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FETAL ORIGINS OF MENTAL HEALTH: EVIDENCE FROM AFRICA

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ABSTRACT. Mental health disorders are a substantial portion of the global disease burden, yet their determinants are understudied, particularly in developing countries. We find that temperature shocks in utero increase depressive symptoms in adulthood in Africa. A ten percent increase in heat exposure increases our depression indices .05 to .07 standard deviations. We find no evidence that the effects of these shocks are smaller for more recent birth cohorts, nor do shocks predict greater treatment of depressive symptoms. Temperature fluctuations, increasingly frequent due to climate change, worsen the mental health disease burden and health care systems in Africa do not mitigate these impacts.
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Mental health disorders comprise 13 percent of the global disease burden (Collins et al., 2011). This cost is highest in poor countries: mental disorders account for 10 million disability-adjusted life years (DALYs) in developed countries, and 55 million DALYs in developing countries (Mathers, Fat and Boerma, 2008). Depressive disorders are the second leading cause of years lived under disability worldwide, and are major contributors to the burden apportioned to ischemic heart disease and suicide (Ferrari et al., 2013). They also form the largest source of disease burden among women (Mathers, Fat and Boerma, 2008). Contemporaneous mental health

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is an important determinant of socio-economic outcomes as well (Kling, Liebman and Katz, 2007; Mani et al., 2013).

The picture is equally stark for the *treatment* of mental disorders. The percentage of mentally ill individuals who have not received treatment in the last twelve months for serious mental illnesses, known as the mental health treatment gap, is estimated to be between 35.5 percent and 50.3 percent in developed countries and between 76.3 percent and 85.4 percent in developing countries (Demyttenaere et al., 2004). While effective treatments in general exist, the majority of those affected do not receive them; this fraction is less than 10 percent in some countries (WHO, 2012). In addition, Kessler et al. (2007) find that about half of all lifetime disorders begin by the mid-teenage years, and three quarters by the mid-20s. In sum, developing country populations are particularly vulnerable to mental health disorders during the most productive years of their life, and are least likely to receive treatment.

We test whether environmental shocks experienced in the year before an individuals's birth increase self-reported symptoms of mental illness using a large sample covering 19 African countries. Our approach merges data on more than 50,000 Africans with geospatial data on historical temperatures. Our fixed-effects method identifies the effect of *in utero* temperature exposure on adult mental health by netting out location-specific mean temperatures and comparing individuals to others from the same birth cohort. This regression specification is similar to the specifications used by other studies in the literature studying the impact of temperature on economic outcomes, such as Dell, Jones and Olken (2012*a*), Dell, Jones and Olken (2012*b*), Deschenes and Greenstone (2007), Deschenes and Greenstone (2011), and Hsiang (2010). Because the idiosyncratic temperature shocks that remain, net of

location and birth cohort means, are plausibly exogenous, our estimates can be interpreted as causal impacts of *in utero* temperature exposure. Further, we show that our results are not driven by potentially omitted confounders that might trend with temperature; that our results are not sensitive to alternative measures of temperature or mental health; and that they are not sensitive to the inclusion of additional controls.

Our main estimates consider indices of mental health that aggregate several measures together. Considering these individual components separately, we show that several symptoms of psychological distress respond to temperature. Self-reported depression in the past thirty days is worsened by *in utero* exposure, and we find evidence that mild, moderate and severe depression all respond to temperature. Similarly, we find that depressive episodes within the past year increase when an individual has been exposed to greater temperatures *in utero*. These include episodes of reduced appetite and energy. We test whether these increases in depressive symptoms are matched with increases in diagnosis, treatment, or medication for depression. There is no evidence of this in our data. Further, we find no evidence that the link between *in utero* temperature and adult depressive symptoms is diminishing in more recent birth cohorts, suggesting that access to mitigating medical care is not improving.

