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The effects of female political participation on missing women: Evidence from the Egyptian protests of 2011–2014☆

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ABSTRACT

This paper examines the effects of political protests during the Egyptian revolution between 2011 and 2014 on "missing women" in Egypt. The term "missing women" refers to the number of women missing in population because of sex-selective abortions, excess female mortality and lower survival rates caused by gender discrimination, infanticide, neglect, malnutrition, domestic violence, unequal healthcare access and provision, and poor treatment. We hypothesize that increased female participation in these protests improved women's empowerment and helped reduce missing women. Using a difference-in-differences analysis, our identification strategy is based on protest intensity heterogeneity, and changes in missing women for the age group of [0–1] before and after the protests across different governorates in urban and rural areas. We find convincing causal evidence that the number of missing women decreased significantly in high protest intensity governorates. Based on protest heterogeneity across different periods, we also show that this effect was most visible after the fourth and final phase of protests. As for possible channels, we find that domestic violence during pregnancy incidence fell significantly in treatment areas, while both relative vaccination rate of girls aged [0–1] as well as women's empowerment increased significantly.

1. Introduction

This paper explores the effects of women's participation in political protests during the Egyptian revolution of 2011–2014 on "missing women" in Egypt. We hypothesize that participation in these political protests helped increase women's empowerment and enabled gains in gender equality, thus reducing the number of missing women.

Empowerment, political participation, and missing women are intrinsically interconnected. The term missing women refers to the number of women missing at birth as well as excess female mortality and lower survival rates caused by infanticide, neglect, nutritional deficiency, lack of health care or poor treatment (Alkema et al., 2014; Anderson and Ray, 2010; Chen et al., 1981; Clark, 2000; Duflo, 2012; Gupta, 1987; Jayachandran, 2015; Kynch and Sen, 1983; Qian, 2008; Sen, 1989). It was first brought to public

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attention by Sen (1990) and has been studied extensively since then. Despite renewed efforts, including those of the United Nations Sustainable Development Goals (SDG), gender discrimination against women continues to be a major problem and it is predicted that the number of missing women around the world will reach 150 million by 2035 (Bongaarts and Guilmoto, 2015).

Studies on the causes of missing women highlight the importance of male-biased societal choices, which manifest themselves through selective sex abortion, female infanticide, unequal access to health care and nutrition, and domestic violence (Bhalotra and Cochrane, 2010; Gupta, 2005; Jayachandran, 2015; Jha et al., 2006; Junhong, 2001). For example, Bhalotra and Cochrane (2010) estimate that between 1995 and 2005 around half a million girls went missing due to selective sex abortions in India. Moreover, women's household conditions, including male-biased allocation of resources and women's lack of bargaining power, contribute to the missing women problem (Anderson and Ray, 2010; Bardhan and Klasen, 1999; Maharana and Ladusingh, 2014).[1] Previous studies also show that the rate of missing women is significantly higher in developing countries where women face a higher degree of gender discrimination.[2] Therefore, we expect that increasing women's empowerment can help drive societal change in favor of gender equality and reduce the number of missing women.[3]

Our work is related to previous studies that highlight the importance of women's political participation, leadership, and activism to improve their social and economic conditions and empowerment (Beaman et al., 2009, 2012; Ghani et al., 2014; Iyer et al., 2012; Stern and Erten, 2024). Women as political agents in collective action have played significant roles in civil rights and pro-democracy movements, and revolutions, including the 1789 French Revolution, 1917 Bolshevik Revolution, 1960s American Civil Rights movement, 1979 Iranian Revolution, and 2011 Egyptian Revolution, among many others. Furthermore, women's empowerment has gone hand in hand with increasing women's participation in social movements, leading to structural economic, political and societal changes. However, although the direct effects of these social movements have been a source of significant discussion and research, their indirect or secondary effects, our focus in this paper, remain underexplored. Previous studies on revolutions also highlight the importance of unobservable and interdependent factors as well as network effects in driving individual decisions to participate in social movements and protests.[4] Among studies that are closest to ours, El-Mallakh et al. (2018) find that the Arab Spring had a positive effect on women's labor force participation and reduced intra-household gender gap in Egypt. Likewise, Bargain et al. (2019) report that women's participation in political protests during the Egyptian Revolution had a significantly positive effect on women's empowerment. Stern and Erten (2024) find that regions in Egypt that were more exposed to women's political participation during the Arab Spring protests experienced a lower probability of physical, sexual and psychological violence from their intimate partners. Furthermore, increased political participation and activism is shown to promote women's empowerment in the marketplace and improve their likelihood of reporting domestic violence and sex crimes (Ghani et al., 2014; Iyer et al., 2012; Sahay, 2021).

However, it is also possible that increased political instability and uncertainty can further reinforce gender-biased household decisions and ultimately hurt women. Giesing and Music (2019), for example, argue that the very short-term effects of the 2011 Egyptian uprising included cuts in overall health expenditures and increased spending for son's but not daughter's tertiary education. Shemyakina (2011) reports a similar negative effect of exposure to armed conflict in Tajikistan on girls' but not boys' school enrollment rates.[5] Increasing women's empowerment and agency may also cause increased intimate partner violence through the 'male-backlash' effect (Angelucci and Heath, 2020).[6] Using the DHS from 23 Sub-Saharan countries, Mattina and Shemyakina (2024) find that exposure to civil war increased women's acceptance of domestic violence. Theoretically speaking, therefore, there are two opposing transmission channels through which political instability, social unrest and social mobilization can affect missing women, one with a positive and another with a negative effect. In this paper, we examine the net effect of these two opposing forces and also explore some of the transmission channels.

The Arab Spring (or Arab Revolutions), which included a wide range of democratic protests and civil disobedience, was (and is) one of the most important political movements in the Middle East and North Africa (MENA) region in recent history. It started in Tunisia in December 2010, then spread to other MENA countries in a series of "revolutionary cascades" (Hale, 2013). In Egypt, the protests began in January 2011 and immediately met with state violence, leading to arrests, injuries, and deaths. Our focus here is on one unique and widely reported aspect of these protests, the unprecedented level of women's participation (Alvi, 2015; Bargain et al., 2019; Dyer, 2013; Gurpinar, 2015; Shalaby, 2016).[7] We argue that the Arab Spring and the ensuing Egyptian protests offer an interesting event study to explore the effects of political and civic participation, civil unrest, and collective action on missing women. In the 2023 Human Development Report of the United Nations Development Program, Egypt ranked 105 out of 159 countries in

[1] Previous studies also show that girls' survival is higher in households where females distribute resources (Duflo, 2012).

[2] While most research focuses on developing countries, there is evidence of similar contributing factors being present in developed countries as well, such as son-preferring behaviors and higher male-to-female ratios, especially among first- or second-generation immigrants (Abrevaya, 2009; Anderson and Ray, 2010; Blau et al., 2020; Dubuc and Coleman, 2007). Source: Author's calculations based on EDHS and the information of Western Europe, Canada, United States, Australia, New Zealand, and Japan (WHO, 2020).

[3] There are other complementary reasons to explain skewed sex ratios, including falling fertility rates (Das Gupta and Mari Bhat, 1997; Park and Cho, 1995). As fertility rate decreases, parents with a strong son-preference are more likely to do sex-selective abortions (Jayachandran, 2017).

[4] For an extensive review of the literature on causes and effects of revolutions, see Kuran and Romero (2019)

[5] Verwimp and Bavel (2014) and Diwakar (2015) report significant negative effects of armed conflict on education, although more for boys than girls, therefore reducing intra-household gender gap. In contrast, El-Mallakh et al. (2018) find no effect of protest intensity in Egyptian revolution on the probability of school enrollment or the educational gender gap.

[6] Wasef (2018) also discusses the effects of the Egyptian uprising on increased domestic violence.

[7] Examining the exact set of factors that led to an unprecedented level of women's participation in these protests are beyond the scope of this paper (for a discussion, see Grinin and Korotayev (2022)). While it is possible that they might also affect missing women, as long as political participation had a positive effect on women's empowerment and agency, as argued by previous studies, our identification strategy remains valid.

gender inequality (UNDP, 2024). The labor force participation rate for women aged 15–64 was only 16% compared to 74% for men in 2023 (World Bank, 2024). Furthermore, based on 2014 Egyptian Demographic and Health Surveys (EDHS) around 30% of ever-married women aged 15–49 reported at least one episode of physical, sexual and/or emotional violence by their current or former spouses, and only 8% had access to any kind of health insurance. As we discuss later in the paper, Egypt also has a disproportionally higher relative female infant death ratio compared to developed countries.[8]

The 2011 Egyptian revolution and the subsequent waves of political protests also allow us to explore event heterogeneity across different revolutionary cascades (Hale, 2013; Kuran and Romero, 2019). As discussed by others, the Egyptian revolution was not homogeneous and encompassed different cascades of protests with varying political, economic, and social motivations and goals, including women's rights (Acemoglu et al., 2018; Alexander and Apell, 2016; Bargain et al., 2019; Costello et al., 2015; Hale, 2013). While "bread, liberty and social justice" was a rallying cry for millions of demonstrators, including many for whom this was their very first political participation and activism, the protests evolved and took different forms over time (Costello et al., 2015; Drukan, 2011; Hale, 2013). Relying on previous research and the report of Egyptian Center for Economic and Social Rights in 2015, we identify four phases of the Egyptian revolution under three different political powers between 2011 and 2014: "President" Hosni Mubarak and his National Democratic Party (NDP), the Military, and the Muslim Brotherhood (Acemoglu et al., 2018; Bargain et al., 2019). As examined further in the empirical section, the first wave started in 2011 and targeted President Hosni Mubarak and the widespread authoritarianism and corruption under his 30-year-long rule. The second phase started right after the fall of President Mubarak when the country was ruled by the Supreme Council of the Armed Forces between 2011 and 2012. The third phase between 2012 and 2013 covers the period of Mohammed Morsi's presidency and the reign of Muslim Brotherhood as the governing party. The fourth phase was from July 2013 to June 2014 and covers the period of President Adly Mansour, who was the president after a military coup and lasted until the 'election' of the Egyptian military Chief of Staff, Abdel Fattah El-Sissi, as President in 2014 (when he received 97% of the votes).

