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Determinants of internet use by school-age children: The challenges for Mexico during the COVID-19 pandemic

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ABSTRACT

The COVID-19 pandemic has further highlighted the deep digital divide in Mexico and the enormous challenge faced by its education system in continuing to educate the country’s students while under confinement. The objective of this article was to examine the determinants of internet access, use and productive uses for school-age children in households of different socio-economic levels. The Heckman selection model was estimated based on data taken from the Encuesta Nacional sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares (ENDUTH or National Survey on the Availability and Use of Information Technologies in the Household) 2018. The results obtained show that the probability of having children internet accessing and usage patterns (homework, courses, and blogs) depends on level of schooling, economic status, digital skills, and place of residence, as well as the presence of electronic devices and infomediaries in the household. These findings suggest the urgent need to redesign current ICT policy with a long-term integrated vision that guarantees access to ICTs and their productive use for students immersed in an ecosystem of educational innovation for the XXI century.

1. Introduction

Since March 2020, the global pandemic caused by the COVID-19 virus forced the interruption of economic, social, educational, and other types of activities in Mexico. As a consequence of social distancing and the isolation of families at home, educational institutions transitioned from in-person to online courses (Gobierno de México, 2020). Even before the pandemic, there existed an evident digital inequality in the country (García-Mora & Mora-Rivera, 2021; Martínez-Domínguez, 2020). However, the public health crisis has further widened the digital divide in school-age children due to the lack of internet connection in their homes and the lack of digital skills needed to use these technologies (Cohen & Mata-Sánchez, 2021; Lorente, Arrabal, & Pulido-Montes, 2020).

At the beginning of the 1990s, the internet was used only for sending e-mails, transferring files, and using some software applications (Greenstein, 2020). Today, it increases commercial and service transactions at a global level, facilitates access to information and knowledge (Salemink, Strijker, & Bosworth, 2017; Goncalves, Oliveira, & Cruz-Jesus, 2018), advances communication, and

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1 The term refers to fixed or mobile internet connection in the household (INEGI, 2018a).

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promotes greater human interaction (Greenstein, 2020). Moreover, the effective use\(^2\) of this technology facilitates better results in areas such as education, labor, and health (Robinson et al., 2015); however, it is necessary to narrow the digital divide\(^1\) in order to achieve the above in developing countries (ITU, 2018). According to statistics obtained by the World Bank, in 2020, approximately half of the world’s population still did not have internet access (World Bank, 2020).

Different levels of progress between developed and developing countries are observed in the advance of the information and knowledge society. In this regard, efforts to bridge the digital gap found in countries, such as the United States and Canada, have progressed at a faster pace (Blank & Groselj, 2014; Robinson et al., 2015) than in developing countries. In countries as China and Brazil, the process has been slower due to the economic and social inequalities that characterize their economies (Nishijima, Ivanaukas, & Sarti, 2017; Song, Wang, & Bergmann, 2020).

The geographic, technological, economic, social, and cultural inequalities and heterogeneities that remain in Mexico function as barriers for the diffusion of the internet (Fierros-Gonzalez, Mora-Rivera, & Avila-Foucat, 2020). In terms of economic inequality, the 2018 Gini index for Mexico was calculated at 0.475, indicating that the income concentration is high and similar to African countries, such as Benin (Instituto Nacional de Estadística y Geografía, INEGI or National Institute of Statistics and Geography, 2018b; World Bank, 2020). For the same year, the richest decile of the Mexican population was 18 times wealthier than the poorest.\(^4\)

According to the 2015 Intercensal Survey, the population of Mexico was approximately 126 million, of whom 27.6% were individuals aged between 5 and 19 years (INEGI, 2020). This indicates that Mexico has a significant school-age population,\(^5\) for whom the internet is a tool that can contribute to their formative process and generate opportunities for their human, social, and economic development. In this regard, Hargittai and Hinnant (2008) indicate the importance of digital competencies for successfully joining the job market. Daoud, Starkey, Eppel, Vo, and Sylvester (2020) and Ferguson, Faulkner, Whitelock, and Sheehy (2015) mention that the internet has a positive effect on the academic, individual, and social development of students by contributing skills, autonomy, and independence to their learning, as well as helping them to interact with society.

Although the literature has studied the role of the information and communication technologies (ICTs) in economic growth, productivity, and the reduction of poverty in developing countries (Palvia, Baqir, & Nemati, 2018). However, as these studies were conducted on a national level, they did not consider the microeconomic nature of the effects of ICTs, due to insufficient data (Martínez-Domínguez & Mora-Rivera, 2020).

While research conducted by Lamberti, Lopez-Sintas, and Sukphan (2021) and Blank and Groselj (2014) has expanded understanding of the determinants for access to and use of ICTs, these studies have mostly focused on developed countries (Blank & Groselj, 2014; Robinson et al., 2015), with the topic rarely explored in developing countries such as Mexico.

There are studies that have analyzed school-age children internet access by different socioeconomic contexts (Alderete, 2019; Daoud et al., 2020; García-Martín & Cantón-Mayo, 2019; Hurwitz & Schmitt, 2020; Katz, Moran, & Ognyanova, 2019). However, there has been very little done in terms of the types of internet use. For example, Liao, Chang, Wang, and Sun (2016) examined the social, economic, and family characteristics associated with digital inequality among students from urban and rural areas in Taiwan. Their results show that self-efficacy (the ability to perform a certain task), internet connectivity at home, the educational level of the mother, and computer classes taught at school play a relevant role in reducing the digital divide between students living in rural and urban backgrounds.

Moreover, Alderete (2019), by means of a Heckman approach, examined the determinants of internet use in children aged 3 to 18 from low-income neighborhoods in Argentina. His findings show that the level of income, education, infomediaries, and geographic location play a role on determining access to the internet. With regard to online activities, Chang et al. (2016) contrasted the forms of internet use between adolescents from urban and rural areas in Taiwan. Their findings show that adolescents living in rural areas have lower levels of digital literacy but show a higher frequency of internet use and online videogames than those living in urban areas.

Furthermore, as there is limited research on the new digital era examining digital inequality in the population (Grishchenko, 2020; Van Dijk, 2006), there remains the necessity to show that digital disparity is an additional dimension of economic, social, and political inequality. The findings of new studies can contribute to the design and implementation of public policies focused on solving the problem of the digital divide (Robinson et al., 2015).

Thus, the objective of the present research is to identify the factors that explain internet accessing and usage patterns (homework, courses and blogs) in a representative sample of Mexican children\(^6\) from households of different socio-economic levels, in order to ascertain the demographic and socioeconomic characteristics that determine internet use by school-age children. We therefore seek to answer the following question: What are the demographic and socioeconomic characteristics that determine internet access, use, and

\(^1\) Indicates whether or not an individual has used the internet in or outside the household in the last three months, at the time of conducting the interview (INEGI, 2018a).