We perform several additional exercises to confirm the robustness of our results. We use data on ethnicity to exclude possible migrants from the sample, showing this does not change our results. Our baseline statistical inference allows for serial correlation at level of geographic points on which our temperature data are recorded. Our results remain robust to allowing for arbitrary serial correlation at even more aggregate levels that are approximately equivalent to districts and provinces. Our

baseline specifications allow for country-specific time trends. A more demanding specification that allows for separate time trends for each geographic point at which temperature is reported does little to the results. As cohort size does not respond to temperature, it is unlikely that our results are driven by selective fertility or mortality.

The probable mechanisms of impact fall into two categories: direct and indirect (Berry, Kathryn and Kjellstrom, 2010). Direct effects cover the impact of temperature on fetal development. Heat stress affects fetal and placental growth, which is strongly associated with adult health outcomes (Hansen, 2009). In the extreme, hyperthermic conditions cause severe intra-uterine growth restriction and fetal demise (Regnault et al., 2002). Further, increased prenatal stress exposure is linked to schizophrenia, major affective disorder, and depressive outcomes in offspring (Brown et al., 2000; O'Connor et al., 2005; St Clair et al., 2005; Watson et al., 1999). Possible mechanisms include the impact of prenatal stress on altering the functioning of the hypothalamo-pituitary-adrenal (HPA) axis (Weinstock, 2008), and compromising the protective capacity of the placenta (Schmitt et al., 2014).

Indirect effects operate through the effects of temperature on the mother's disease exposure and economic environment. Increases in temperature may create a more favourable environment for the transmission of malaria, for example (Barreca, 2010). Exposure to malaria *in utero* and early life is known to produce anemia, interrupted nutritional transmission, hamper cognitive development, and raise vulnerability to other illness; as a result, it predicts later life outcomes such as literacy, education and income (Bleakley, 2010; Lucas, 2010). Adult mental health difficulties may be created alongside these health impacts or result from them and their

later consequences. Several recent contributions have established that temperature shocks reduce agricultural and industrial output, increase conflict, and harm economic growth, among other effects (Dell, Jones and Olken, 2012*a*,*b*). These effects reduce maternal health and the ability of parents to invest in young children, both of which are crucial determinants of adult health (Almond and Currie, 2011; Conti et al., 2012; Heckman, 2007).

1. LITERATURE

There is a rich literature on how economic shocks *in utero* and during early life may impact adult economic outcomes (Heckman, 2006; Knudsen et al., 2006; Maccini and Yang, 2009). In addition, Shonkoff (2011) shows that some components of mental health may be coded during fetal development. Previous papers have linked prenatal exposure to disasters such as famine (Brown et al., 2000; St Clair et al., 2005; Yehuda, Halligan and Bierer, 2001), earthquakes (Watson et al., 1999), and other situations of extreme stress exposure such as war (van Os and Selten, 1998), and the Holocaust (Yehuda, Halligan and Bierer, 2001). While case study evidence has found that these stressors can negatively affect mental health among adults (Berry et al., 2011; Wilcox et al., 2013), relatively little is known about how relatively milder shocks *in utero* and early life circumstances impact mental health during adulthood. One exception is Adhvaryu, Fenske and Nyshadham (2014), who find that individuals born in cocoa-growing regions in Ghana experience higher levels of psychological distress as adults if they were born in years of lower cocoa prices. Another is Persson and Rossin-Slater (2014), who show for Sweden that the death of a maternal relative in early life increases take-up of medications that treat

mental illness in later life. Our paper extends this small literature by using nationally representative samples covering a large number of respondents from multiple African countries.