The empirical analysis in this paper is based on the 2014 EDHS, the most recent EDHS, and the Egyptian Revolution Database from the Egyptian Center for Economic and Social Rights. Using a difference-in-differences methodology, our identification strategy relies on protest intensity heterogeneity and changes in missing women before and after the protests across different rural/urban governorates in Egypt.[9] We also analyze the effects of different protests in the four phases of the Egyptian revolution on missing women. Focusing on the age group of [0–1], the empirical results suggest that the relative female/male death ratio in Egypt, compared to the reference group of developed countries, was on average 2.8 times higher between 2007 and 2014. In fact, using Anderson and Ray (2010) estimates for the age group of [0–1], Egypt (i.e., 2.37) had 2.4, 2.0 and 2.8 times higher death ratio for women than in India (i.e., 0.99), China (i.e. 2.02) and Sub Saharan Africa (i.e., 0.85), respectively. We also show that female political participation had a significantly negative effect on missing women, particularly those at the ages of [0–1]. The rate of missing women remained high in low protest intensity rural/urban governorates, averaging 1.43, while decreasing significantly in high protest rural/urban governorates, averaging 0.83. Furthermore, we find that these effects on missing women were the highest after the fourth wave of protests, and decreased in the ages of missing women. Our empirical analysis reveals three transmission channels. First, we find that domestic violence during pregnancy fell significantly in treatment areas. Second, the relative vaccination rate of girls aged [0–1] increased significantly. Third, women's empowerment increased significantly in the same areas. These effects likely to have contributed to the decrease in the number of missing women in treatment areas. These results are robust to a rich set of sensitivity checks.

The rest of the paper is organized as follows. Section 2 introduces the empirical analysis, including the measurement of missing women, treatment and control area classification, the data, and the empirical model. Section 3 provides the empirical results, followed by exploring mechanisms in Section 4. Section 5 concludes.

2. Empirical analysis

2.1. Measuring missing women

We estimate the number of missing women for different age groups, in different rural/urban governorates, and in different years in Egypt. We follow Anderson and Ray (2010) approach, which is based on (Sen, 1990) and calculate death ratios for different sexes and compare them with counter-factuals from developed countries where men and women receive more equal treatment than in developing countries (Sen, 1990).[10] Particularly, and focusing on the age group [0–1], in Eq. (1) we calculate the age-specific measure of "reference death rate" of women, $u^{w}_{irt}(a)$, at age a in rural/urban governorates ir and year t where i denotes a governorate and r denotes either rural or urban area within that governorate i ($r \in \{rural, urban\}$):

$$u^{w}_{irt}(a) = \frac{d^{m}_{irt}(a)}{\hat{d}^{m}_{t}(a)/\hat{d}^{w}_{t}(a)} \tag{1}$$

Where a is the age group, $a = 1,..,n$, and $a = 0$ indicates birth. In any age group $a \geq 1$, a includes all deaths between the age of $a-n$ and a. n can be different based on different age group classifications. $d^{m}_{irt}(a)$ and $d^{w}_{irt}(a)$ represent the death rate of men and

[8] Diop-Sidibe et al. (2006), Basyoni et al. (2024), Zaghloul and Megahed (2019) and Hassan et al. (2024) provide an in-depth examination of domestic violence and femicide in Egypt.

[9] The geographic unit rural/urban governorates indicate either rural or urban area within a governorate.

[10] We should note that we abstain from the analysis of missing women at birth and limit our analysis to missing women by age.

women at age group a in rural/urban governorates ir and year t (i.e.,2007–2014). Likewise, $\hat{d}_t^m(a)$ and $\hat{d}_t^w(a)$ are the average death rates of men and women (per 100,000 people at age group a in year t) in the reference age and country group. Thus, the reference death rate for women is given by the death rate of men that is normalized by the relative death rate of men and women for the same age group in developed countries. As explained later, our focus here is on the age group [0–1]. For the reference group, we choose the developed economies of Western Europe (Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland), Canada, United States, Australia, New Zealand, and Japan, based on 2020 World Bank country classification and the mortality data from WHO (2020).

As argued by Anderson and Ray (2010), even if there is a *natural* or *biological* variation in female and male death ratios, such differences should not vary across countries. Furthermore, similar to Anderson and Ray (2010), we are not suggesting that there is no gender discrimination in developed countries but that they set an upper threshold for gender equality, allowing us to compare other countries against this norm. We also assume that the 'discrimination free' death ratios are roughly the same in developed and developing countries as we see no evidence that the genetic makeup of developed countries, including ethnically diverse colonial settler states of Australia, Canada, New Zealand, and US, is any different than those in developing countries.

We calculate the number of extra female deaths (i.e., missing women, $mw_{irt}(a)$) at age a in rural/urban governorates ir at time t (i.e.,2007–2014) in Eq. (2). It equals the actual death rate for women, $d_{irt}^w(a)$, minus the "reference death rate" for women, $u_{irt}^w(a)$, weighted by the number of women in that age group, $\pi_{irt}^w(a)$ (i.e., the beginning population of women at age a.):

$$mw_{irt}(a) = \left[d_{irt}^w(a) - u_{irt}^w(a)\right]\pi_{irt}^w(a) \tag{2}$$

Although the DHS dataset provides households' location information by ultimate areas, because of data limitations, we calculate missing women at a higher aggregation level, the urban and rural governorate levels. There are 884 ultimate areas in Egypt and the average number of households surveyed per ultimate area is 20.70, while the average number of households that had children aged [0–1] is 15.65. Furthermore, the average number of male and female children for the age group [0–1] in an ultimate area are 27.58 and 25.35, respectively.[11] Because the average number of households surveyed in an ultimate area that had children aged [0–1] is only 52 (26 for the bottom 20 percentile), we find that the male death rate for that age group is often zero in a given year.[12] As a result, the male/female relative death ratio (d_{irt}^m/d_{irt}^w) in an ultimate area, becomes zero as well.

As shown in Eq. (2), we cannot estimate the missing women for an ultimate area without the information on the reference death rate, $u_{irt}^w(a)$. To overcome the missing value problem of relative death ratios in an ultimate area, we choose to use a larger geographic unit, the governorates, numbering 25 in Egypt. To further incorporate regional heterogeneity, we calculate missing women in rural and urban areas for each governorate, which becomes our unit of analysis. The total number of observations in our sample for the period of 2007–2014 reaches 328, excluding border governorates.

2.2. Treatment and control groups

We use two alternative methods to classify the treatment and control groups. First, to measure protest intensity in the benchmark analysis we use the total number of people who are killed during and after the Arab Spring protests between January 2011 and December 2014 at the governorate level in Egypt. We find that the group classification based on the fatality numbers is identical to that based on the injured and arrested people during this period. The data on the number of killed, injured, and arrested is from Bargain et al. (2019) and is based on Wiki Thawra Statistical Database on the Egyptian Revolution, maintained by the Egyptian Center for Economic and Social Rights (ECESR, 2014).[13] We rely on information on the number of killed, injured, and arrested people at the governorate level during the entire period (N_{ij}) and divide it by the average population of governorates to obtain the index (I_{ij}) in Eq. (3).

$$I_{ij} = \frac{N_{ij}}{P_i} \times 100,000 \tag{3}$$

where j refers to the fatalities, injuries, and arrests in governorate i. The numerator, N_{ij}, is the total number of fatalities, injuries, and arrests in different governorates in Egypt between 2011 and 2014. The denominator, P_i, is the average population in different governorates during this period. We estimate I_{ij} at the aggregate rather than rural/urban governorate level for the following reasons. While the protests were mainly carried out in urban areas rather than rural areas, protesters came from both urban *and* rural areas. Furthermore, we do not have the hometown location information of the protesters who were injured, arrested, or killed in a protest.

After calculating I_{ij} for each of the fatality, injury, and arrest cases, we classify the treatment group in a given governorate as the one with a higher incident value than the median value.[14] This is our benchmark classification. The treatment and control groups' classifications in these three indexes across different governorates are 100% consistent with each other and are represented by different colors on vertical lines in Fig. 1, which also show the aggregate totals between 2011 and 2014.

[11] The average number of male and female children for the age group [0–1] are calculated based on the average number of households surveyed in an ultimate area in a given year.

[12] The maximum number of children in surveyed households in each area is 294 and the minimum is 1.

[13] We use data provided by Bargain et al. (2019), which provide further description of the dataset. For other studies that used this database to measure protest intensity, see El-Mallakh et al. (2018) and Giesing and Music (2019). Admittedly, this is an indirect proxy for women's involvement in these protests as it is not gender-specific and does not distinguish between male and female protesters, for which the data are not available. Therefore, as a robustness check, we use the Survey for Young People in Egypt (SYPE) to classify the treatment and control groups as it provides a direct measure of women's protest participation.

[14] Note that there is no information on the injured protesters in Phase 1, or the arrested protesters in Phase 1 and 2. For a similar application, see El-Mallakh et al. (2018) and Giesing and Music (2019).

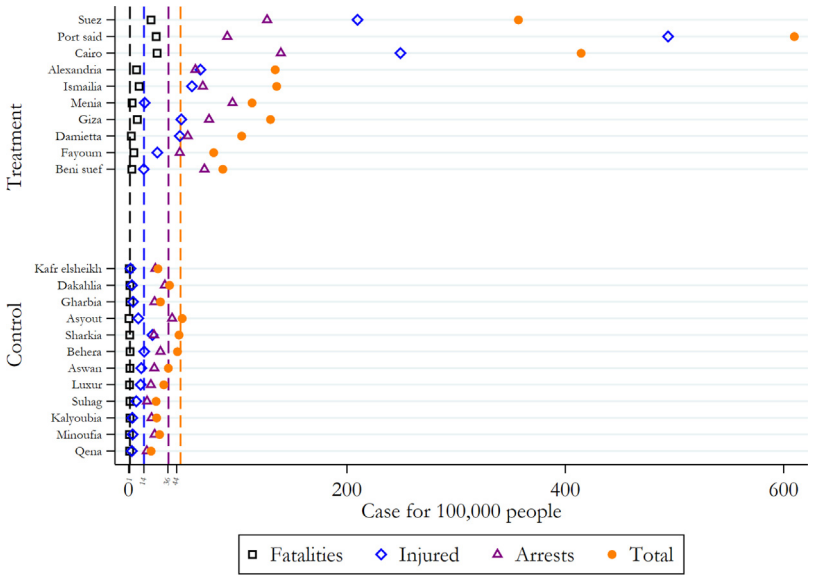

Fig. 1. Control and treatment group classification.
Notes: The baseline analysis treatment and control groups classification during the entire Arab Spring. This Figure does not include all border governorates which are Red Sea, New Valley, Matroh, North Sinai, and South Sinai.
Source: Authors' calculations based on Bargain et al. (2019) and the Egyptian Revolution Database.

Second, to examine event heterogeneity, we use the fatality information in each of the four phases of protests separately to categorize the treatment and control groups. There are four phases ('cascades') of protests during the Egyptian revolution, each with different political regimes and structural characteristics. In other words, these protests were not homogeneous in terms of political, social, and economic motivations and goals of the protesters, likely affecting the level of female participation and its social, economic, and political effects (Alexander and Apell, 2016; Hale, 2013). Briefly, the four phases of protests correspond to three different power centers that ruled Egypt between 2011 and 2014: Hosni Mubarak and his National Democratic Party (NDP), the Muslim Brotherhood, and the Egyptian Military (Acemoglu et al., 2018; Bargain et al., 2019).

The first phase of protests started right after the Tunisian protests and lasted from January 25, 2011 to February 11, 2011. It targeted the autocratic regime of President Hosni Mubarak, who ruled Egypt as a strong man for 30 years. There was an unprecedented number of women participating in this first stage of the Egyptian Revolution, which caught world's attention and made it to international news headlines (Alvi, 2015; Bargain et al., 2019; Dyer, 2013; Gurpinar, 2015; Lyden, 2013; Shalaby, 2016).