\(^2\) The “divide between individuals, households, enterprises, and geographic areas of different socio-economic levels, with regards to their opportunities for accessing ICTs, such as the use of the internet for a wide variety of activities” (Organisation for Economic Cooperation and Development, OECD, 2001, p. 5).

\(^3\) Decile X was worth 579.5 billion pesos quarterly, while Decile I was worth 31.7 billion pesos quarterly (INEGI, 2018b).

\(^4\) The document makes no distinction between children and students, with both terms denoting individuals between 6 and 17 years old and attending school in 2018.

\(^5\) According to the Convention on the Rights of the Child (CRC), people under 18 years old are recognized as subjects with full rights under this international treaty (ONU, 1989).
2. Review of the literature on the digital divide

This section addresses the origin and evolution of the term digital divide, as well as the research conducted on this topic in the Latin American context, with the purpose of identifying the barriers and facilitators for ICT access and use.

The digital divide is still one of the challenges faced by developing countries in seeking to participate in the information and knowledge society (Grishchenko, 2020; Van Dijk, 2006). A term which emerged in the 1990s in the United States and which has evolved conceptually into a classification comprising three consecutive levels: access; use; and, benefits (Norris, 2001; Scheerder, Van Deursen, & Van Dijk, 2017; Selwyn, 2004).

Early studies on the digital divide at a global level focused on access, identifying the conditions for infrastructure development and the acquisition of goods and digital services (Selwyn, 2004; Van Dijk, 2006). Once citizens in developed countries had overcome ICT access, use appeared in the academic literature as a second level of analysis (Hargittai, 2005) via research examining the types of online activities performed by people and the digital skills required to perform them (Martínez-Dominguez & Mora-Rivera, 2020; Scheerder, Van Deursen, & Van Dijk, 2017; Van Deursen & Van Dijk, 2014). In the last decade, studies have focused on analyzing the factors by

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7 Term coined by Prensky (2001).
8 The term refers to internet use associated with school activities, taking courses to complement their educational training, and website development (INEGI, 2018a).
which benefits are obtained by internet users (Blank & Groselj, 2014; Lucendo-Monedero, Ruiz-Rodríguez, & González-Relano, 2019; Song et al., 2020).

The digital skills defined as “the capabilities of users to locate content on the web in an effective and efficient manner” (Hargittai, 2005, p. 372). These are key to understanding the second level of the digital divide, with three types of skills identified: basic; intermediate; and, advanced. Basic skills enable a minimum level of performance in society and comprise the use of hardware (keyboard and touchscreen use), software (file management and word processing), and basic online operations (use of e-mail and information seeking), which facilitate interaction with other people and access to government, commercial, and financial services.

The second type of digital skills enable people to join the job market effectively, via the creation of content using digital design and marketing skills and the use of cloud services.

Finally, advanced skills are necessary for digital technology professionals and include artificial intelligence, big data, cybersecurity, the internet of things (IoT), and the development of mobile applications (ITU, 2018; James, 2019).

Research conducted on the digital divide in the Latin American context has been oriented around the first two levels discussed above access and use (Mariscal, Mayne, Aneja, & Sorgner, 2019; Nishijima et al., 2017; Tirado-Morueta, Mendoza-Zambrano, Aguaded-Gómez, & Marin-Gutiérrez, 2017). Grazzi and Vergara (2012 and 2014), in studies conducted on the diffusion of the internet in Latin American countries, indicate income, education, geographic location, social capital, and the presence of students in the household as facilitators of the aforementioned levels. In contrast, Gutiérrez and Gamboa (2010) found that, for the low-income populations of Colombia, Mexico, and Peru, the most significant barrier is the lack of formal education. In order to deepen the analysis of the multifactorial and multidimensional elements affecting the digital divide, these variables are described in Table 1.

The decision to use the internet can be explained by means of Davis’ (1989) Technology Acceptance Model (TAM), which establishes two essential factors that determine the acceptance of technology: perceived utility; and, ease of use. This model is the most commonly used to predict and explain the behaviour of digital technology users in various contexts, due to its simplicity and high predictive power (Alcayde, 2019; Garín-Munoz, López, Pérez-Amoral, Herguera, & Valarezo, 2019; Gupta & Jain, 2015).

In order to analyze the digital divide, the present study analyzed the key variables that impact on internet access and use in school-age children, with a special emphasis on the role of digital skills (James, 2019; Onitsuka, Hidayat, & Huang, 2018) and infomediaries (Alderete, 2019; Mariscal et al., 2016). The study considered that both digital skills and infomediaries may contribute to the use of the internet as a complementary tool for children’s teaching-learning process.

3. Child population, internet use and educational strategies for dealing with COVID-19

Currently, 40 million children live in Mexico (35% of the total population) and the current and future economic-social development

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9 Both paid and free virtual data hosting (INEGI, 2018a).
of the country depends on their wellbeing (UNICEF, 2018), therefore, optimal conditions must be accomplished in order to fulfill this objective. Today, ICTs play an increasingly important role in the lives of new generations, however, inequalities in terms of use that go beyond internet access still persist (Alderete, 2019; Tirado-Morueta et al., 2017).

Thus, the following section is divided in three parts. We first show the importance of the child population in Mexico. Second, we characterize the uses of the internet (productive, communication, and leisure) and the role that these have in the day-to-day life of school-age children. Addressing these types of internet uses by means of a descriptive analysis shows that this subset of the population requires intermediate and advanced digital skills in order to make productive use of cyberspace. Third, we characterize the Mexican Education System and the strategies implemented in the sector in response to the COVID-19 pandemic.

### 3.1. Child population trends

Graph 1 shows trends in the population aged between 6 and 17 years old, considering historical data and future projections. In 1977, the number of children in Mexico comprised nearly one third of the national population (32%), a population share that is expected to have decreased, by 2039, in absolute terms by almost half (17%). By 2020, this population segment represented one fifth (20%) of the total national population. With this educational process already underway for this child population, it is important to increase investment in human capital, health, and vocational training to improve their life expectations.

### 3.2. Internet use in school-age children

Table 2 shows internet use by school-age children, with entertainment and seeking information for school activities the most frequent uses, which intensify as children get older. On the other hand, the activities least performed by students at all educational levels are related to the development of sites or blogs and the use of cloud services, such as Dropbox or Google Drive.

In terms of the intensity of internet use, the number of hours varies according to age and educational level, where elementary school students spend 2 h per day and high school students 5 h per day in cyberspace.