Our results have implications for the future effects of climate change on Africa. Global temperatures are projected to increase by at least 1.5 degree Celsius by 2100, with increased probability of heat waves (IPCC, 2013). Several sectors of the economy are projected to be affected, including agriculture (Deschenes and Greenstone, 2007; Kurukulasuriya et al., 2006; Lobell, Schlenker and Costa-Roberts, 2011) and industry (Adhvaryu, Kala and Nyshadham, 2014; Hsiang, 2010). While there is considerable work on how rising temperatures may increase mortality (Danet et al., 1999; Deschenes and Greenstone, 2011) and increase the burdens of certain diseases such as malaria (Martens et al., 1995), there is little work on how climate change might impact mental health outcomes. Ours is the first study to our knowledge that estimates whether higher temperatures experienced *in utero* are linked to adult mental health. Given the critical role of mental health in adult wellbeing and economic outcomes, understanding how future climate change may impact mental health is important to inform comprehensive estimates of the benefits of climate change mitigation, as well as climate adaptation policies.

2. SPECIFICATION

We are interested in estimating the impact of *in utero* temperature shocks on adult mental health outcomes as well as treatment-seeking behaviors. Our sample consists of a cross-section of African adults from nineteen countries. Our primary regression specification is given by:

$$(1) \qquad Depression_{i,j,t} = \beta \cdot Temperature_{j,t-1} + x'_{i,j,t}\gamma + \delta_i + \eta_t + t_c + \epsilon_{i,j,t}$$

Here, $Depression_{ijt}$ is a measure of depression for person i adjacent to temperature point j, born in year t. We join each respondent to the temperature point closest to his or her geographic coordinates. We discuss possible migration below. $Temperature_{j,t-1}$ is the temperature at point j in the year before individual i was born. Because individuals report their ages, rather than precise dates of birth, this is the best proxy measure available for *in utero* temperature exposure. We use both linear temperature and its natural log in different specifications. $x_{i,j,t}$ is a vector of controls. In all specifications this includes a constant and rainfall recorded at point j in the year before individual i was born. In additional specifications, $x_{i,j,t}$ also includes dummies for female and urban.

δ_j and η_t are fixed effects for temperature point and year of birth. The inclusion of these fixed effects means that we are identifying the effect of temperature off of deviations of temperature from location-specific long-run historical means and removing any unobserved determinants of mental health that might affect all individuals in a given birth cohort. Put differently, this "difference in differences" specification estimates the causal impacts of idiosyncratic shocks to in utero temperature on adult mental health, and the fact that some regions are simply warmer than others plays no role in our inference.

t_c is a vector of country time trends. These will ensure that our results are not driven by unobserved variables whose trends may be correlated with country-specific patterns of climate change. Similarly, these trends remove the possibility

of spurious correlations with unobserved non-stationary time series variables. Standard errors are clustered at the temperature point level. In addition to depressive symptoms, we also analyze the impact of temperature shocks on other symptoms of mental illness, as well as treatment for symptoms, using the same empirical approach.

3. DATA

We combine two primary sources of data – one concerning mental health, and one concerning temperature.

3.1. **Mental Health.** Data on mental health is taken from the World Health Organization's (WHO) World Health Surveys. These surveys were conducted from 2002-2004 in partnership with 70 countries. The WHO has made data available for 69 of these, including 20 in Africa. The survey questionnaire was designed for use in multiple cultures and locations, and translated into several local languages. Enumerators were instructed to interview respondents in private over the course of roughly 90 minutes. Respondents were sampled from the *de facto* population of each country using a sample frame encompassing all adult members of the general population aged 18 or older. Households were selected using a random, stratified procedure with known probabilities and without replacement.

The WHO data includes comprehensive information on individual physical and mental health outcomes, as well as some economic and demographic information. In addition to questions on health, the data include latitude and longitude coordinates that allow us to match respondents to historical weather data. We include only adults in our sample (aged 18 to 65 years), and those with valid data on location. Our base sample, then, potentially includes 61,885 individuals from 19 countries:

Burkina Faso, Chad, Comoros, Republic of Congo. Côte d'Ivoire, Ethiopia, Ghana, Kenya, Malawi, Mali, Mauritania, Mauritius, Morocco, Namibia, Senegal, South Africa, Swaziland, Zambia, and Zimbabwe.[1] Reported sample sizes differ from this number because not every individual answered every survey question.