The second phase of protests targeted the Military Council, which grabbed power after the fall of Hosni Mubarak and lasted from February 11, 2011, to June 30, 2012. During this period, the Supreme Council of the Armed Forces was single-handedly responsible for ruling Egypt. The common slogans of the protesters during this phase included dignity, liberty, democracy, free and fair elections, and social justice. This is the phase that further attracted the global attention as protesters occupied the Tahrir Square in Cairo, and inspired the Occupy Wall Street movement in the US (Acemoglu et al., 2018).

The third phase was from July 1, 2012 to June 30, 2013 and corresponded to the ruling period of President Mohammed Morsi of the Muslim Brotherhood, who was elected as the fifth president of Egypt. This was a period of increased sectarian divisions and conflicts between the secularist and Islamist segments of the population, especially given the President Morsi's and Muslim Brotherhood's efforts to implement undemocratic, gender biased and Islamist legislation (BBC, 2012; Kirkpatrick and El Sheikh, 2012).[15] Even though an unprecedented number of women joined the protests in Phases 1 and 2, there was an increased focus on gender equality and women's rights in Phase 3 of protests (Alexander and Apell, 2016; Alvi, 2015; Dyer, 2013; Gurpinar, 2015; Lyden, 2013).[16]

The fourth phase was from July 1st, 2013 to June 30, 2014 and corresponds to the military rule under the interim presidency of Adly Mansour, who was appointed by the military as president after a military coup that toppled President Morsi (who later died in military custody in 2019).[17] The military government stayed in power until the head of the Egyptian Armed Forces, general Abdel

[15] For example, Egypt's Islamist-led Constituent Assembly during the rule of President Morsi approved a new constitution in December 2012, which was heavily criticized for violating freedom of religion, human rights and women's rights, and faced significant opposition (Amnesty International, 2012). Article 2 of the new constitution stated that "Islam is the state's religion..." and "[T]he principles of Islamic law (sharia) form the main source of legislation". Furthermore, Article 4 gave the task of interpreting the Islamic law to religious scholars at Azhar University (Saleh, 2012). McLarney (2013), however, argued that the issues surrounding Islam and women in the new constitution reflected continuity rather than a break with the previous constitution(s).

[16] The attitudes towards women's rights to protest were also seen differently by the Morsi government. For example, Morsi is quoted to have said "It is undignified for women to protest, and they should leave their brothers and fathers to protest for them" (Alvi, 2015).

Fattah El-Sissi, was elected after a controversial and undemocratic election as president in June 2014 (Democracy International, 2014; Fadel, 2014; Rutherford, 2018). Civil liberties, including press freedoms and the right to assembly were heavily restricted during this period. In this phase, the protesters aimed at restoring Morsi presidency and targeted the military government and were mostly from the Islamist leaning segments of the population. Using their sweeping powers, the military and security forces suppressed most of these protests violently, leading to injuries, deaths and tens of thousands of arrests (Freedom House, 2021; Hamzawy, 2016; Holmes, 2019).

Using the data from the Egyptian Revolution Rights which is collected by the Egyptian Center for Economic and Social Rights, we find that the death incidence for women protesters were 2.3% in the beginning of the first wave, 2.1% in the second, 1.9% in the third, and 2.8% in the fourth wave (ECESR, 2014).[18] In Phase 4, the protests continued from Phase 3 and included clashes between the pro-Islamists and anti-Islamists as well as between the pro-army and pro-democracy groups (Acemoglu et al., 2018; ECESR, 2014).

When comparing these four phases of Egyptian protests, we use only the fatality information because of lack of data on the number of injured and arrested in Phase 1, and lack of data on the number of arrested protesters in Phase 2. Eq. (4) shows the fatality index for different phases.

$$I_{it} = \frac{D_{it}}{P_{it}} \times 100,000 \tag{4}$$

where D denotes number of fatality, i is governorates and t is year 2011, 2012, 2013 and 2014.

After calculating the governorate-level fatality index for four phases of the Egyptian revolution, we select the associated median fatality index among all governorates in each phase to classify the treatment groups. Fig. 2 reveals that the treatment and control groups overlap around 70% between each phase of the protests. The classification in different phases is also 70%, consistent with the group classification in Fig. 1.

To further check the treatment and control group classifications, we also use the Survey of Young People in Egypt (SYPE), which includes information on protest participation of women aged 18 to 35 in non-border governorates and their attitudes on protests.[19] Using this information from SYPE, we conduct a more direct governorate-level measure of women's protest participation. The classification variable equals one if they participated in or supported any of the protests, and zero otherwise. This classification, which is in Fig. 3, is 70% identical with the one from the Egyptian Revolution dataset in Fig. 1.

2.3. Dataset and control variables

We use the 2014 EDHS as our main source for control variables in the regression analysis.[20] The EDHS includes information on household and family characteristics, incomes, demographics, health and living conditions. Even though this is a one-year dataset, it includes panel information on children from 1978 to 2014 at the household level. Of this period, we focus on 2007–2014 to measure the missing women given that it is the closest to the Egyptian revolution.[21] The 2007–2014 period is also reported to have no significant changes in women rights in Egypt (Bargain et al., 2019). Furthermore, the 2014 EDHS was conducted right after the end of Egyptian protests, April–May 2014, and was also after the new presidential election on May 26–28, 2014, which will help with our identification.

We should note that because we only have annual information from EDHS, the four protest phases are classified using annual information rather than month-year. In the empirical analysis, the four phases cover the periods of 2011–2012 (Phase 1),2012–2013 (Phase 2),2013–2014 (Phase 3) and 2014 (Phase 4). Furthermore, because the effect of protests on missing women, especially the newborn, may not manifest itself immediately, and may have a lag, we used full calendar years.

As for sample selection, we focus on married women, aged 15 to 49, and exclude households from the border governorates (i.e., Red Sea, New Valley, Mathroh, North Sinai, and South Sinai), which are mostly occupied by Bedouin tribes who have nomadic traditions and their reactions to the protests could arguably be different than people in urban areas and inner cities. These border governorates are mostly desert areas where only 2% of Egyptians live (CAPMAS, 2017). However, in the robustness analysis, we include these five border governorates and find consistent result. The final dataset contains 328 rural/urban governorate-level observations, where 136 are from high-protest and 192 observations are from low-protest intensity areas.[22]

Table 1 presents summary statistics on the demographic characteristics of respondents in high- and low-protest intensity areas at the household level (based on the median level of protest intensity using the aggregate-level classification, which includes the total number of fatalities, injuries, and arrests). The upper panel shows that women in high-protest intensity areas have higher levels of primary but lower levels of secondary education as their terminal degrees than low-protest intensity areas. They also have a slightly higher rate of higher education, albeit statistically not significant. We find no significant difference in terms of female employment to population ratio (i.e., work rate), number of children, or the respondent age in either areas.

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[17] For a discussion of the military coup, see ElMasry and Ketchley (2020); Grewal (2023); Holmes (2019); Mandour (2024); Rutherford (2018).

[18] For example, in Phase 1, the total number of people killed is 1075 in 22 different governorates including 23 women. We use 23 divided by 1075 to get 2.1%. Similar calculations are done in other phases.

[19] For further discussion of the SYPE database, refer to Liu et al. (2019).

[20] We do not use the EDHS dataset in 2004, 2007 or 2010 as they only contain information on children born before the Arab Spring protests started.

[21] There is a high level of volatility in the missing women numbers in Egypt prior to 2007, suggesting possible data problems in the EDHS. An alternative could be to focus on the period of 1978–2006. However, this would be too far away from the Egyptian uprising, making identification difficult.

[22] Although the number of rural/urban governorates is 27 in Egypt, we consider only non-border governorates in our analysis. Hence, we have 21 rural/urban governorates in the dataset for each year, yielding 328 observations for the sample period of 2007–2014.

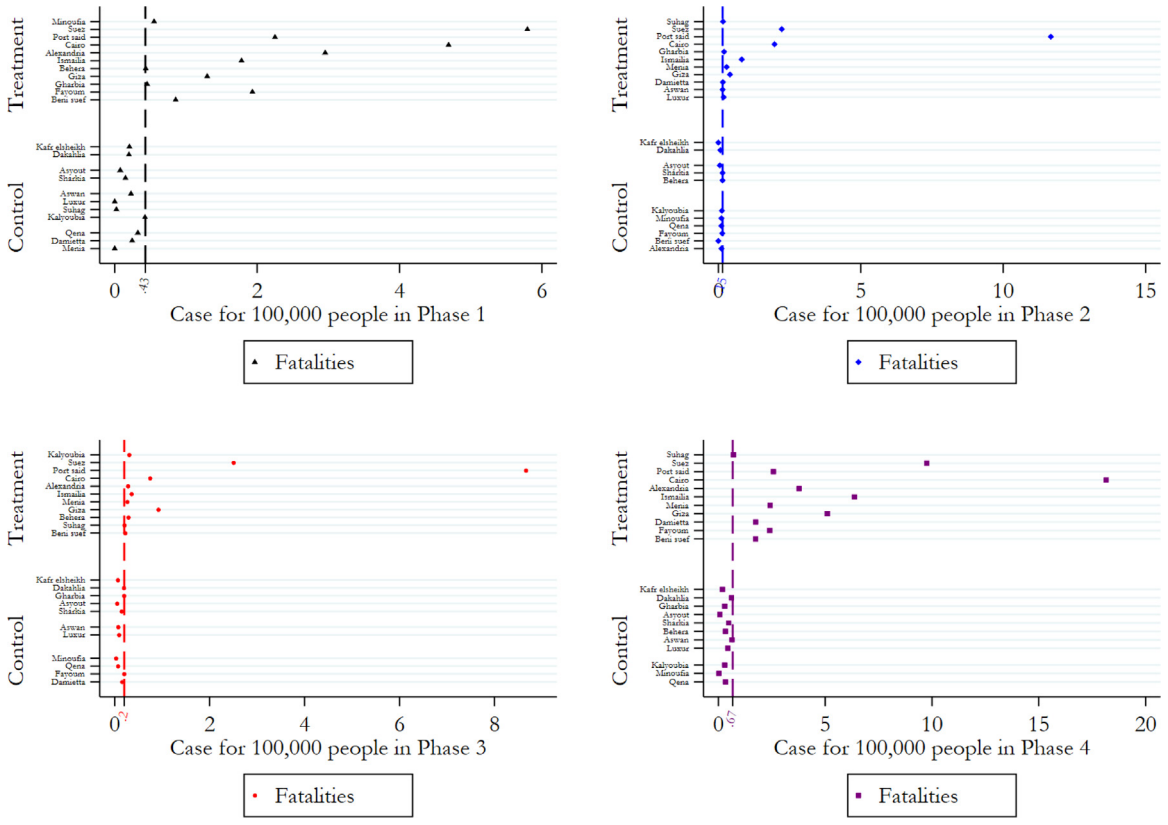

Fig. 2. Control and treatment groups in different phases of Egyptian protests.
Notes: The treatment and control groups classification in different phases in the Arab Spring. This Figure does not include border governorates of the Red Sea, New Valley, Matroh, North Sinai, and South Sinai.
Source: Authors' calculations based on Egyptian Revolution Database.