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**Table 2**

Internet use by the child population in Mexico.

| Internet use                                           | Children’s age (years) |
|--------------------------------------------------------|------------------------|
|                                                       | 6-11 | 12-14 | 15-17 | 6-17 |
| **Intensity of internet use**                          |       |       |       |      |
| Hours per day                                         | 2.3   | 3.7   | 5     | 3.7  |
| **Productive use of the internet (%)**                 |       |       |       |      |
| Seeking information for homework                       | 81.8  | 96.9  | 97.3  | 90.6 |
| Seeking information for courses                        | 15.7  | 25    | 40.5  | 25.2 |
| Development of websites or blogs                       | 2.1   | 5.2   | 11.5  | 5.6  |
| Downloading software and applications                  | 37.1  | 56.7  | 66.9  | 51.5 |
| Cloud services (Dropbox or either paid or free data hosting) | 1.6   | 10.3  | 24    | 10.6 |
| **Use for communication (%)**                          |       |       |       |      |
| Instant messages via WhatsApp and Messenger            | 43.5  | 78.6  | 91.7  | 67.9 |
| Conversations via Skype or WhatsApp                    | 31    | 60.4  | 74.4  | 52.2 |
| Sending e-mails                                        | 8.9   | 38.9  | 70.7  | 35.5 |
| **Digital leisure activities (%)**                     |       |       |       |      |
| Entertainment (audio and video content and online games) | 94.2  | 94.6  | 97.3  | 95.2 |
| Social networks (Facebook, Twitter, and others)        | 20.9  | 77.3  | 94.3  | 58.8 |

Source: Prepared by the authors with data taken from ENDUTH (INEGI, 2018a).

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**Table 3**

Main characteristics of the Mexican education system.

| Levels of the Mexican education system | Educational level | Age (years) | Skills | Classroom hours in the academic year |
|----------------------------------------|-------------------|-------------|--------|-------------------------------------|
| Basic Education                         | Elementary (general, community, and indigenous) | 6-11  | Reading and writing, basic mathematical literacy, skills in the selection and use of information. | 900 |
|                                        | Secondary         | 12-14       | Express ideas with precision and clarity, learn arithmetic, algebra, and geometry, learn about natural environmental phenomena, synthetize information pertaining to history, geography, and civics, learn english. | 1400 |
| Tertiary Education                      | High school       | 15-17       | Obtain scientific, technical, and humanistic knowledge, in conjunction with research methodologies and language mastery. | Not available |

Source: Prepared by the authors based on information from the SEP (2020b).
This section presents a general overview of the Mexican education system and the strategies applied in the Learn at Home, Learn at Home II and Learn at Home III programs (Aprende en Casa, Aprende en Casa II y Aprende en Casa III), which were implemented by the Federal Government to provide continuity to classroom learning in the context of the COVID-19 pandemic.

In Mexico, basic education is provided by the State free of charge and on a mandatory basis, comprising six grades of elementary school and the three grades of secondary school, while the subsequent level comprises the three years of upper secondary or high school (see details in Table 3). Until January 2020, prior to the COVID-19 pandemic, 30.6 million students in Mexico were enrolled in basic and secondary education across 254,100 educational campuses (SEP, 2020a), in which writing, reading, mathematics, and research skills, as well as humanistic and environmental knowledge, are developed. However, the development of digital skills has not been a priority in these study programs (see Table 3).

The education system prepares students between the age of 6–11 to develop competencies in language (reading and writing), basic arithmetic, and the use and selection of information. In the case of 12 to 14-year-old students, the aim is to develop competencies that facilitate their integration into the job market, while 15 to 17-year-old students are taught scientific knowledge, research methodology, and language mastery (SEP, 2020b).

First reported in the city of Wuhan, China, in December 2019, the SARS-CoV-2 virus soon became a global pandemic and subsequently arrived in Mexico. This infectious disease jeopardized health and the integrity of the population in general, due to its easy transmission via contact with infected people. In order to guarantee the health and safety of the Mexican population, the National Healthy Distance Campaign (Jornada Nacional de Sana Distancia) was implemented with the aim of avoiding the propagation of the virus and mitigating its impact (Gobierno de México, 2020).

The implementation of the program involved the closure of the nation’s schools and affected more than 30.6 million students, who, instead of receiving conventional classroom instruction, continued their studies through the Learn at Home program, which delivered online and televisual course content and study guides via cellphones, tablets, and computers. These learning modalities have been developed for each educational level, for both public and private educational sectors and both rural and urban school populations (SEP, 2020b).

Under these circumstances, the use of the internet as learning tool has taken center stage, with Google Classroom, Facebook, Zoom, Microsoft Teams, and WhatsApp becoming the main virtual instruments enabling students to continue their studies and not lose the entire school year. However, in reality, parents’ associations, teachers, and authorities have organized themselves in order to establish

Graph 2. Lack of digital technologies (computer, internet, or television) in the home, 2015–2019.
Source: Prepared by the authors with information obtained from INEGI (2018a).
educational strategies appropriate to their local context (De León-Martínez, Palacios-Ramírez, Rodriguez-Aguilar, & Flores-Ramírez, 2020; Van Lancker & Parolin, 2020).

In August 2020, the Learn at Home II program was launched for the 2020–2021 school year, consisting in courses transmitted via television for both basic and secondary education. The main challenges faced by this program are the following: a) The digital divide, in terms of internet access, as one out of two households is unable to access the internet, due to a lack of financial resources and lack of telecommunications infrastructure. Furthermore, in 2019, more than half of Mexican households, 55.7%, did not have a computer and one out of every twenty households did not have a television (see details in Graph 2); and, b) Students do not have the digital skills required for autonomous online study, thus interfering with their learning process (Tirado-Morueta et al., 2017).

4. Methodology

4.1. Data

The data used in the econometric analysis was taken from ENDUTIH 2018, which gathered survey data on ICT equipment in the household, digital skills, internet connection, frequency and intensity of internet use, places of internet use, activities performed online, and aspects related to the use of cellular telephony (INEGI, 2018a).

The survey was conducted on 151,396 Mexican households, with 79.4% of those surveyed residing in urban areas and 20.6% in rural areas. The information sampled is representative at a national, state, rural, urban, and city level and included 90,100 children aged between 6 and 17 years and enrolled in the Mexican education system.

4.2. Econometric strategy

The digital divide is a complex phenomenon influenced by multiple economic, human, sociodemographic, and technological factors. The variables included in the Heckman model are based on the relevant literature on this topic (see Table 1) (Alderete, 2019; Galperin & Arcidiacono, 2019; Martínez-Domínguez & Mora-Rivera, 2020; Salemink et al., 2017; Tirado-Morueta et al., 2017; Van Deursen & Van Dijk, 2014).