The survey includes questions regarding self-reported measures of depression and anxiety as well as their symptoms for two time frames: the last 30 days and the past 12 months. We use 9 of these in our analysis:

- *Depression: 30 days*: On a five point scale, ranging from "none" to "extreme," the respondent's answer to "Overall in the last 30 days, how much of a problem did you have with feeling sad, low or depressed?"
- *Anxiety*: On a five point scale, ranging from "none" to "extreme," the respondent's answer to "Overall in the last 30 days, how much of a problem did you have with worry or anxiety?"
- *Feel depressed, past 12 months*: The respondent's yes/no answer to the question "During the last 12 months, have you had a period lasting several days when you felt sad, empty or depressed?"
- *Lost interest: past 12 months*: The respondent's yes/no answer to the question "During the last 12 months, have you had a period lasting several days when you lost interest in most things you usually enjoy such as hobbies, personal relationships or work?"
- *Decreased energy: past 12 months*: The respondent's yes/no answer to the question "During the last 12 months, have you had a period lasting several

[1]While data from Tunisia was available, the lack of GIS data meant that we were unable to include it in the sample, and so the sample comprises of 19 countries out of the 20 for which mental health data are available.

days when you have been feeling your energy decreased or that you are tired all the time?"

- *Feel depressed, more than two weeks*: Having answered yes to one of the three questions about a period lasting several days and to the question "Was this period [of sadness/loss of interest/low energy] more than 2 weeks?"
- *Feel depressed most of time*: Having answered yes to one of the three questions about a period lasting several days and to the question "Was this period [of sadness/loss of interest/low energy] most of the day, nearly every day?"
- *Lost appetite: past 12 months*: Having answered yes to one of the three questions about a period lasting several days and to the question "During this period, did you lose your appetite?"
- *Slow thinking: past 12 months*: Having answered yes to one of the three questions about a period lasting several days and to the question "During this period, did you notice any slowing down in your thinking?"

The exact survey questions used in this analysis are given below. We exclude two types of mental health measures from our main analysis. First, we do not include reports of diagnoses in our baseline. In very poor countries such as those in our sample, actual diagnoses are rare, and so respondents' answers will better capture access to care than the existence of illness. We consider these as separate outcomes but do not include them in our aggregate indices. Second, a small number of questions were targeted towards schizotypal or psychotic disorders. For example, respondents were asked whether they felt that their thoughts were "being directly interfered or controlled by another person", or that their minds were "being taken over by strange forces." We restrict our analysis to symptoms that resemble anxiety and depression.

In addition to considering these raw measures as outcomes, we construct aggregate indicators of mental health. There are two reasons for this. The first is that these aggregates measure general tendencies for several individual components of mental health to move in the same direction in response to early life health shocks. Second, they improve statistical power by smoothing over measurement error in any individual measure. We use two methods of aggregation: sums and a mean effects analysis that follows other recent papers (Glennerster, Miguel and Rothenberg, 2013; Kling, Liebman and Katz, 2007). In particular, we present results using four summary measures. Each of these differs in how it weights the disaggregate measures and treats missing values. Our results, then, do not depend on the weights we choose or on how we treat missing responses to specific survey questions:

- *Depression: m.e., avg. of nonmissing*. We begin by converting each of the individual measures into a standard normal variable with mean 0 and standard deviation 1. For each respondent, we average over the non-missing measures. We then convert this average into a standard normal variable with mean 0 and standard deviation 1.
- *Depression: m.e., no missing*. We again begin by converting each of the individual measures into a standard normal variable with mean 0 and standard deviation 1. For each individual, we sum over the non-missing measures. We keep only individuals with no missing values, i.e. those who provided valid answers to all nine survey questions. We then convert this sum into a standard normal variable with mean 0 and standard deviation 1.
- *Depression: avg. of nonmissing*. We average over the non-missing individual measures. We then convert this average into a standard normal variable with mean 0 and standard deviation 1.