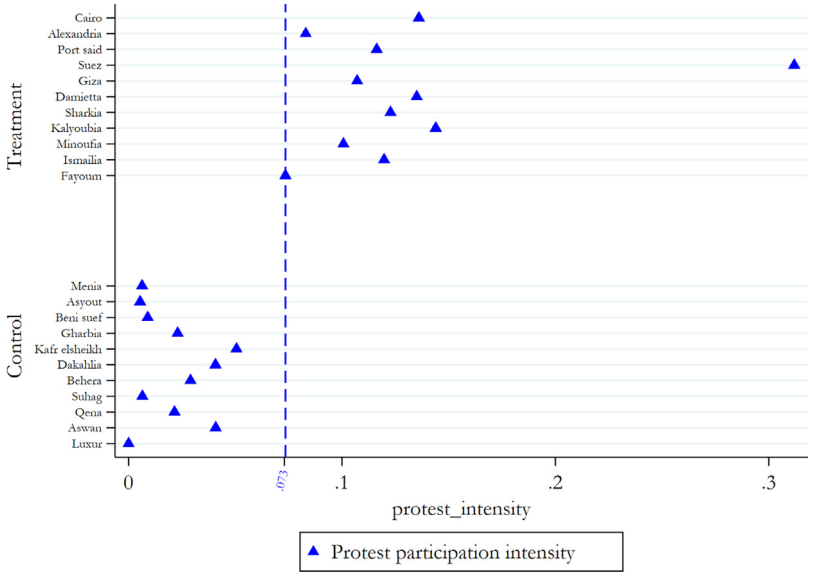

Fig. 3. Control and treatment group groups using SYPE.
Notes: The treatment and control group classification during the entire Arab Spring through SYPE dataset. This Figure does not include all border governorates which are Red Sea, New Valley, Matroh, North Sinai, and South Sinai.
Source: Authors' calculations based on SYPE.

Table 1
Summary statistics.

	Aggregate (1)	High protest (2)	Low protest (3)	Difference (4)
Female Respondent Information				
No Education	0.154	0.163	0.147	0.016
Primary Education	0.078	0.085	0.073	0.012**
Secondary Education	0.574	0.559	0.584	−0.025**
Higher Education	0.184	0.189	0.181	0.008
Work Rate	0.149	0.149	0.150	−0.001
Age	30.216	30.120	30.284	−0.163
	(2.218)	(2.208)	(2.228)	(0.249)
All Children Ever Born	2.943	2.902	2.972	−0.071
	(0.515)	(0.470)	(0.544)	(0.058)
Husband Information				
No Education	0.124	0.129	0.120	0.008
Primary Education	0.137	0.160	0.121	0.039***
Secondary Education	0.551	0.537	0.561	−0.024***
Higher Education	0.190	0.178	0.198	−0.020**
No Job	0.020	0.019	0.020	−0.001
Tech Job	0.237	0.235	0.238	−0.003
Clerical	0.046	0.043	0.048	−0.005
Sale	0.054	0.050	0.057	−0.007**
Self-Agriculture	0.055	0.053	0.057	−0.004
Employed Agriculture	0.074	0.076	0.073	0.003
Services	0.110	0.102	0.115	−0.012**
Skilled manual	0.353	0.364	0.346	0.019*
Unskilled manual	0.090	0.102	0.082	0.020***
Unknown	0.011	0.010	0.012	−0.002
Husband Age	37.128	36.811	37.353	−0.541*
	(2.671)	(2.544)	(2.742)	(0.298)
Household Information				
Female Heads	0.047	0.048	0.046	0.002
Muslim	0.963	0.966	0.960	0.006
Christian	0.036	0.033	0.039	−0.006
Unknown Religion	0.001	0.001	0.001	0.000
Urban	0.537	0.588	0.500	0.088
Household Size	5.414	5.271	5.515	−0.245***
	0.729	0.513	0.837	−0.041
Women Number	1.107	1.085	1.123	−0.038***
	(0.107)	(0.082)	(0.120)	(0.012)
Household Head Age	39.336	38.952	39.609	−0.657**
	(2.758)	(2.478)	(2.917)	(0.307)
Wealth	3.325	3.516	3.189	0.327***
	(1.044)	(1.049)	(1.021)	(0.116)
No of observations	328	136	192	

Notes: Standard deviations, except for dummy variables, are reported in parenthesis. Column (4), Difference reports the t-test results of the difference between the treatment and control group. $NoEducation$ refers to respondents with no education. $Primary$, $Secondary$, and $HigherEducation$ means the highest education of the respondent is the primary, secondary or higher school (i.e., college, Masters, or Ph.D.) education, respectively. $WorkRate$ is the number of women with a job divided by the total number of women. Age is the average age of the respondent. $Allchildreneverborn$ is the average total number of children born to the respondent until the survey time. $NoJob$ is the share of husbands without a job. $TechJob$ is the share of husbands with a technology job, professional jobs, and managerial jobs. $Clerical$ is the share of husbands with a religious job. $Sale$ is the share of husbands with a sale job. $Self-Agriculture$ is the share of husbands with their own farmland. $EmployedAgriculture$ is the share of husbands in other people's farmlands. $Services$ is the share of husbands with service jobs. $SkilledManual$ and $UnskilledManual$ are the shares of husbands with skilled and unskilled manual jobs, respectively. $Unknown$ refers to husbands for whom we have no occupational information. $FemaleHeads$ is the share of households with women household heads. $Muslim$ and $Christian$ are the shares of households who are Muslim or Christian, respectively. $UnknownReligion$ is the share of households with no information on their religion. $Urban$ is the share of households living in urban areas. $HouseholdSize$ is the average number of household members. $WomenNumber$ is the average number of women in a household. $HouseholdHeadAge$ is the average age of the household head. $Wealth$ is the household wealth index, including poor, middle, richer, and richest, increasing in wealth. N is the number of observations. Standard deviations are reported in brackets. All job classifications and information in this table are based on the country specific coding system.

The middle panel of Table 1 presents the demographic information on respondents' husbands. We find that the share of husbands with primary education is higher in high protest intensity areas. They are also younger and have more skilled and unskilled manual jobs. In contrast, low-intensity areas display a higher share of husbands with secondary and higher education. They are also more employed in services and sales jobs. We do not observe any significant difference in terms of unemployment (i.e., *nojob*), the

Table 2
Summary statistics of death ratios in the reference group and Egypt from 2007 to 2014.
Source: Author's calculations based on EDHS and the information of Western Europe, Canada, United States, Australia, New Zealand, and Japan WHO (2020).

Year	Reference group death ratio			Egyptian death ratio		
	Female DR (1)	Male DR (2)	Relative DR (3)	Female DR (4)	Male DR (5)	Relative DR (6)
2007	0.004	0.005	0.812	0.032	0.015	2.126
2008	0.004	0.004	0.815	0.029	0.015	1.884
2009	0.004	0.004	0.817	0.027	0.011	2.392
2010	0.004	0.004	0.819	0.032	0.014	2.281
2011	0.004	0.004	0.827	0.027	0.010	2.644
2012	0.003	0.004	0.829	0.027	0.011	2.476
2013	0.003	0.004	0.833	0.024	0.012	2.055
2014	0.003	0.004	0.838	0.026	0.008	3.106

Notes: $FemaleDR$, $MaleDR$, and $RelativeDR$ represent female, male, and relative death ratio at age [0–1]. $RelativeDeathRatio$ is calculated by Female Death Ratio divided by Male Death Ratio. We use the group of Established Market Economies as defined by the World Bank: Western Europe, Canada, United States, Australia, New Zealand, and Japan.

prevalence of technical jobs (i.e., $TechJob$), clerical jobs (i.e., $Clerical$), self-employed in agriculture (i.e., $Self - Agriculture$), or employed in agriculture (i.e., $Employed - Agriculture$). The bottom panel of Table 1 provides information at the household level. We observe no economically or statistically significant difference in the religious characteristics or the share of female-head households. However, households in high-protest areas are smaller in size, have fewer number of women in the household, have younger heads of household, and are wealthier.

In Table 2 we present the average male, female, and relative death ratios for the age group of [0–1] in the reference group (i.e., developed countries) and Egypt between 2007 and 2014. We find that the relative death ratio of both girls and boys in Egypt are two to four times higher than those in the reference group. We also see that while the relative death ratio in developed countries is less than one, it is significantly larger than one in Egypt, indicating a higher death ratio for females than males.

In Table 3 we compare the female, male and relative death ratios, the reference death rate for women of age 1 (u_{it}^{w}), the starting population of females of age 1 (π) and the missing women in high- and low-protest intensity regions in Egypt between 2007 and 2014. We find that the female death ratio (column 1) is significantly lower in high-protest areas in every year. The same is true for male death ratio (column 2) in most years. As a result, except for two years, 2007 and 2008, we find the relative death ratio for females to be significantly lower in high-protest areas (column 3). The reference death ratio for females aged between 0 and 1 (column 4 vs. column 10) is also lower in this group, except for in three of the eight years analyzed here. Furthermore, we observe a steady decline in missing women (column 6) in the high-protest areas after 2011 while no such change is visible in low-protest areas. In Table 4, we highlight the differences in female and male death ratios, relative death ratios, reference death rates, starting populations and missing women and their statistical significance between high and low protest intensity regions. We find that while the difference in missing women between the two regions was not statistically significant prior to 2013, it became significant at the 1% level after that.

Before moving to the empirical model, in Fig. 4 we check the missing women trend in the treatment and control groups. We find that while the missing women in the treatment group was lower than that in the control group before the Egyptian protests started in 2011, they both displayed a parallel trend, suggesting no major changes were affecting either group differentially.[23] After 2011, however, we see a sharp decline in missing women in the treatment group compared to the control group. While both Table 4 and Fig. 4 suggest a significant effect of protests on missing women, likely through the effect of increased civic participation of women in political protests, they are not conclusive regarding a causal relationship. We will explore this question more in depth in the next subsection.

2.4. Empirical model

We use a difference-in-differences method to explore the extent to which the likely participation of women in Egyptian protests affected missing women in the age group of [0–1], who are likely to suffer the most from the negative effects of gender discrimination.[24] We focus on missing women of age [0–1], given that the higher mortality rates of girls at younger ages is a major contributor to the missing women (Anderson and Ray, 2010, 2012). Previous studies show that the mortality rates for girls are higher than those for older women due to imbalances in health investment (Jensen and Oster, 2009) and parental discrimination (Barcellos et al., 2014; Jayachandran and Kuziemko, 2011; Junhong, 2001). Gender discrimination worsens the health care and food availability for girls, causing higher female mortality (Gupta, 1987) and lower survival rate (Chen et al., 1981). The shorter

[23] In addition to the actual trend in missing women, Appendix Figure 1 presents the predicted trends for the treatment and control groups. The predicted trends are obtained by interacting the post dummy with year fixed effects. We find that Appendix Figure 1 displays a pattern similar to that in Fig. 4.