4.2.1. Dependent variables

In order to ascertain the factors that have an impact on internet access, use and usage patterns by Mexican children from households with different socioeconomic levels, three equations were estimated based on the dependent variables of access, use and usage patterns (homework, courses and blogs).

The empirical model corresponding to the first equation is as follows:

\[ y = \beta_1 \text{age} + \beta_2 \text{electronic devices} + \beta_3 \text{primary assist} + \beta_4 \text{secondary assist} + \beta_5 \text{highschool assist} + \beta_6 \text{Internet access home} + \beta_7 \text{index wealth} + \beta_8 \text{socioeconomic stratum} + \beta_9 \text{infomediaries family} + \beta_{10} \text{digital skills} + \beta_{11} \text{place residence} + \epsilon_i \]  

(1)

The dependent variable, \( y_i \), is a binary variable that takes the value of 1 if the person used the internet and 0 if they did not. The function for modeling the probability of an individual using the internet is:

\[ P_r(Y_i = 1) = P_r(U_i > 0) = \varphi[X_i\theta] \]  

(2)

where \( U_i \) represents the indirect benefits associated with the use of the internet and \( \varphi \) is the cumulative distribution function for \( \epsilon_i \) (error in the utility function). Hence, \( X_i \) is a matrix of independent variables that explain access and use, while the determinants of internet use can be examined via the estimation of \( \theta \) parameters in Equation (1). The appropriate econometric technique for estimating Equation (1) is the application of the method of maximum likelihood via a probit regression.

The variable \( y_i \) (internet use) from Equation (1) assumes that a child can use the internet via devices such as computers, tablets, or mobile phones. While internet access, or the absence thereof, in the household is not a necessary condition for internet use or the lack thereof, internet access in the household does increase the probability of internet use. Thus, those households that do have an internet connection are not random and their characteristics generate biased estimates (Heckman, 1979). Hence, it is probable that said households present better socioeconomic conditions, namely higher educational and income levels and a higher number of digital devices.

A theoretical structure that controls for this problem is the bivariate probit model with sample selection, for the purposes of which, the Heckman procedure enables the estimation of the dependent variable, \( y_i \), in two stages (Van de Ven & Van Praag, 1981).

The Heckman model is specified as:

\[ P_r(Y_i = 1) = \varphi[X_i\theta + \xi\lambda] \]  

(3)

Specifically, \( \xi \) is a coefficient matrix that measures access and use and \( \lambda \) is the inverse Mills ratio. Once the theoretical form for estimating Equation (1) is restructured, the next step is to empirically estimate Equation (2), which measures access as follows:

\[ P_r(Y_i = 1) = \varphi[X_i\theta + \xi\lambda] \]  

(3)
Therefore, this equation enables the construction of the inverse Mills ratio using pseudo-residuals, which represent the unobserved factors that determine the decision of the household not to have internet access. As this procedure requires a variable that directly affects internet access, but not individual internet use, the presence of a head of the household with a steady job fulfills this condition.

Finally, to measure use, the selection bias correction term \( \lambda \) is included in the probit equation for internet use, which is also estimated using the maximum likelihood process (5).

\[
P, (\text{Internet use} = 1) = F(\text{head household with stable job})
\]

(4)

The third equation establishes the selection of online activities, which are conditioned by the decision to use the internet. Internet usage patterns \( j \) (where \( j = 1, 2, 3 \)) are defined in the equation \( y_j = X_i \beta + \varepsilon_j \), where \( y_j \) measures usage, \( X_i \) represents the matrix of independent variables, and \( \varepsilon_j \) is the normally distributed random error term. To estimate these equations, Heckman’s two-stage method was applied under the assumption that \( \varepsilon_0 \) and \( \varepsilon_3 \) follow a bivariate normal distribution with zero mean and correlation \( (\varepsilon_0, \varepsilon_3) = \rho \). As a result, when applying this methodology, we can state that if the estimated \( \rho \) (rho) coefficient is significantly different from zero, then it indicates the presence of a bias (Wooldridge, 2010-). Once the Heckman procedure had been finalized, the results were then interpreted.

4.2.2. Independent variables

The independent variables, selected based on the literature review on the digital divide (see Table 1), comprised sociodemographic, familial, economic, and geographic variables, as well as one pertaining to access to complementary technologies. The metrics for the variables used in the econometric regressions are described below:

- **Girl.** A variable that adopts the value of one for a girl and zero for a boy.
- **Age.** The individual’s age in years at the time of conducting the interview. As the study sample included subjects born between 2003 and 2014, these could be considered digital natives (Kershawani, 2020; Prensky, 2001).
- **Education.** Three categories were established: elementary school; secondary school; and high school. A binary variable was established for each educational level, with 1 indicating that the individual is enrolled at this level and 0 if not, with elementary school taken as the base category.
- **Age and educational attainment of head of household.** Refers to the age, in years, of the person assuming the role of head of household and their highest completed level of education at the time of conducting the interview.
- **Household wealth index.** As the ENDUTIH does not include information on monetary income, the household wealth index was constructed as a proxy for standard of living. The index was constructed based on the methodology of Filmer and Pritchett (2001).
- **Availability digital skills.** Indicates whether the respondent had used the internet to download and use software or applications, as well as using cloud services (Dropbox, Google Drive, or other paid or free data hosting services) in the three months prior to the time of conducting the interview.
- **Reasons for the non-use of the internet.** Dichotomous variables that explain the reasons why users do not use the internet: i) they do not have access (lack of economic resources and digital infrastructure) and ii) they do not know how to use it (lack of digital skills).
- **Use of the internet at school.** Binary variable where 1 indicates that children have used the internet in their educational institutions and 0 otherwise.
- **Frequency of internet use.** Binary variable where the value 1 indicates that children use the internet seven days a week and 0 otherwise.
- **Access to complementary technologies.** This refers to the availability of Smart TV, cellphone and computer use in the household. In each variable, 1 indicates the presence of one of these electronic goods and 0 the absence thereof.
- **Internet use.** Refers to whether the respondent had used the internet either in or outside the household in the last three months.
- **Internet access at home.** A dummy variable was considered, where 1 indicates that the household has a fixed or mobile internet connection and 0 if not.
- **Number of members of the household that used the internet (infomediaries).** People in the household with digital skills who transmit these competencies to other members of the household.
- **Socioeconomic stratum.** This variable was constructed as part of the sample design, where households with similarities were grouped together and classified as low, medium-low, medium-high, and high, based on 34 sociodemographic indicators. These included the

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11 This shows an inverse relation for the probability of internet use and is expressed as a quotient between the density function of said probability over its accumulated function (Wooldridge, 2010).
12 According to Kershawani (2020, p.3), “… these are people born after the 1980s, who have, therefore, had contact with technologies prior to adolescence, making them familiar with cyberspace and facilitating their adoption of digital technologies”.
13 Variables included in the index: type of flooring; access to drinking water; sewerage service; access to electricity; refrigerator; and, washing machine.
following: the sociodemographic and educational profile of the members of the household; access to healthcare services; the physical characteristics of the dwelling and the services to which it has access; the possession of electronic devices and home appliances; and, family assets (e.g. automobiles) (INEGI, 2018a).

