literacy and Internet-and Mobile App Based Health Services: A Systematic Review of the Literature. *Proceedings of the Association for Information Science and Technology*, 52(1): 1–4.

Kolar, D. R., Hammerle, F., Jenetzky, E., Huss, M., & Bürger, A. (2016). Aversive Tension in Female Adolescents with Anorexia Nervosa: A Controlled Ecological Momentary Assessment Using Smartphones. *BMC Psychiatry*, 16(97): 1-11.

Kontodimopoulos, N., Pappa, E., Niakas, D., Yfantopoulos, J., Dimitrakaki, D., & Tountas, Y. (2008). Validity of the EuroQoL (EQ-5D) Instrument in a Greek General Population, *Value in Health*, 11(7): 1162-1169.

Lick, D. J., Durso, L. E., & Johnson, K. L. (2013). Minority Stress and Physical Health Among Sexual Minorities. *Perspectives on Psychological Science*, 8(5): 521–548.

Lim, S., Xue, L., Yen, C. C., Chang, L., Chan, H. C., Tai, B. C., Duh, H. B. L., & Choolani, M. (2011). A Study on Singaporean Women's Acceptance of Using Mobile Phones to Seek Health Information. *International Journal of Medical Informatics*, 80(12): 189–202.

Marcolino, S. M., Oliveira, Q. J. A., D'Agostino, M., Ribeiro, L. A, Alkmim, M. M. B., & Novillo-Ortiz, D. (2018). The Impact of mHealth Interventions: Systematic Review of Systematic Reviews. *JMIR Mhealth Uhealth*, 6(1): 1-11.

Meads, C. (2020). Health and Wellbeing Among Sexual Minority People, in. K. F. Zimmermann (Ed). *Handbook of Labor, Human Resources and Population Economics*. London: Springer.

Meskó, B., Drobni, Z., Bényei, É., Gergely, B., & Győrffy, Z. (2017). Digital Health is a Cultural Transformation of Traditional Healthcare. *mHealth*, 3(38): 1-8.

Meyer, I. H. (2003). Prejudice, Social Stress, and Mental Health in Lesbian, Gay, and Bisexual Populations: Conceptual Issues and Research Evidence. *Psychological Bulletin*, 129(5): 674–697.

Mohapatra, D., Mohapatra, M., Chittoria, R., Friji, M., & Kumar, S. (2015). The Scope of Mobile Devices in Health Care and Medical Education. *International Journal of Advance Medical Health Research*, 2(1): 3–8.

Morgan, S. L. (2013). *Handbook of Causal Analysis for Social Research*. Dordrecht: Springer.

Morse, S. S., Murugiah, M. K., Soh, Y. C., Wong, T. W., & Ming, L. C. (2018). Mobile Health Applications for Pediatric Care: Review and Comparison. *Therapeutic Innovation and Regulatory Science*, 52(3): 383-91.

Mosa, A. S. M., Yoo, I., & Sheets, L. (2012). A Systematic Review of Healthcare Applications for Smartphones. *BMC Medical Informatics and Decision Making* 2012, 12(67): 1-31.

Mutebi, I., & Devroey, D. (2018). Perceptions on Mobile Health in the Primary Healthcare Setting in Belgium. *mHealth*, 4(44): 1-10.

Nelson, M. K., Perry, S. N., Horvath, J. K., & Smith, R. L. (2020). A Systematic Review of mHealth Interventions for HIV Prevention and Treatment Among Gay, Bisexual, And Other Men Who Have Sex with Men. *Translational Behavioral Medicine*, 10(5): 1211–1220.

Nie, P., Wanglin, M., and Sousa-Poza, A. (2020 on-line first). The Relationship Between Smartphone Use and Subjective Well-Being in Rural China. *Electronic Commerce Research*, 1-27.

Ohrnberger, J., Fichera, E., & Sutton, M. (2017). The Relationship Between Physical and Mental Health: A Mediation Analysis. *Social Science and Medicine*, 195, 42–49.

Pappa, E., Kontodimopoulos, N., & Niakas, D. (2005). Validating and Norming of the Greek SF-36 Health Survey. *Quality of Life Research*, 14(5): 1433–1438.

Pardhan, S., & Drydakis, N. (2021). Associating the Change in New COVID-19 Cases to GDP per Capita in 38 European Countries in the First Wave of the Pandemic. *Frontiers in Public Health: Health Economics*, 8: 1065.

Phillips, C. (2021). How Covid-19 Has Exacerbated LGBTQ+ Health Inequalities. *The BMJ*; 372: m4828.