[24] For similar uses of the difference-in-differences methodology in the context of the effects of Egyptian revolution, see El-Mallakh et al. (2018), Bargain et al. (2019), Giesing and Music (2019), and Liu et al. (2019).

Table 3
Summary statistics of death ratios in high- and low-protest areas in Egypt.

Panel A: High Protest Intensity						
Year	Female death ratio	Male death ratio	Relative death ratio	u^w_{irt}	π^w_{irt}	Missing women
	(1)	(2)	(3)	(4)	(5)	(6)
2007	0.023	0.010	2.332	0.007	61.588	0.924
2008	0.023	0.012	1.959	0.007	75.471	0.971
2009	0.024	0.012	2.023	0.010	72.588	1.040
2010	0.029	0.015	1.956	0.011	64.941	1.115
2011	0.023	0.009	2.404	0.007	70.529	0.998
2012	0.020	0.009	2.160	0.005	71.941	0.879
2013	0.018	0.012	1.472	0.009	75.588	0.599
2014	0.009	0.008	1.139	0.005	53.294	0.096

Panel B: Low Protest Intensity						
Year	Female death ratio	Male death ratio	Relative death ratio	u^w_{irt}	π^w_{irt}	Missing women
	(1)	(2)	(3)	(4)	(5)	(6)
2007	0.039	0.020	1.944	0.015	52.792	1.222
2008	0.037	0.020	1.896	0.013	59.208	1.267
2009	0.033	0.011	3.001	0.007	56.417	1.352
2010	0.037	0.014	2.662	0.010	55.708	1.464
2011	0.034	0.012	2.934	0.007	61.917	1.511
2012	0.034	0.013	2.694	0.009	67.000	1.579
2013	0.031	0.011	2.757	0.008	70.292	1.566
2014	0.041	0.010	4.070	0.008	47.167	1.510

Notes: $u^w_{k,t}$ is the reference death ratio for women at age [0–1], which is calculated using Eq. (1), $u^w_{irt}(a) = \frac{d^m_{irt}(a)}{\hat{d}^m_{ir}(a)/\hat{d}^w_{ir}(a)}$ where $a \in \{0, 1\}$. The notation π^w_{irt} represents the starting population of women aged 0–1 in a rural/urban governorate (ir). For other variable definitions, refer to Table 2. The missing women is based on Eq. (2), $mw^w_{irt}(a) = [d^w_{irt}(a) - u^w_{irt}(a)]\pi^w_{irt}(a)$.

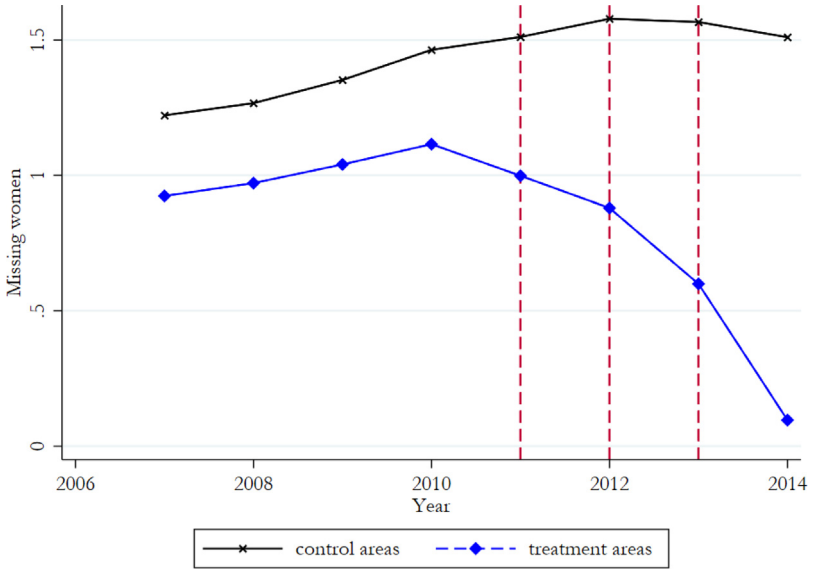

Fig. 4. Missing women trend before and after the arab spring.
Note: These two lines represent the missing women from 2007 to 2014 in treatment and control areas for ages 0–1 group. The first vertical red dash line is the Arab Spring period which is also the first phase starting time during the Arab Spring. The second and third dash lines are the second and third phases of the Arab Spring.
Source: Authors' calculations based on DHS.

time span of the data also makes it easier to identify the effect of political participation on missing women for this age group. Given the short-run findings in Giesing and Music (2019), we also expect the reduced household health care spending during the

2011 Egyptian protests to hurt girls more than boys. By focusing on the [0–1] age group, we also avoid a possible heterogeneity problem, caused by the effect of political participation on women's agency, influencing missing women directly for older age groups. In the sample, we find that the share of missing women in total number of women for different age groups is the highest for the age group of [0–1] (Appendix Table A1.2). We also see that it is higher in the low-protest intensity governorates than in the high-protest intensity ones (Appendix Table A1.2). Here the identification works through the effect of political participation on mothers', fathers' and other family members' gender attitudes and women's empowerment. We use Eq. (5) to estimate this relationship:

$$mw_{i_r at} = \alpha + \beta_1\left(Post_t \times Treat_i\right) + \beta_2 Post_t + \beta_3 Treat_i + \gamma X_{i_r at} + V_{i_r} + \varepsilon_{i_r at} \tag{5}$$

where mw_{irat} measures the missing women, calculated from Eqs. (1) and (2), in rural/urban sub-governorate i_r where i denotes a governorate and $r \in \{rural, urban\}$, at age a (i.e., 0–1), and in year t. Thus, our unit of analysis is i_r for a specific age group a. $Treat_i = 1$ if the missing women are in the high-protest intensity governorate areas (10 governorates), and $Treat_i = 0$ if they are in low-protest intensity governorate areas (11 governorates). $Post_t = 1$ for year t in the post-Egyptian revolution period of 2011–2014, and $Post_t = 0$ for 2007–2010. V_{i_r} is the vector of rural/urban governorate level fixed effects and $\varepsilon_{i_r at}$ is the error term. In total we have 328 observations, 136 from high- and 192 from low-protest intensity areas. We cluster the standard errors at the rural/urban governorate level because missing women measure does not vary within a rural/urban governorate. In estimating Eq. (5) we use information on children from 2007 to 2014 using the 2014 EDHS.[25]

The coefficient β_1 from the interaction of $Post$ and $Treat$ is the difference-in-differences estimation term, capturing the effect of the Egyptian protests on missing women in the treatment group (i.e., the high-protest governorates). β_2 captures the effect of Egyptian protests in both control and treatment groups and β_3 shows the effect of existing differences in missing women rates between the treatment and control groups, irrespective of protest intensities. $X_{i_r at}$ controls for other observables that can affect missing women rates in both the treatment and control groups, and include the respondent's education level (i.e., primary, secondary, higher), employment status, age, religion, income level (i.e., poorest, middle, richer, richest), husbands' age, employment status, and education, urban/rural residence, birth order of children, and the number of children in the households.

The key identifying assumption of our difference-in-differences strategy is that the trends in the number of missing women were similar between the treatment and control groups prior to the Arab Spring movement. To assess the validity of this assumption, we present pre-treatment trends in Fig. 4. The parallel trends of missing women in treatment and control areas during 2007–2010 shown in Fig. 4 support the credibility of our estimation approach and allow us to estimate the causal impact of the Arab Spring movement on missing women in Egypt. Given the double difference and the inclusion of rural/urban governorate level fixed effects in Eq. (5), any location specific cultural difference should not affect the results.

3. Results

3.1. Main results

The benchmark results for the effect of protests on the treatment group (i.e., $Post \times Treat$) from Eq. (6) are presented in Panel A of Table 5 (full regression results are provided in Appendix Table A2.1 Panel A). Column (1) includes the bare-bones version of Eq. (5) and includes only the treatment group dummy, the time dummy, and their interaction term. Column (2) adds a full set of individual controls. Column (3), which is our benchmark specification, adds governorate urban and rural fixed effects, in addition to individual control variables. Columns (4)–(6) replicate column (3) but using different weighting methods: propensity score weighting (PS) in column (4), DHS survey weighting (Survey) in column (5), and a self-created weighting in column (6) (Kids Age-1 weighting).[26] The standard errors are clustered at the governorate urban and rural levels.

The empirical results suggest that Egyptian protests helped reduce the number of missing women significantly, around 0.722 in the treatment group, using the benchmark estimate of column (3) (per 1167 people, where 1167 is the average number of women in the treatment group before the Arab Spring). Based on point estimates in columns (1)–(6), we provided the estimates for the number of deaths prevented in Table 6 showing that the number of missing women decreased by around 38–89 per 100,000 women per year in the high-protest intensity governorates compared to the low-protest intensity governorates.[27] This is an economically and statistically significant effect. Furthermore, in column (4) we repeat the regression analysis using the propensity score reweighting method to relax the linearity assumption. Because the treatment variable is a dummy variable, we use the propensity of being treated and use the inverse propensity score (PS) to get the propensity score weighting (Hirano et al., 2003). First, we use $p_i = P(Treat_i = 1)$ as the probability of i being in a high protest intensity group, based on the set of control variables X_{iat}. We then calculate the weights to use as $1/p_i$ for the treatment group and $1/(1 - p_i)$ for the control group. We also experiment with the survey weighting instead of the propensity score weighting and report the results in column (5). We also created our own weights in column (6) by using the number of total populations in different governorates in different years from EDHS divided by the number of total populations in different governorates in different years from Egyptian census. The results from these exercises in columns (4)–(6) are quite

[25] All estimations are done in Stata 17.

[26] The self-created weighting uses the number of children in Age-1 group in different governorates in different years from EDHS divided by the relative number of children in Age-1 in different governorates in different years from the Egyptian census.

[27] We use the coefficient of interaction term in column (3) (0.722), divided by the average number of women in the treatment group before the Arab Spring from 2007 to 2010 (1167), and then multiply by 100,000. We then get the estimated missing women per 100,000 women, 61.87. The differences with the table are because of rounding. We use the same method to estimate all the missing women in this paper.

Table 4
Differences in death ratios and missing women in high- and low-protest areas in Egypt from 2007–2014.
Source: Author's calculations based on DHS in Egypt and the information of Western Europe, Canada, United States, Australia, New Zealand, and Japan WHO (2020).