### 5. Results

#### 5.1. Main descriptive statistics

Table 4 presents the descriptive statistics pertaining to the respondents. In terms of gender, it is observed that, as the sample comprised a similar proportion of men and women, it presented a symmetrical distribution. Eight out of ten children were enrolled in basic education, five in elementary and three in secondary school. More than half of the heads of household were in stable employment.
as blue-collar workers, employees, or employers.

With regard to access to digital technologies, six out of ten children lived in household with an internet connection, while in terms of use, eight out of ten students used the internet, in places such as the household, at school, at a cybercafe, in public places with no connection cost, or in the house of a relative, in the three months prior to taking the survey. Seventy-five percent of respondents were mobile telephony users, of whom nine out of ten used a Smartphone. Seven out of ten children lived in households classified in the low and medium-low socioeconomic strata. Finally, in terms of geographic location, one out of four children lived in rural areas.

### 5.2. Determinants of internet access and use for school-age children

Table 5 presents the results for factors that have an impact on internet access and use, while models 1 and 2 are based on a probit

| Variable | Model 1 | Model 2 | Model 3 |
|----------|---------|---------|---------|
|          | Marginal effects | s.e | Marginal effects | s.e | Marginal effects | s.e |
| Sociodemographic | | | | | | |
| Girl† | −0.42 | 0.0030 | −0.29 | 0.0028 | −0.12 | 0.0030 |
| 6-11-years-old children † | Ref. | | | | | |
| 12-14-years-old children † | 18.81 | *** 0.0032 | 16.80 | *** 0.0028 | 14.96 | *** 0.0052 |
| 15-17-years-old children † | 21.73 | *** 0.0045 | 18.67 | *** 0.0037 | 20.21 | *** 0.0119 |
| Elementary school † | Ref. | | | | | |
| Secondary school † | 8.88 | *** 0.0053 | 8.25 | *** 0.0046 | 8.35 | *** 0.0082 |
| High school † | 13.13 | *** 0.0069 | 11.64 | *** 0.0050 | 12.82 | *** 0.0169 |
| Family | | | | | | |
| Average age of the head of household (years) | −0.02 | * 0.0001 | −0.12 | *** 0.0001 | −0.14 | *** 0.0001 |
| Household wealth index | 2.30 | *** 0.0012 | 0.35 | *** 0.0011 | 0.71 | *** 0.0016 |
| Average education of the head of household (years) | 1.04 | *** 0.0005 | 0.49 | *** 0.0004 | 0.44 | *** 0.0005 |
| Access to complementary technologies | | | | | | |
| Computer use † | 22.47 | *** 0.0034 | 8.24 | *** 0.0034 | 7.68 | *** 0.0035 |
| Cellphone use † | 17.85 | *** 0.0099 | 0.17 | 0.0069 | 6.48 | *** 0.0172 |
| Smart TV in the household † | 3.92 | *** 0.0037 | 1.03 | *** 0.0033 | 1.43 | *** 0.0037 |
| Internet access at home † | 2.35 | *** 0.0034 | | | | |
| Digital skills, frequency and place of internet use | | | | | | |
| Number of members of the household that used the internet | 12.64 | *** 0.0013 | 8.05 | *** 0.0016 | | |
| Availability digital skills † | 6.48 | *** 0.0066 | 6.48 | *** 0.0052 | 5.38 | *** 0.0079 |
| Lack digital skills † | −41.36 | *** 0.0156 | −31.01 | *** 0.0181 | −18.08 | *** 0.0121 |
| No access to internet † | −34.86 | *** 0.0148 | −19.64 | *** 0.0155 | −17.26 | *** 0.0162 |
| Internet use in school † | 5.19 | *** 0.0072 | 6.25 | *** 0.0055 | 3.52 | *** 0.0093 |
| Internet use frequency † | 11.66 | *** 0.0048 | 8.92 | *** 0.0041 | 8.10 | *** 0.0064 |
| Household socioeconomic level | | | | | | |
| Low stratum † | −6.29 | *** 0.0055 | −2.49 | *** 0.0050 | −2.35 | *** 0.0060 |
| Medium-low stratum † | Ref. | | | | | |
| Medium-high stratum † | 5.36 | *** 0.0040 | 4.10 | *** 0.0036 | 3.36 | *** 0.0039 |
| High stratum † | 7.85 | *** 0.0054 | 6.64 | *** 0.0045 | 6.18 | *** 0.0056 |
| Head of household in formal or steady employment † | 11.54 | *** 0.0032 | | | | |
| Geographic | | | | | | |
| Rural † | −9.32 | *** 0.0048 | −2.10 | *** 0.0042 | −2.58 | *** 0.0048 |
| North-west region † | 3.04 | *** 0.0057 | 0.66 | 0.0055 | 1.06 | ** 0.0059 |
| North-east region † | 0.55 | *** 0.0065 | −1.62 | ** 0.0064 | −0.99 | 0.0065 |
| West region † | 4.77 | *** 0.0062 | 1.80 | ** 0.0061 | 0.52 | 0.0075 |
| South-central region † | −2.46 | *** 0.0065 | −2.22 | *** 0.0061 | −1.95 | *** 0.0065 |
| North-central region † | −0.70 | 0.0068 | −1.07 | * 0.0064 | −0.09 | 0.0068 |
| East region † | 2.89 | *** 0.0058 | 2.68 | *** 0.0052 | 0.57 | 0.0069 |
| South-east region † | 1.27 | ** 0.0064 | −1.04 | * 0.0064 | −1.43 | ** 0.0067 |
| South-west region † | Ref. | | | | | |
| Number of observations | 90,100 | | | | | |

*Significance level of 10%; ** Significance level of 5%; *** Significance level of 1%. Standard errors in parenthesis.

Note.

† 1 indicates the presence of the respective attribute or characteristic.