Rauschenberg, C., Schick, A., Hirjak, D., Seidler, A., Paetzold, I., Apfelbacher, C., Riedel-Heller, S. G., & Reininghaus, U. (2021). Evidence Synthesis of Digital Interventions to Mitigate the Negative Impact of the COVID-19 Pandemic on Public Mental Health: Rapid Meta-review. *Journal of Medical Internet Research*, 23(3): e23365.

Price, M., Yuen, E. K., Goetter, E. M., Herbert, J. D., Forman, E. M., Acierno, R., & Ruggiero, K. J. (2014). mHealth: A Mechanism to Deliver More Accessible, More Effective Mental Health Care. *Clinical Psychology and Psychotherapy*, 21(5): 427-436.

Sagar, R., & Pattanayak, R. (2015). Use of Smartphone Apps for Mental Health: Can they Translate to a Smart and Effective Mental Health Care? *Journal of Mental Health and Human Behaviour*, 20(1): 1–3.

Salerno, J. P., Williams, N. D., & Gattamorta, K. A. (2020). LGBTQ Populations: Psychologically Vulnerable Communities in the COVID-19 Pandemic. *Psychological Trauma: Theory, Research, Practice, and Policy*, 12(S1), S239–S242.

Sen, A. (1985). Well-Being, Agency and Freedom: The Dewey Lectures 1984. *The Journal of Philosophy*, 82(4): 169-221.

Sen, A. (1999). *Development as Freedom*. Oxford: Oxford University Press.

Sharpe, J. S., & Kamara, M. T. (2018). A Systematic Evaluation of Mobile Apps to Improve the Uptake of and Adherence to HIV Pre-Exposure Prophylaxis. *Sexual Health*, 15: 587–594.

Shrestha, R., Lim, S. H., Altice, F. L., Copenhaver, M., Wickersham, J. A., Saif, R., Halim, M. A., Naning, H., & Kamarulzaman, A. (2019). Use of Smartphone to Seek Sexual Health Information Online Among Malaysian Men Who Have Sex with Men (MSM): Implications for mHealth Intervention to Increase HIV Testing and Reduce HIV Risks. *Journal of Community Health*, 45: 10-19.

Sidiropoulou, K., Drydakis, N., Harvey, B., & Paraskevopoulou, A. (2020-on line first). Family Support, School-Age and Workplace Bullying for LGB People. *International Journal of Manpower*, 41: 717-730.

Smith, M. L., Spence, R., & Rashid, A. T. (2011). Mobile Phones and Expanding Human Capabilities. *Information Technologies and International Development*, 7(3): 77-88.

Sroiter, A. (2014). Autopsy: Homophobic Attacks. Athens: Alpha TV.

Torous, J., & Keshavan, M. (2020). COVID-19, Mobile Health and Serious Mental Illness. *Schizophrenia Research,* 218: 36–37.

Vaisey, S., & Miles, A. (2017). What You Can—And Can't—Do with Three-Wave Panel Data. *Sociological Methods and Research*, 46(1): 44–67.

Ventuneac, A., John, S. A., Whitfield, T. H. F., Mustanski, B., & Parsons, J. T. (2018). Preferences for Sexual Health Smartphone App Features Among Gay and Bisexual Men. *AIDS Behavior*, 22(10): 3384-3394.

Ware, J., Snow, K., Gandek, B., & Kosinski, M. (1993). *SF-36 Health Survey Manual and Interpretation Guide*. Boston: Medical Center.

Ware, J., Snow, K., Kosinski, M., & Gandek, B. (1994). *SF-36 Physical and Mental Summary Scales: A User's Manual*. Boston: The Health Institute.