Year	Female death ratio	Male death ratio	Relative death ratio	u^{w}_{irt}	π^{w}_{irt}	Missing women
	(1)	(2)	(3)	(4)	(5)	(6)
2007	−0.017	−0.011	0.388	−0.009*	8.797	−0.298
2008	−0.015	−0.008	0.063	−0.006	16.26	−0.295
2009	−0.009	0.001	−0.978	0.003	16.17	−0.312
2010	−0.008	0.001	−0.706	0.001	9.233	−0.348
2011	−0.012	−0.002	−0.531	−0.0002	8.613	−0.513
2012	−0.015	−0.004	−0.534	−0.004	4.941	−0.699
2013	−0.014	0.001	−1.285	0.001	5.297	−0.967***
2014	−0.032	−0.002	−2.931	−0.003	6.127	−1.414***

Notes: Columns (1)–(6) refer to differences between High- and Low-Protest Areas in each column in Table 3. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. $u^{w}_{k_i t}$ is the reference death ratio for women aged 0–1, which is calculated using Eq. (1), $u^{w}_{irt}(a) = \frac{d^{m}_{irt}(a)}{\hat{d}^{m}_{i}(a)/\hat{d}^{w}_{i}(a)}$ where $a \in \{0, 1\}$. The notation π^{w}_{irt} represents the starting population of women aged 0–1 in a rural/urban governorate (ir). For other variable definitions, refer to Table 2. The missing women is based on Eq. (2), $mw^{w}_{irt}(a) = [d^{w}_{irt}(a) - u^{w}_{irt}(a)]\pi^{w}_{irt}(a)$.

consistent with our benchmark results.[28] Overall, the findings are quite significant (at 10%, 5%, or 1% level), showing a significant reduction in missing women in high-protest intensity areas. These findings are robust to additional control variables, estimation method, clustering of standard errors and weighting method.

3.2. Robustness analysis

In this section we conduct a large set of robustness checks to scrutinize our earlier findings. All these tests are based on the benchmark linear model in column (3) of Table 5.

First, to rule out the possibility that other unobserved factors might have influenced the missing women in the treatment and control groups before the Egyptian protests started in 2011 and therefore affected our results, we implement a placebo test by setting an artificial intervention event before 2011. Thus, we use 2010 as the artificial "Egyptian Revolution" date and only use the sample before 2011. We use the same approach as in Panel A of Table 5 to analyze the changes in missing women from 2007 to 2010. In this placebo test, we set $Post_{it} = 1$ for missing women observed in 2010 and $Post_{it} = 0$ for missing women observed from 2007 to 2009. If the Egyptian revolution and ensuing protests were the true drivers of decreasing missing women in the treatment group, we should find no significant effect of the placebo event and the coefficient of the interaction variable should be zero. Panel B in Table 5 shows the results from this exercise. Independent of specification methods in columns (1)–(6), we find that the interaction term is not significant and is near zero, both economically and statistically, supporting our earlier findings. This result is also consistent with the common trend changes before and after 2011 in treatment and control groups in Fig. 4.[29]

Second, we cluster the standard errors at the aggregate governorate level, rather than urban and rural governorate levels, and use different regional fixed effects (i.e., municipality vs. governorate levels) and a different bootstrap approach. The results are reported in Table 6 where column (1) is the benchmark result from Table 5 column (3). In column (2), we replace governorate urban and rural fixed effects with aggregate governorate fixed effects. In column (3) we keep the governorate urban and rural fixed effects but cluster the standard errors at the governorate level. In column (4)–(6), we use the bootstrap at 800 replications, 1000 replications, and the 'wild bootstrap' i, respectively (Cameron et al., 2008; Roodman et al., 2019). The results are consistent with those from Table 5.

Third, we check the sensitivity of our results to sample selection and treatment and control group classification. We present results in Table 7. First, women's age can influence the baby's health conditions (UNICEF, 2008). Thus, to rule out any heterogeneous effects among mothers based on age, in column (1) of Table 7 we limit the sample to those women aged from 20 to 40, which is 93.4% of sample observations. Next, because we rely on respondent women's answers to survey questions, the presence of their husbands during the interviews may bias their survey responses and influence the accuracy of our missing women calculations. Societal factors may cause the respondents to give incorrect answers not to disclose any discrimination towards women. To account for this possibility, we exclude women, who are interviewed in the presence of their husbands (column 2) or any other family members (column 3). The results are again consistent with our earlier findings.

[28] In an additional robustness check, we replace the Post dummy variable with year fixed effects and report the results in Appendix Table A2.2. As shown, the post × treatment coefficients in these model specifications are consistent with our main findings in Table 5, further supporting the robustness of our difference-in-differences estimates.

[29] We also try addressing the concern that variables related to protest intensity may have differential effects on missing women over time by including an interaction term for 'Post × Controls' for the main specification of Table 5 and report the results in Appendix Table A2.3. However, in this exercise, the regression model suffers from the over-parameterization problem as we end up introducing additional 17 parameters, for a total 61 parameters, all estimated using only 328 observations. Additionally, the regression model appears to suffer from the multicollinearity problem with a very high R^2 and VIF values above 10 for multiple variables.

Table 5
Effect of Egyptian protests on missing women.

				Propensity Score	Survey weighting	Children Age-1 weighting
	(1)	(2)	(3)	(4)	(5)	(6)
A. Missing Women						
Post × *Treatment Group*	−0.585**	−0.450*	−0.722**	−0.696**	−0.663*	−1.039**
	(0.295)	(0.270)	(0.305)	(0.294)	(0.353)	(0.396)
Number of deaths prevented per 100,000 women	−50.115	−38.571	−61.885	−59.654	−56.829	−89.074
Observations	328	328	328	328	328	328
R^2	0.060	0.290	0.515	0.537	0.561	0.472
B. Placebo: 2007–2010						
Post × *Treatment Group*	−0.047	0.004	0.143	0.026	−0.579	0.347
	(0.492)	(0.442)	(0.490)	(0.493)	(0.644)	(0.677)
Number of deaths prevented per 100,000 women	−3.987	0.354	12.215	2.235	−49.602	29.774
Observations	164	164	164	164	164	164
R^2	0.016	0.311	0.666	0.691	0.685	0.634
Controls	No	Yes	Yes	Yes	Yes	Yes
FE	No	No	Yes	Yes	Yes	Yes
PS reweighting	No	No	No	Yes	No	No
Survey weighting	No	No	No	No	Yes	No
Self-created weighting	No	No	No	No	No	Yes
Cluster	No	No	Yes	Yes	Yes	Yes

Notes: Linear estimations based on 2014 DHS. Estimation of missing women is from the missing women calculation in Eq. (1). The treatment group includes those governorates whose protest intensity is above-median protest intensity (based on the Egyptian Revolution database and defined as the governorate-level proportion of fatalities, injured, and arrested). Number of deaths prevented per 100,000 refers to predicted effect of $Post \times Treat$ on missing women per 100,000 population. $Controls$ refer to control covariates and include wealth of households, work condition of respondents, urban, number of kids in the households, education of the respondents, age of wife and husband, husbands' work condition, religion, and kids birth order. FE are governorate urban and rural level fixed effects. $PropensityScore$ refers to propensity score reweighting; $Surveyweighting$ refers to DHS survey weighting. $ChildrenAge-1weighting$ refers to the number of children in age 1 group in different governorates in different years from EDHS divided by the relative number of children in age 1 in different governorates in different years from Egyptian census. $Cluster$ refers to the standard errors in parentheses being clustered at governorate urban and rural level. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Table 6
Sensitivity to alternative clustering choices.

	(1)	(2)	(3)	(4)	(5)	(6)
Post × *Treatment Group*	−0.722**	−0.568*	−0.722**	−0.722**	−0.722**	−0.722***
	(0.305)	(0.307)	(0.329)	(0.316)	(0.320)	(0.256)
Number of deaths prevented per 100,000 women	−61.885	−48.694	−61.885	−61.885	−61.885	−61.885
R^2	0.515	0.380	0.515	0.515	0.515	0.515
No of Observations	328	328	328	328	328	328
All Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	G_{UR}	G_{UR}	G	G	G	G
FE	G_{UR}	G	G_{UR}	G_{UR}	G_{UR}	G_{UR}
Bootstrap	No	No	No	800 rep	1,000 rep	Wild BS

Notes: $Clustering$ and Fixed Effects (FE) units at the governorate urban and rural (G_{UR}) or governorate (G) level. Bootstrap refers to clustering based on standard bootstrap (800 or 1000 replications) or wild bootstrap. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

Fourth, in the benchmark regressions, we excluded the border governorates, which display structural differences from the rest of the country, including their lower population density (i.e., only 2% of the total population lives in those locations between 2007 and 2015) and ethnic composition (i.e., mostly Bedouin tribes) (CAPMAS, 2017). Their inclusion may increase the societal, cultural, and political heterogeneity of the sample and influence the participants' reactions to protests. To test the sensitivity of our results to this exclusion, we now include these governorates in the sample. The results in column (4) of Table 7 are again consistent with those from before even if slightly lower.

Fifth, we change our main method of treatment and control group identification method and use the 2014 Survey of Young People in Egypt (SYPE), which sampled around 10,000 women aged 19–35, not living in the border governorates. SYPE includes information about women's protest participation experience and attitudes towards Arab Spring protests, and is the largest survey of young people in the Middle East and North Africa. There are three SYPE data sets from 2009, 2014, and 2022. For this robustness check, we only used the 2014 SYPE survey as it contains information on young people's attitudes and ideas about protests before

Table 7
Robustness to sample selection.

	Age 20–40	Interview: No husband	Interview: Alone	Border Governorates	SYPE	No Cario	No Alexandria	75% Support
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × *Treat*	−0.790***	−0.628**	−0.458*	−0.577*	−0.759***	−0.624**	−0.806**	−0.700
	(0.280)	(0.276)	(0.256)	(0.310)	(0.260)	(0.294)	(0.330)	(0.493)
Number of deaths prevented per 100,000 women	−67.699	−53.812	−39.238	−49.412	−65.075	−53.489	−69.055	−59.982
R^2	0.488	0.494	0.365	0.522	0.518	0.521	0.511	0.518
No of Observations	328	328	328	376	328	320	312	376
All Other Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All regressions include governorate urban and rural fixed effects. Subsample in column (1) is the age of respondents from 20 to 40. Subsample in column (2) is the interview condition without husband's presence. Subsample in column (3) is the interview condition for the respondent alone. Column (4) includes all border governorates (Red Sea, Matrouh, New Valley, North Sinai and South Sinai). Column (5) used the SYPE data set to classify the treatment and control groups. Columns (6) and (7) exclude Cairo and Alexandria. Column (8) uses the Matrouh and Fayoum as the treatment group. Standard errors in parentheses are clustered at the governorate urban and rural level. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

and after the Arab Spring, as well as important issues to youth in the new political and societal environment. The dataset is from the Egyptian Center for Economic and Social Rights and can be accessed through Wiki Thawra, which is an independent website, documenting all the incidents that occurred from the beginning of the Egyptian Revolution.[30]

We classify all women who participated in the protests at least once and had a supportive attitude of those protests into the treatment group; and otherwise into the control group. With this new classification, our treatment and control groups display a 70% overlap with the original classification. Column (5) of Table 7 reports results using this exercise, showing even a larger effect whereby the point estimate increases (in absolute value) from −0.722 to −0.759 and remain significant. The most intense protests during the Egyptian revolution took place in big cities, particularly Cairo and Alexandria, whose distinct socio-political and economic characteristics may bias our results. Therefore, we drop Cairo (column 6) and Alexandria (column 7) and repeat the benchmark regression analysis. The results are again very robust.