Source: Prepared by the authors.
Table 6
Determinants of school-age children productive uses of the internet.

| Variables                        | Homework | s.e | Courses | s.e | Blogs | s.e |
|----------------------------------|----------|-----|---------|-----|-------|-----|
|                                  | Marginal effects |     | Marginal effects |     | Marginal effects |     |
| **Sociodemographic**             |          |     |          |     |       |     |
| Girl\(^a\)                       | 0.73 *** | 0.0018 | 0.13 | 0.0012 | 0.07 | 0.0007 |
| 6-11-year-old-children\(^a\)     | Ref.     |     |          |     |       |     |
| 12-14-year-old children\(^a\)    | 0.59 *** | 0.0024 | 0.40 ** | 0.0020 | 0.45 *** | 0.0012 |
| 15-17-year-old children\(^a\)    | −1.11 *** | 0.0041 | 1.20 *** | 0.0028 | 0.80 *** | 0.0015 |
| Elementary school\(^a\)          | Ref.     |     |          |     |       |     |
| Secondary school\(^a\)           | −0.76 *** | 0.0028 | 0.14 | 0.0022 | 0.11 | 0.0012 |
| High school\(^a\)                | −2.01 *** | 0.0048 | 0.51 * | 0.0029 | 0.18 | 0.0015 |
| **Family**                       |          |     |          |     |       |     |
| Average age of the head of household (years) | −0.02 *** | 0.0001 | −0.01 *** | 0.0001 | 0.00 | 0.0000 |
| Household wealth index           | −0.22 *** | 0.0008 | −0.07 | 0.0006 | 0.01 | 0.0004 |
| Average education of the head of household (years) | −0.03 | 0.0003 | 0.01 | 0.0002 | 0.02 | 0.0001 |
| **Digital skills, frequency and place of internet use** | | | | | |
| Number of members of the household that used the internet | −0.69 *** | 0.0008 | −0.05 | 0.0005 | −0.02 | 0.0003 |
| Availability digital skills\(^a\) | 13.71 *** | 0.0045 | 3.56 *** | 0.0018 | 1.51 *** | 0.0011 |
| Internet use in school\(^a\)     | 19.03 *** | 0.0056 | 4.29 *** | 0.0018 | 1.02 *** | 0.0010 |
| Internet use frequency\(^a\)     | 20.47 *** | 0.0047 | 5.84 *** | 0.0020 | 1.31 *** | 0.0012 |
| **Household socioeconomic level**|          |     |          |     |       |     |
| Low stratum\(^a\)                | 0.36     | 0.0032 | −0.12 | 0.0025 | −0.04 | 0.0015 |
| Medium-low stratum\(^a\)         | Ref.     |     |          |     |       |     |
| Medium-high stratum\(^a\)        | −0.80 *** | 0.0024 | −0.01 | 0.0015 | 0.03 | 0.0008 |
| High stratum\(^a\)               | −1.47 *** | 0.0034 | −0.25 | 0.0020 | −0.10 | 0.0011 |
| **Geographic**                   |          |     |          |     |       |     |
| Rural\(^a\)                      | 0.41     | 0.0027 | −0.07 | 0.0021 | −0.08 | 0.0012 |
| North-west region\(^a\)          | −1.41 *** | 0.0036 | −0.25 | 0.0025 | −0.27 ** | 0.0014 |
| North-east region\(^a\)          | −0.47 *** | 0.0038 | −1.01 *** | 0.0029 | −0.28 | 0.0015 |
| West region\(^a\)                | −1.28 *** | 0.0042 | −0.37 *** | 0.0028 | −0.23 | 0.0015 |
| South-central region\(^a\)       | 0.42     | 0.0039 | 1.26 *** | 0.0028 | 0.02 | 0.0016 |
| North-central region\(^a\)       | −0.48    | 0.0037 | 0.48 * | 0.0026 | −0.06 | 0.0014 |
| East region\(^a\)                | −0.39    | 0.0036 | 0.62 ** | 0.0026 | −0.05 | 0.0014 |
| South-east region\(^a\)          | −0.52    | 0.0039 | 0.57 ** | 0.0029 | −0.01 | 0.0015 |
| South-west region\(^a\)          | Ref.     |     |          |     |       |     |
| Number of observations           | 90,100   |     |          |     |       |     |

\(^a\) Significance level of 10%; ** Significance level of 5%; *** Significance level of 1%. We use robust standard errors.

Note.
* 1 indicates the presence of the respective attribute or characteristic.

Source: Prepared by the authors.

The estimation of internet access and use. To verify the statistic robustness and the consistency of the results obtained via the econometric methodology used in the present study, the following process was followed: Model 1 is the baseline (column 1), with independent variables then added to Model 2 (internet access at home and internet use by family members) and finally, the sample selection was controlled (Model 3).\(^14\)

While Model 2 is preferable to Model 1 in terms of goodness-of-fit, Heckman’s sample selection methodology best fits the decision to use the internet (Model 3). As the main concern over the use of this method lies in the identification of the selection equation (Greene, 2003), a variable affecting access, but not the decision to use the internet, must be included, leading to the use of a dummy variable indicating whether or not the head of household had a steady job.

With regard to the estimation of the sample selection, the Wald test verifies whether all the coefficients (except for the constant) are zero. The likelihood-ratio test proves whether rho = 0 and was calculated as the comparison between the probit joint probability for the selection equation and the regression model for the internet use data observed, charted against the probability of the Heckman model. The Chi2 result of 6280 justified the use of the Heckman selection model.

According to the table above, models 1 and 3 show that the probability of using the internet increases with age and educational level. This show that students in the last grades of elementary school and those in secondary and high school use the internet to a greater extent for various reasons, such as information seeking for educational purposes, instant messages via WhatsApp, Facebook, and Messenger, audio and video entertainment, and online games (Martínez-Domínguez & Mora-Rivera, 2020; Penard et al., 2015).

Internet access in school-age children is favoured by their parents’ occupation, in that a parent in permanent or stable employment...
is more likely to contract an internet service and have the available economic resources to purchase digital devices (Alderete, 2019). Likewise, household members who have made use of the internet can play an infomediary role in order to share these digital competencies to the children in the household (Mariscal et al., 2016).

With regard to the availability of electronic devices at home, the findings of the present study indicate that the more ICT equipment in their household the higher the level of internet use by children, as the possession of a computer, tablet, cellphone, and digital television offers a variety of options for children to interact with the internet.

Among the factors that discourage children’s use of the internet are the lack of economic resources and telecommunications infrastructure as well as the lack of digital skills. In contrast, a factor that promotes the use of cyberspace is the educational institution, which plays an important role in providing children a learning tool and that can be used towards other productive online activities such as homework, courses, and blogs (Ferguson et al., 2015; García-Martín & Cantón-Mayo, 2019). Likewise, the frequency of internet use is essential for children to be able to expand online activities.

In socioeconomic terms, it was found that children who live in households from the high socioeconomic stratum and with a higher wealth index are more likely to be cyberspace users than those from medium stratum households, with the opposite found for students from the low stratum, who were less likely to explore the internet.