Ware J. (2000). SF-36 Health Survey Update. *Spine*, 25(24): 3130–3139.
Ware, J. E., Kosinski, M., and Gandek, B., (2004). SF-36 Health Survey Manual and Interpretation Guide. Lincoln, RI: Qualiymetric Incorporated.
Wattanapisit, A., Hai Teo, C., Wattanapisit, S., Teoh, E., Jun Woo, W., & Jenn Ng, C. (2020). Can Mobile Health Apps Replace GPs? A Scoping Review of Comparisons between Mobile Apps and GP Tasks. *BMC Medical Informatics and Decision Making*, 20(5): 1-11.
Weinstein, R. S., Lopez, A. M., Joseph, B. A., Erps, K. A., Holcomb, M., Barker, G. P., & Krupinski, E. A. (2014). Telemedicine, Telehealth, and Mobile Health Applications That Work: Opportunities and Barriers. *The American Journal of Medicine*, 127(3): 183-187.
Whittaker, R., McRobbie, H., Bullen, C., Rodgers, A., & Gu, Y. (2016). Mobile Phone-Based Interventions for Smoking Cessation. *The Cochrane Database Systematic Review*, 10(4): 1-54.
WHO (2020). *M-Health Hub: M-Health Solutions for Managing the Covid-19 Outbreak*. Geneva:
Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*. Second Edition. Cambridge MA: The MIT Press.
World Health Organization (2011). *mHealth New horizons for Health through Mobile Technologies. Geneva*: World Health Organization.
Yuan, S., Ma, W., Kanthawala, S., & Peng, W. (2015). Keep Using My Health Apps: Discover Users Perception of Health and Fitness Apps with the UTAUT2 Model. *Telemedicine and e-Health*, 21(5):735-41.
Zheng, Y., & Walsham, G. (2008). Inequality of What? Social Exclusion in the E-Society as Capability Deprivation. *Information Technology and People*, 21(3): 222-243.

Table 1. Descriptive statistics.

	Panel I: 2018	Panel II: 2019	Panel III: 2020	Panel IV: 2018-2020
Men (percent)	65.02 (0.47)	66.31 (0.47)	60.60 (0.49)	64.17 (0.47)
Cis-gender (percent)	91.92 (0.27)	91.44 (0.28)	90.90 (0.28)	91.47 (0.27)
Age (c.)	32.50 (10.01)	33.19 (9.79)	34.58 (9.91)	33.32 (9.93)
Higher education (percent)	32.73 (0.47)	34.22 (0.47)	36.36 (0.48)	34.26 (0.47)
Unemployed (percent)	26.90 (0.44)	25.66 (0.43)	28.48 (0.45)	26.95 (0.44)
Inactive (percent)	7.62 (0.26)	6.41 (0.24)	5.45 (0.22)	6.60 (0.24)
Economic condition (c.)	2.76 (1.09)	2.83 (1.02)	2.82 (0.90)	2.80 (1.01)
Smartphone owners (percent)	93.27 (0.25)	94.11 (0.23)	95.75 (0.20)	94.26 (0.23)
Use of m-physical health apps (percent)	18.75 (0.39)	25.98 (0.43)	34.17 (0.47)	25.59 (0.43)
Use of m-mental health apps (percent)	12.98 (0.33)	20.33 (0.40)	27.84 (0.44)	19.70 (0.39)
Physical health status; SF-36 GH (c.)	67.01 (14.90)	66.36 (12.62)	65.87 (13.68)	66.47 (13.83)
Mental health status; SF-36 MH (c.)	68.37 (15.67)	68.04 (14.01)	66.74 (14.17)	67.80 (14.71)
Observations	223	187	165	575

Notes. (c.) Continuous variable. Standard deviations are in the parenthesis.

Table 2. Correlation matrix

	Physical health status; SF-36 GH	Mental health status; SF-36 MH	m-physical health apps	m-mental health apps
Physical health status; SF-36 GH	1			
Mental health status; SF-36 MH	0.88*	1		
m-physical health apps	0.41*	0.33*	1	
m-mental health apps	0.33*	0.32*	0.21*	1

Notes. Obs.=541. Periods: 2018-2020. The sample is restricted to smartphone owners. (*) Statistically significant at the 1percent.

Table 3. Random effects physical health (SF-36 GH) estimates

	Model I	Model II	Modell III	Model IV
Use of m-physical health apps	5.256 (0.958)*	5.191 (0.918)*	5.654 (0.894)*	5.773 (0.860)*
Use of m-mental health apps	1.880 (1.018)***	2.053 (0.977)**	1.345 (0.970)	1.145 (0.937)
2020 period	-1.842 (0.467)*	-0.893 (0.474)***	-0.924 (0.475)***	-1.061 (0.464)**
Men	-	5.815 (1.542)*	4.691 (1.380)*	3.534 (1.285)*
Cis-gender	-	4.219 (2.794)	2.767 (2.482)	1.980 (2.295)
Age	-	-27.310 (3.560)*	-23.098 (3.247)*	-18.778 (3.059)*
Higher education	-	-	2.010 (1.077)***	1.606 (1.020)
Unemployed	-	-	-7.410 (0.992)*	-5.297 (1.007)*
Inactive	-	-	-0.777 (2.031)	-0.089 (1.923)
Economic condition	-	-	-	3.910 (0.544)*
Wald	43.98	142.51	238.93	330.38
Prob>x^2	0.000	0.000	0.000	0.000

Notes. Obs=541. Periods: 2018-2020. The sample is restricted to smartphone owners. Standard errors are in parentheses. (*) Statistically significant at the 1 percent. (**) Statistically significant at the 5 percent. (***) Statistically significant at the 10 percent.