We further checked the robustness of our findings to the classification of treatment group. After the fall of Hosni Mubarak's regime, the first free and fair election in Egyptian history took place in 2012 and the political Islamist Muslim Brotherhood won 51.7% of the votes with Mohammed Morsi becoming the president. Given significant academic research on the degree of conservatism of Muslim Brotherhood as well as the ensuing popular protests against Morsi government's efforts to undermine secularism and women's rights, we hypothesize that the electorate who voted for President Morsi were more conservative than others. If this was the case, we should see a weaker effect of protest intensity on missing women among this group of electorates.[31] This is also an indirect way of testing our main hypothesis that protest participation helps with women's empowerment and lowers the missing women incidence. We use two governorates, Matruh and Fayoum, where Mohammed Morsi won 75% of the votes as the treatment group and the rest as the control group. The results are reported in column (8) of Table 7 and provide further support to our identification approach and confirm previous findings. We find that the effect of protest incidence on missing women is considerably weaker (and insignificant) in those governorates where Mohammed Morsi was the winning presidential candidate.

Next, in Table 8 we check the robustness of our results to different age groups of missing women, using the benchmark specification. For comparison purposes, in column (1) we report the benchmark result from Table 5. Column (2) shows the results for age group [1–9], where the economic size of the effect drops by almost half and becomes statistically significant only at the 10% level. In columns (3) and (4) we repeat the same exercise for age groups [10–19] and [20–29] and find no effect, both economically and statistically speaking. In fact, the point estimate for the interaction variable drops to near zero. The results here suggest that the effect of Egyptian protests was most visible for younger women.

Last but not the least, we conduct a final sensitivity analysis based on protest intensity. Specifically, we may expect the effects on missing women to be larger in governorates with a higher protest intensity. Therefore, we now exclude four governorates – Menia, Damietta, Fayoum, and Beni – because they are very close to the treatment group classification threshold in Fig. 1. We report the results without these four governorates in Appendix Table A2.4 and show that the coefficients of 'Post × Treatment Group' in columns (1), (2), (3) and (5) are higher than those in Table 5, and remain almost the same in columns (4) and (6). These results suggest that the effects of Egyptian protests were marginally higher in higher protest intensity governorates. This exercise also helps partially address the concern of spillover effects between low and high-protest intensity areas. We should also note that in the event of any spillovers from treatment to control groups, the bias would be against finding any significant effect. Therefore, our results can be interpreted as the lower boundary of the net effect of Egyptian protests on missing women.

[30] The website can be accesses at https://wikithawra.wordpress.com
[31] Note that Giesing and Music (2019) undertake a similar exercise.

Table 8
Missing women in different age groups.

	Age 1 (1)	Age 1–9 (2)	Age 10–19 (3)	Age 20–29 (4)
Post × *Treatment Group*	−0.722**	−0.396*	0.052	0.009
	(0.305)	(0.204)	(0.067)	(0.047)
Number of deaths prevented per 100,000 women	−61.885	−9.152	1.859	1.586
R^2	0.515	0.264	0.194	0.144
No of Observations	328	328	328	328
All Other Controls	Yes	Yes	Yes	Yes
Governorate Urban and Rural FE	Yes	Yes	Yes	Yes
Governorate Urban and Rural Cluster	Yes	Yes	Yes	Yes

Notes: The model specification used in columns (1)–(4) aligns with that implemented in column (3) of Table 5. The dependent variable is the missing women in age groups of [0–1] in column (1), [1–9] in column (2), [10–19] in column (3) and [20–29] in column (4). ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

3.3. Event heterogeneity and missing women

The Egyptian protests, as discussed earlier, came in multiple waves between 2011–2014. Even though the treatment and control groups in different phases of the Egyptian Revolution overlap with each other and with the benchmark classification for the full period by 70% (see Figs. 1 and 2), there were substantial differences across the four waves of protests, including demands and motivations of protesters. Therefore, in this section we address the event heterogeneity and examine if the effect of protests on missing women differs across different phases of the Egyptian revolution.

Using the same analytical model and group classification, we repeat the analysis of Table 5 for each wave of the protests and report the results in columns (1)–(4) of Table 9. While we use the same group classification method (i.e., the median value of protest intensity), the governorate urban and rural areas in the treatment and control groups are now different in each phase. We find that the effect of protests on missing women is statistically significant and negative in the first and the fourth phases, likely to reflect the cumulative effect of political participation over time. However, it loses statistical significance in the second and third phases but remains negative. In fact, the effect becomes the highest in the fourth phase, a 71% increase compared to the first phase (i.e., −0.949 in column (4) compared to −0.554 in column (1)). The number of deaths prevented per 100,000 women increased from 47 in the first phase to 79 in the fourth phase. While we cannot pinpoint the exact reason for this increased effect, we hypothesize that it is because of changing nature of the protests, with an increasing focus on women's rights in later phases. It is equally likely that social change takes time.[32] As discussed earlier, the initial protests targeted President Mubarak as well as the corruption and authoritarianism under his rule. After the fall of Mubarak, during the second phase of the protests, the attention was on democracy, free and fair elections, and social equality. Then came the third phase where women's rights were a central demand as protesters clashed with the Islamist Morsi government and its attempts to erode secularism and reinforce Islamic rule in the country (BBC, 2012). Another possible reason for the increased effect of protest participation is the delayed and cumulative effects of protests on missing women as women participants become politically more involved and empowered together with increased awareness of women's rights (Acemoglu et al., 2018; Bargain et al., 2019). The same is likely true for male participants, particularly fathers, influencing their attitudes towards their daughters.

4. Exploring mechanisms

In this section, we examine three possible channels that can help explain how the Egyptian protests could have affected missing women for the age group of [0–1]. Previously, to test the effect of protests on missing women, we aggregated the individual-level data at the lowest available geographic unit, i.e. subgovernorate-level. However, because we now explore possible channels through different outcome variables, we can use data at the individual level. In what follows, we use the benchmark specifications used in Table 5 together with individual-level control variables listed in Table 1.

4.1. Domestic violence during pregnancy

First, we explore the effect of protests on domestic violence during pregnancy, which is shown to have a major influence on infant survival rate (Aizer, 2011; Currie et al., 2022; Reader, 2023). Furthermore, there is evidence to suggest that this is a gendered effect. Silverman et al. (2011) find that intimate partner violence leads to significantly higher infant and child (aged five and younger) mortality for girls but not boys in India. Gender-based discrimination is expected to be more pronounced in households experiencing domestic violence, exacerbating the effects of malnutrition, low birth weight, inadequate preventive care for infectious diseases, neonatal violence against girls, and disparities in medical care favoring boys over girls. These factors contribute to a higher

[32] We should note that even though statistically insignificant, the economic effect estimated in column (3) is larger than that in column (1).

Table 9
Different phases of Egyptian protests and missing women.

	Phase 1 (1)	Phase 2 (2)	Phase 3 (3)	Phase 4 (4)
Post × *Treatment*	−0.554*	−0.091	−0.618	−0.949**
	(0.293)	(0.306)	(0.372)	(0.469)
Number of deaths prevented per 100,000 women	−47.498	−7.730	−52.312	−79.302
Observations	328	328	328	328
R^2	0.509	0.500	0.510	0.516
Controls	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes
Cluster	Yes	Yes	Yes	Yes

Notes: Linear estimations based on 2014 DHS. Standard errors in parentheses are clustered at the governorates urban and rural level. ***, ** and * indicate significance at the 1%, 5% and 10% levels. Phases 1–4 refer to 2011, 2012, 2013 and 2014, respectively. For other definitions, refer to Table 5.

incidence of missing women. Furthermore, domestic violence against women is likely to be correlated with other forms of patriarchy, misogyny and discrimination against girls, and therefore capture a broader set of compounding factors.

To explore this channel, we run the following regression model in Eq. (6) and replace the dependent variable with a binary domestic violence variable, which takes the value of 1 when a woman experiences domestic violence during pregnancy.

$$DV_{mi_r at} = \alpha + \beta_1 \left(Post_t \times Treat_i \right) + \beta_2 Post_t + \beta_3 Treat_i + \gamma X_{mi_r at} + V_{mi_r} + \varepsilon_{mi_r at} \tag{6}$$

where $DV_{mi_r at}$ denotes whether individual mother m of aged a living in rural–urban governorate i_r experienced domestic violence during pregnancy in year t. To check the parallel trend assumption, we present the predicted trend of domestic violence in Appendix Figure 2.[33]

We report the summary statistics of domestic violence in Appendix Table A1.1.[34] Because the outcome variable is binary, we use the logit model and report the results in Table 10.[35] As shown in columns (1)–(5) of Table 10, and consistent with the findings in Stern and Erten (2024), the probability of experiencing domestic violence during pregnancy significantly declines in high protest intensity areas, suggesting that lower mental stress and physical injury related to domestic violence potentially help reduce the infant mortality rates in the post-protest period.[36]

4.2. Infant's vaccination

In this section, we focus on infant vaccination rate given that childhood vaccination helps reduce infant mortality rate at a significant level (Greenwood et al., 2016; McGovern and Canning, 2015; PrabhuDas et al., 2011). Particularly, we calculate the relative vaccination rate of female- over male-infants for age group [0–1] and examine whether a disproportionate increase in vaccination by gender can explain the fall in missing women after the Egyptian protests.[37] As shown in Fig. 5, the relative female vaccination rate had an upward trend in the treatment area.[38] In contrast, it decreased in the control group from 2011–2013 and then improved in 2014, suggesting that infants born in treatment and control areas experienced different levels of vaccinations during and after the Egyptian protests.[39]

To further investigate the impact of heterogeneous vaccination rates in the treatment and control groups, we use a difference-in-difference model in Eq. (7), where the dependent variable, $Vac_{i_r at}$, denotes the relative female/male vaccination rate for infants aged [0–1] in rural–urban governorate i_r in year t.

$$Vac_{i_r at} = \alpha + \beta_1 \left(Post_t \times Treat_i \right) + \beta_2 Post_t + \beta_3 Treat_i + \gamma X_{i_r at} + V_{i_r} + \varepsilon_{i_r at} \tag{7}$$

[33] The predicted values of domestic violence are obtained by interacting the post-dummy with year-fixed effects. We find that the control and treatment groups have similar trends of predicted domestic violence from 2007–2010. However, in 2008 domestic violence in the treatment area increased sharply compared to the control group.