In terms of geographic location, rural communities lagged behind urban communities, as these regions lack the telecommunications infrastructure due to private companies considering this an unprofitable investment, given their low population densities and remoteness from urban centers (García-Mora & Mora-Rivera, 2021; Onitsuka et al., 2018). Taking the south-west as the reference, the north-east, north-central, and south-east were the regions where children present a lower level of internet use.

5.3. Determinants of school-age children productive uses of the internet

With regard to the role of the sociodemographic variables, there are differentiated effects. Compared to boys, girls are more likely to use the internet for schoolwork. However, in terms of online courses and the use of blogs, gender does not have a statistically significant effect.

Table 6 shows that the prerequisites in the use of the Web are different, given the level of specialization of digital skills that each of them requires. With respect to gender, significant differences were found regarding the type of use, an example of this is that girls make greater use of cyberspace for school activities compared to boys. This refers to that the parents exert greater parental control over girls (Katz et al., 2019).

Additionally, secondary school children (12–14 years old) show a higher internet use for schoolwork relative to their high school peers (15–17 years old), since high school students are more interested in recreational purposes such as audio and video content, online videogames, and social networks (see Table 2). In this sense, the literature has shown that in the early ages of children, parents can establish greater parental mediation on the use of the Internet, in contrast to older children. This causes younger children to have less autonomy to use the internet (Hurwitz & Schmitt, 2020; Katz et al., 2019).

With respect to the family dimension, children who belong to households whose head is an older adult have less opportunity to use the internet for homework because these household members are digital immigrants, most of whom lack the skills to make use of ICTs (Prensky, 2001). On the other hand, a better economic situation in the home does not translate into productive use of cyberspace (homework) (Daoud et al., 2020; Martínez-Domínguez & Mora-Rivera, 2020). Regarding the presence of infomediaries in the household, a greater number of children who have used the internet does not guarantee any positive effects on its use by school-age children for school related activities (Tirado-Morueta et al., 2017).

A set of extremely important aspects in the productive use of the internet are digital skills, frequency of use, and school as a space that can facilitate homework, courses, and blogs. Geographic location does not have differentiated impacts on internet use for homework, except for the west and north-west regions. This may mean that children residing in these areas of the country are more likely to use the internet for recreational purposes (social networks, entertainment, and communication) (Martínez-Domínguez & Mora-Rivera, 2020).

Online courses are associated with the characteristics of individuals, for example, the older the age and educational level (high school) of the children, the more likely they are to use the internet for this activity. Other variables such as digital skills, frequency of use, and school promote this use of the Web. In terms of regional differences, school-age children in the south-central, east and south-east regions of the country are more likely to take online courses than those in the north-east. This is due to the provision of a developed digital services infrastructure (García-Mora & Mora-Rivera, 2021).

Finally, the creation of blogs requires advanced skills related to homework and course development. In age, middle and high school children are more likely to create blogs, which suggests that digital natives are intellectually curious for the exploration of technology. Children with parents with high levels of education are more likely to develop these types of activities since they can be technically and emotionally incentivized and have more favourable environments to develop advanced skills that facilitate the use of cyberspace (Hurwitz & Schmitt, 2020; Katz et al., 2019).

In the creation of blogs, the acquisition of digital skills, constant use, and the school are fundamental in order to stimulate children’s creativity, which advise that the use of these tools in the classroom has a significant impact on student performance and in the development of new emerging tasks (James, 2019; Martínez-Domínguez, 2020). At the regional level, the north-west and north-east

15 “Refers to how parents restrict, discuss, and use media with their children” (Katz et al., 2019, p. 4).
regions have a negative impact on use for this purpose since it is possible that these areas that border the United States have a strong trend of consumption of recreational services (streaming, games, and online music) (Martínez-Domínguez & Mora-Rivera, 2020).

6. Discussion

The present study examined the socioeconomic factors that influence internet access, use and usage patterns by 6 to 17-year-old children, obtaining results suggesting that the most important determinants are related to age, education, socioeconomic stratum, digital skills, infomediaries, and place of residence. The results of the analysis presented here contribute to the debate on digital natives and public policy design, topics explored in the literature on the digital divide which can assist in the design of government interventions.

6.1. Determinants of internet access and use by children in Mexico

Among the sociodemographic factors, age and level of educational attainment are essential in internet use, with the significance of both variables verified by the literature on this topic (Correa, Pavez, & Contreras, 2017; Lera-López, Billon, & Gil, 2011; Martínez-Domínguez & Mora-Rivera, 2020; Penard et al., 2015). In this regard, Correa et al. (2017) found that the age of individuals in Chilean households is an outstanding factor in internet use, wherein the youngest use cyberspace with more intensity than their elders.

In this article, instead of considering an aggregate analysis of the children, three age ranges were established (6–11 years, 12–14 years and 15–17 years) in order to identify the differences that exist within this group population. Although some previous studies have examined age as a fundamental variable that explains the use of this digital technology (Galperin & Arcidiacono, 2019; Kershawani, 2020; Prensky, 2001). However, there are other studies that challenge this assumption and show that children and young people, considered digital natives, are not necessarily natural and talented users in the productive use of the internet (Alderete, 2019; Hurwitz & Schmitt, 2020; Liao et al., 2016). Therefore, future research requires addressing this issue from a multidimensional perspective to deepen this problem.

Another key element in internet use is the role played by infomediaries as transmitters of digital skills to other members of the household, where households with a larger number of internet users generate positive externalities by encouraging new internet users (Martínez-Domínguez & Mora-Rivera, 2020; Penard et al., 2015). Moreover, digital competencies enable information seeking, interaction with other people, and access to government, commercial, and financial services (Penard et al., 2015; Scheerder, Van Deursen, & Van Dijk, 2017). As shown by Martínez-Domínguez and Mora-Rivera (2020) and Alderete (2019), the availability of electronic goods, such as computers, tablets, cellphones, and Smart TV, fosters internet use.

As stated in previous literature, income is the economic barrier conditioning the diffusion of the internet (Robinson et al., 2015; Song et al., 2020), which is fundamental in the Mexican context due to the deep social and economic inequalities that generate disparities in participation in the information and knowledge society. Ovando and Olivera (2018) highlight that, in 2015, less than 1% of decile I-VI households had an internet connection, while almost 10% of decile VII-VIII households had an internet connection that year.

Socioeconomic inequalities are a central point in the discussion, as, to date, research conducted on this topic has not considered the economic heterogeneity that prevails in developing countries.

The geographic dimension is another key piece in the digital divide, where rural residents in southern Mexico are less likely to use the internet, showing very low levels of telecommunication infrastructure in these regions as well as dispersed and isolated settlements, a finding consistent with that reported by Martínez-Domínguez and Mora-Rivera (2020). Given that one out of four Mexicans lives there, the rural sector is of great importance in the Mexican context (INEGI, 2020).