Table 4. Random effect mental health (SF-36 MH) estimates

	Model I	Model II	Modell III	Model IV
Use of m-physical health apps	4.341 (0.893)*	4.281 (0.858)*	4.474 (0.851)*	4.651 (0.830)*
Use of m-mental health apps	3.098 (0.944)*	3.268 (0.909)*	2.617 (0.917)*	2.372 (0.897)*
2020 period	-2.425 (0.421)*	-1.355 (0.433)*	-1.275 (0.437)*	-1.387 (0.429)*
Men	-	6.684 (1.678)*	5.550 (1.536)*	4.422 (1.462)*
Cis-gender	-	5.529 (3.042)***	5.025 (2.770)***	4.269 (2.618)
Age	-	-31.405 (3.843)*	-29.340 (3.579)*	-25.551 (3.437)*
Higher education	-	-	-0.288 (1.091)	-0.513 (1.053)
Unemployed	-	-	-6.100 (0.957)*	-4.723 (0.965)*
Inactive	-	-	-4.088 (2.056)**	-3.804 (1.982)**
Economic condition	-	-	-	3.415 (0.544)*
Wald	57	167.93	237.46	300.78
Prob>x^2	0.000	0.000	0.000	0.000

Notes. Obs=541. Periods: 2018-2020. The sample is restricted to smartphone owners. Standard errors are in parentheses. (*) Statistically significant at the 1 percent. (**) Statistically significant at the 5 percent. (***) Statistically significant at the 10 percent.

Table 5. Random effects physical health (SF-36 GH) and mental health (SF-36 MH) estimates

	Panel I Physical health; SF-36 GH	Panel II Mental health; SF-36 MH
Use of m-physical and m-mental health apps	3.114 (0.673)*	1.729 (0.617)*
2020 period	-1.621 (0.583)*	-3.062 (0.510)*
Use of m-physical and m-mental health apps x 2020 period	1.079 (0.679)	3.352 (0.590)*
Men	3.570 (1.278)*	4.430 (1.438)*
Cis-gender	2.163 (2.281)	4.305 (2.576)***
Age	-18.749 (3.048)*	-24.899 (3.381)*
Higher education	1.400 (1.021)	-0.635 (1.027)
Unemployed	-4.942 (1.015)*	-4.294 (0.934)*
Inactive	0.591 (1.932)	-3.066 (1.937)
Economic condition	4.047 (0.555)*	3.912 (0.549)*
Wald	325.25	341.13
Prob>x^2	0.000	0.000

Notes. Obs=541. Periods: 2018-2020. The sample is restricted to smartphone owners. Standard errors are in parentheses. (*) Statistically significant at the 1 percent. (***) Statistically significant at the 10 percent.

Table 6. Robustness test. Physical health (SF-36 GH) and mental health (SF-36 MH) estimates

	Physical health; SF-36 GH			Mental health; SF-36 MH		
	Model I Random effects	Model II Pooled OLS	Model III Fixed effects	Model IV Random effects	Model V Pooled OLS	Model VI Fixed effects
Use of m-physical health apps	5.773 (0.994)*	8.609 (0.912)*	3.852 (1.098)*	4.651 (0.954)*	6.486 (0.966)*	3.907 (1.003)*
Use of m-mental health apps	1.145 (1.085)	5.520 (1.033)*	-0.618 (1.116)	2.372 (0.909)*	6.241 (0.946)*	1.458 (0.953)
2020 period	-1.061 (0.413)*	-1.955 (0.856)**	0.970 (0.650)	-1.387 (0.449)*	-2.288 (0.889)**	-0.237 (0.544)
Wald	458.99	-	-	431.47	-	-
Prob>x^2	0.000	-	-	0.000	-	-
F	-	111.24	4.05	-	97.17	8.40
Prob>F	-	0.000	0.000	-	0.000	0.000

Notes. Obs=541. Periods: 2018-2020. The sample is restricted to smartphone owners. Models I, II, IV and V control for gender, gender identity, age, higher education, employment status, and economic condition. Robust standard errors are in parentheses. (*) Statistically significant at the 1 percent. (**) Statistically significant at the 5 percent.