[34] As shown in Appendix Table A1.1, 5.55% of women in the sample experienced domestic violence during pregnancy, with the treatment group exhibiting a slightly higher incidence compared to the control group.

[35] We do not use the linear probability model (LPM) instead of the logit model because, as reported in Appendix Table 10.4, the proportion of predicted values falling outside the [0,1] interval ranges from 18.4% to 33.6%. These results indicate that the OLS model is most likely misspecified.

[36] We should note that selective abortions are expected to be higher in households with domestic violence. However, our calculations do not include prenatal missing women, and therefore underestimate the net effect.

[37] To compute the relative vaccination rate, we divide the female vaccination rate by the male vaccination rate for the age group [0–1].

[38] The Appendix Table A1.1 shows that the average female-to-male infant vaccination ratio in Egypt is 1.02, indicating slightly higher vaccination rates among female infants. In the treatment area, this ratio is 0.08 higher than in the control areas.

[39] In Appendix Figure 3, we present the vaccination rates for male and female infants separately and find that while vaccination rates for both genders in the treatment areas rose more than in the control areas, the increase in vaccination rates for females was slightly higher than for male infants. As a result, Fig. 5 depicts an upward trend in the relative vaccination rate for females in the treatment area following the Egyptian revolution.

Table 10
Effects of Egyptian protests on domestic violence during pregnancy.

	(1)	(2)	(3)	(4)	(5)
Post × *Treatment*	−0.866***	−0.866***	−0.884***	−0.421***	−0.869***
	(0.114)	(0.142)	(0.143)	(0.153)	(0.153)
Treat	0.618***	0.618***	0.602***	0.453***	0.636***
	(0.069)	(0.094)	(0.094)	(0.101)	(0.100)
Post	0.187**	0.187*	0.190*	0.088	0.235**
	(0.074)	(0.098)	(0.099)	(0.103)	(0.110)
Controls	Yes	Yes	Yes	Yes	Yes
FE	No	Yes	Yes	Yes	Yes
PS reweighting	No	No	Yes	No	No
Survey weighting	No	No	No	Yes	No
Self-created weighting	No	No	No	No	Yes
Cluster	No	Yes	Yes	Yes	Yes
R^2	0.152	0.152	0.146	0.136	0.158
Observations	27,484	27,484	27,481	27,484	27,484

Notes: The estimates of the Logit model marginal effects are based on 2008 and 2014 DHS. The outcome variable, domestic violence during pregnancy, is a dummy variable equaling one if yes, and zero otherwise. The treatment group includes individuals who live in the governorates where protest intensity is above-median protest intensity (based on the Egyptian Revolution database and defined as the governorate-level proportion of fatalities, injured, and arrested). $Controls$ refer to control covariates and include wealth of households, work condition of respondents, urban, number of kids in the households, education of the respondents, age of wife and husband, husbands' work condition, religion, and kids birth order. FE are governorate urban and rural level fixed effects. $PropensityScore$ refers to propensity score reweighting; $Surveyweighting$ refers to DHS survey weighting. $ChildrenAge-1weighting$ refers to the number of children in age 1 group in different governorates in different years from EDHS divided by the relative number of children in age 1 in different governorates in different years from Egyptian census. $Cluster$ refers to the standard errors in parentheses being clustered at governorate urban and rural level. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

The coefficient of interest, $Post \times Treatment$, captures the impact of Egyptian protests on female infant's relative vaccination rate with respect to males. The results, which are reported in Appendix Table A9.1, suggest that the protests had a significantly positive impact on relative female vaccination rate. Increasing vaccination rate, in turn, likely helped lower the relative female death ratio and the missing women.

Fig. 5 shows that the relative vaccination rate in the control group sharply declined in 2012 and 2013. We have performed two counterfactual exercises to address the concern that the declining relative vaccination rate in the control group might be driving the results. First, we sequentially drop 2012 and 2013, as well as both years together, and find that the positive effect of the Egyptian protests on relative vaccination rates remains consistent with the results in Appendix Table A9.1, indicating that no single year is driving these findings.[40] In the second counterfactual analysis, we replace the relative vaccination rates for 2012 and 2013 with the value observed in 2011 and report the results in Appendix Tables A9.5–A9.7. Under this hypothetical scenario, the effect of the Egyptian protests on relative vaccination rates is positive and statistically significant, consistent with the results presented in Appendix Table A9.1.

4.3. Women's agency and empowerment

Next, we explore the effects of participation in the Egyptian protests on women's agency and decision making power as proxies for women's empowerment, as suggested by Bargain et al. (2019).[41] We particularly focus on household gender norms and patriarchy, which are shown to influence missing women. Following previous research, we use several measures of women's empowerment in the household, including decision making over one's own health care and household expenditures (Allendorf, 2007; Debnath, 2015; Mabsout and Staveren, 2010; Mishra and Sam, 2016). Using data from the 2008 and 2014 EDHS, we focus on three outcome variables, whether women can make decisions about their own health, whether women can make decisions to make household purchases, and whether women can make decisions about visiting their family members. To estimate the impacts of the Egyptian Protests on these outcome variables we use the following difference-in-difference model in Eq. (8), where $Emp_{mi_r at}$ denotes one of the three outcome variables related to women's empowerment for mother m of aged a living in rural–urban governorate i_r at period t.

$$Emp_{mi_r at} = \alpha + \beta_1\left(Post_t \times Treat_i\right) + \beta_2 Post_t + \beta_3 Treat_i + \gamma X_{mi_r at} + V_{i_r} + \varepsilon_{mi_r at} \tag{8}$$

The survey questions are reported as binary variables, 'yes' or 'no', and therefore we use logit model and report the results in Appendix Tables A10.1–A10.3.[42] The interaction terms, $Post \times Treatment$, in Appendix Tables A10.1–A10.3, are statistically

[40] We show the results in Appendix Tables A9.2–A9.4.

[41] We should note that we are utilizing three direct empowerment measurements here, while Bargain et al. (2019) employs composite measures of women's intra-household empowerment. We report the summary statistics of these three variables in Appendix Table A1.1

[42] We have also used Probit and linear probability models and obtained similar results.

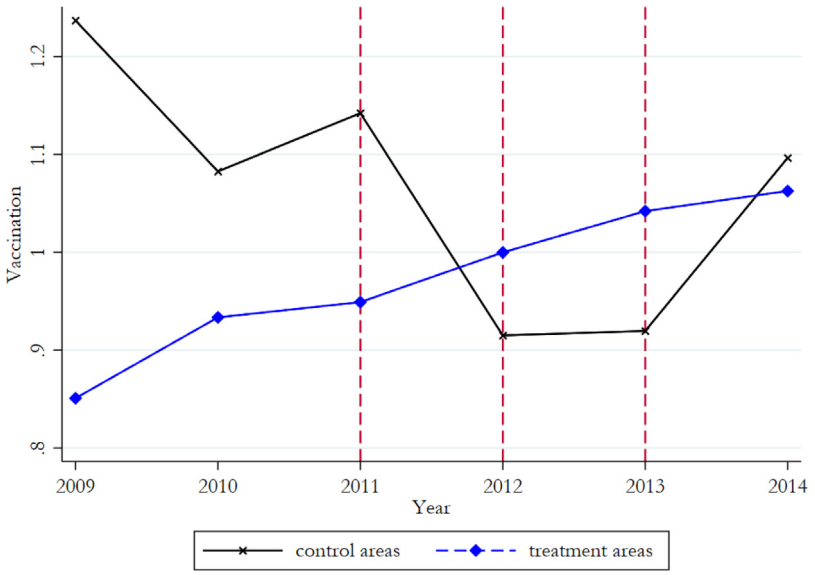

Fig. 5. Trend of vaccination ratio of female/male infants age group 0–1.
Note: The vaccination ratio is defined as female over male vaccination for control group and treatment group.
Source: Authors' calculations based on DHS Database.

significant at 1% level and are economically meaningful. Therefore, the results unanimously suggest that in areas with a higher intensity of protests, women experienced a substantial increase in their household bargaining power across all three measures. This enhanced bargaining power likely enabled women to provide better care for female infants, contributing to a decrease in missing women of age group [0–1] in the high protest intensity areas.[43]

5. Conclusion

The Arab Spring is one of the most important events in recent world history and provides a good opportunity to analyze the linkages between political participation, social unrest, revolutions, women's empowerment, and missing women. Using the geographical variation in political protests, this paper studies the effects of protest intensity on missing women before and after the Egyptian Revolution of 2011–2014. Using a difference-in-differences method, we show that these protests had an economically and statistically significant negative effect on missing women, reducing it substantially in high-protest intensity areas. We also find that the negative effect on missing women reached its highest level in the last wave of protests in 2014, highlighting both the cumulative effect of protest participation as well as event heterogeneity. Furthermore, these findings are found to be the strongest for missing women at younger age groups of [0–1] and [1–9]. Our empirical analysis reveals three possible transmission mechanisms from political protests to missing women: decreasing domestic violence during pregnancy, increasing relative female vaccination rate, and increasing women's empowerment. These channels are consistent with findings from recent studies that highlight the positive transformative effect of Egyptian revolution on women's empowerment and gender equality, and contribute to the broader literature on political participation and gender equality.

Our study also raises new questions with regard to the indirect and 'surprise' effects of social movements and revolutions. The same is true with regard to revolution cascades both within and between countries with or without a common set of motivating factors. We should note that our findings relate to an exceptional period of political activism by both men and women. Can we expect to find similar effects of women's participation in other social movements, protests, and revolutions? Or, was it something peculiar about the Egyptian Revolution or Egyptian society itself, making it unlikely to observe similar effects in other revolutions such as those in former Soviet Union satellite states or the Orange Revolution in Ukraine? In other words, what is the external validity of our findings? Furthermore, how do these effects dissipate over time and space? Our study is short-term by design and by data limitations, and therefore cannot speak for the long-term effects, including changes in other factors affecting missing women such as marriage and matching decisions. Whether the improvements in missing women in high protest intensity areas will be persistent and/or diffuse to non-protest areas remains to be seen. We should also acknowledge that our identification is based on the effect of protests at the governorate urban and rural levels and therefore ignores spatial effects that transmit across regions. As pointed out by Liu et al. (2019), the effect of protests can spread to non-protest areas through the media, word-of-mouth, or protesters who lived in the non-protest areas but traveled to protest locations. We hope that future studies will explore these questions further.

[43] We leave it for future research to conduct a more in-depth exploration of other possible channels.

Assuming improved data availability, future work can further examine the channels through which political and civic participation affects missing women, as well as the effects of participant heterogeneity, based on individual and socio-economic, political and environmental characteristics. The cumulative effects on women's empowerment in following years also need to be explored once EDHS is available for later years beyond 2014. Our analysis is limited to missing women by age, particularly in the age group of [0, 1]. However, we expect to find similar effects for missing women before birth, which we hope to explore in future work.

CRediT authorship contribution statement

Firat Demir: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Conceptualization. **Pallab Ghosh:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Conceptualization. **Zhengang Xu:** Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jce.2025.09.003.

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