Despite the advances in the study of the digital divide, today, there is considerable debate as to whether internet access and use either increase or decrease the social divide (Robinson et al., 2015; Scheerder, Van Deursen, & Van Dijk, 2017; Witte & Mannon, 2010). On the one hand, some studies conclude that increased access to this digital technology will create an even playing field enabling all to enjoy the benefits of the internet, while others argue that the internet may reinforce the different forms of social inequality (Song et al., 2020; Van Deursen, Van Dijk, & Peter, 2015) and increase the digital skills divide (Penard et al., 2015; Song et al., 2020; Sujarwoto & Tampubolon, 2016; Witte & Mannon, 2010). For instance, Song et al. (2020) found that, despite having a high number of internet users, China still has regional and intergenerational divides in terms of internet access and use, highlighting that the development of digital skills is a first step to closing these divides.

6.2. Determinants of productive uses of the internet (homework, courses, and blogs)

In previous studies regarding the digital divide, little has been examined regarding school-age children productive uses of the internet. This work therefore identifies the factors that determine online activities (homework, courses, and blogs). In the case of homework, the results show that being a woman, being between 12 and 14 years old, having digital skills, and using the internet daily at school encourage the use of cyberspace. Factors that promote course taking are age, high levels of education and digital skills, frequency of use, school, and geographic location. For more sophisticated uses such as the creation of blogs, average schooling of the head of the household, daily internet use, and the school are factors that promote this activity, as well as the acquisition of digital skills, which are more common in children between the ages of 12 and 17.

The use of the internet at school highly promotes all of the three different purposes. Our results show that digital skills are essential for the productive use of cyberspace. This finding confirms previous research by Daoud et al. (2020) and Tirado-Morueta et al. (2017), who showed the importance of digital skills. Thus, schools can have the potential to generate creative habits and promote collaborative
The foregoing has been highlighted by the COVID-19 pandemic, which has put into sharp relief the profound digital inequalities in Mexico and has led to a rethinking of how to integrate ICTs into the teaching-learning process in the National Education System. The digital divide is a complex and multifactorial phenomenon associated with insufficient connectivity and the use of digital technologies by students (De Alva, 2004).

6.3. The incorporation of ICTs in education programs in Mexico (1997–2016)

Table 7 presents the ICT education programs implemented in Mexico in order to highlight the public policy initiatives which aim to reduce the digital divide in school-age children. This show that the programs failed to accomplish their original objectives due to a lack of long-term planning and the impact of social, economic, and political issues (Trejo-Quintana, 2020).

These programs were aimed at providing teacher training on the use of digital technologies and delivering digital devices without previously considering connectivity problems such as an absence or failure of internet connectivity or the devices themselves. A large portion of these initiatives was aimed at students studying the final grades of elementary education in schools located in the country’s large cities. These policies were carried out from a deterministic point of view, that is, it was believed that the provision of digital devices would bring about the reduction of the digital divide (Aydin, 2021; Martínez-Domínguez & Mora-Rivera, 2020; Penard et al., 2015; Scheerder, Van Deursen, & Van Dijk, 2017; Van Deursen & Van Dijk, 2014). It is therefore clear that there are still great leaps to be made in order to breach the digital divide between students in Mexico.

6.4. Public policy interventions in internet access and use by Mexican children

While, in the last two decades, six ICT initiatives have been implemented in the Mexican education system with the objective of closing the digital divide (Table 7), to date, the results obtained have been deficient. This failure is partly due to the deterministic vision of ICTs without considering the regional heterogeneities involved or the prevailing economic inequalities in the country, which have acted as barriers to the successful integration of ICTs into the teaching-learning process. With regard to this last point, it should be noted that said programs have been fragmented and short term in nature and lack a vision of the future that takes into account the disruptive changes of the digital age. The digital divide is a complex and multifactorial phenomenon associated with insufficient telecommunications infrastructure, the high cost of access, and the lack of digital skills that enable internet use.

The foregoing has been highlighted by the COVID-19 pandemic, which has put into sharp relief the profound digital inequalities in Mexico and has led to a rethinking of how to integrate ICTs into the teaching-learning process in the National Education System. The closing of schools due to the COVID-19 pandemic forced students and parents to manage school activities at home. Among the greatest challenges for the development of the Aprende en Casa, Aprende en Casa II and Aprende en Casa III initiatives are the disparities of access and use of the internet between urban and rural contexts, as well as between different regions of the country (García-Mora &
7. Conclusions

Some of the greatest challenges for Mexico’s development are the enormous economic and social inequalities that restrain both...
access to and the productive use of the internet, both of which provide direct benefits for the population. The digital divide is an obstacle to economic development in the information and knowledge society. This study identified the factors that explain the level of internet access and use by school-age children in households of different socioeconomic levels. The analysis used the Heckman selection model due to the interdependence between internet access and use. As, in the national literature, there are few studies addressing the digital divide for this population group, the results of the present research provide a much more detailed picture of the socioeconomic factors that determine internet access and use.

The findings obtained show that children from low and medium-low socioeconomic strata and living in rural areas have fewer opportunities for internet access, use and online activities (homework, courses and blogs), in contrast, students living in urban areas and from high stratum households are more likely to form part of the information and knowledge society. Furthermore, the present study found that infomediaries play an important role as transmitters of digital skills, encouraging ICT use in other members of the household.

The public health emergency currently faced by Mexico due to the COVID-19 pandemic has exposed the magnitude of this digital divide. This pandemic has not only affected students directly, but has also generated negative externalities for their families and guardians. They have been involved with schoolwork, requiring the restructuring of their daily schedule. The COVID-19 pandemic has exposed the urgent need to establish measures that address the digital divide and prevent it from widening further, which requires the reconsideration of the educational model for basic education, from an inclusive, equitable, and quality-focused perspective, in which the internet is used as a tool that contributes to students’ learning. Therefore, the findings point to the need for the design of a long-term integrated ICT policy which includes access to and the productive use of ICTs in the teaching-learning process, from the perspective of promoting educational innovation for the XXI century.

Likewise, these empirical results contribute to a greater understanding of the digital divide, in particular because they focus on basic education and high school students, as well as on the distinction of the uses of the internet (homework, courses, and blogs), both of which are topics little explored in the contexts of developing countries due to the lack of information or because ICTs have not yet managed to become a relevant issue in education.

Despite the fact that the results presented here are statistically robust, the following aspect can be explored in more depth in future research: regional research can be conducted to obtain solid evidence as to the spatial disparities that exist in Mexico given its great geographic, economic, social, political, environmental, and cultural heterogeneity.

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Declaration of competing interest

The authors declare that they have no conflict of interests.

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