- *Depression: avg., no missing*. We average over the individual measures. We keep only individuals who gave valid answers to all nine survey questions, and so have no missing values. We then convert this average into a standard normal variable with mean 0 and standard deviation 1.

3.2. **Temperature.** The weather data we use comes from the well-known Matsuura *et al.* (2009) series hosted by the University of Delaware. These provide monthly temperature and rainfall at the $0.5^\circ \times 0.5^\circ$ degree resolution for the period 1900-2010. This series is constructed by combining station-level data from several sources, including the Global Historical Climatology Network (GHCN) and the Global Surface Summary of Day (GSOD), with interpolation techniques to account for missing data, and spatial cross-validation to check the accuracy of the interpolation.[2] These data have been used in several other studies (e.g. Dell, Jones and Olken (2012*b*)) and are chosen because of their geographic scope and long time scale. We are not aware of any alternative daily series that would overlap with more than a small fraction of the in-utero periods of the individuals in our sample, the youngest of whom were born in 1986. We merge each individual to the mean annual temperature and rainfall outcome at the nearest geographic point in the year before the individual was born. Respondents in the WHO data are thereby joined to weather data from 1,164 grid points.

We estimate the impact of temperature shocks in the calendar year before the individual's year of birth. Since the survey contains information on age in years, not precise birth dates, the primary right hand right side variable may be measured

[2]For more details, please refer to `http://climate.geog.udel.edu/~climate/html_pages/Global2011/README.GlobalTsT2011.html`.

TABLE 1. Summary statistics

	Mean	s.d.	Min	Max	N
Depression: avg., no missing	0.0	1.00	-0.76	3.65	51,647
Depression: avg. of nonmissing	0.0	1.00	-1.29	10.1	60,188
Depression: m.e., no missing	0.0	1.00	-0.67	3.33	51,647
Depression: m.e., avg. of nonmissing	0.0	1.00	-0.99	4.21	60,188
Depression: 30 days	1.75	1.02	1	5	59,930
Depression: 30 days mild	0.44	0.50	0	1	59,930
Depression: 30 days moderate	0.21	0.41	0	1	59,930
Depression: 30 days severe	0.084	0.28	0	1	59,930
Depression: 30 days extreme	0.014	0.12	0	1	59,930
Anxiety	1.75	1.02	1	5	56,600
Depression: diagnosed past 12 months	0.040	0.20	0	1	58,630
Depression: ever treated	0.022	0.15	0	1	51,467
Depression: medicated past 2 weeks	0.017	0.13	0	1	51,044
Feel depressed, past 12 months	0.25	0.43	0	1	59,050
Lost interest: past 12 months	0.20	0.40	0	1	58,970
Decreased energy: past 12 months	0.24	0.42	0	1	58,788
Feel depressed, more than two weeks	0.12	0.32	0	1	56,100
Feel depressed most of time	0.17	0.37	0	1	56,022
Lost appetite: past 12 months	0.19	0.39	0	1	56,036
Slow thinking: past 12 months	0.15	0.35	0	1	56,006
Temperature L1	23.0	4.33	5.36	31.3	61,885
Log Temperature L1	3.12	0.20	1.68	3.44	61,885
Female	0.54	0.50	0	1	61,826
Urban	0.37	0.48	0	1	61,589
Year of Birth	1,968	12.6	1,937	1,986	61,885

Notes: Source: Authors' Calculations.

with error. However, measurement error will bias our estimates downward, and so the impacts we find are lower bounds on actual impacts.

3.3. **Other controls.** The additional controls female and urban are recorded in the World Health Survey data. Rainfall is also taken from Matsuura and Wilmott (2009), and is constructed in the same manner as temperature. We present summary statistics in table 1.

4. RESULTS

4.1. **Main results.** In Table 2, we report our main results. In columns (1) through (3), we employ linear temperature, while in columns (4) through (6) we use its natural log. In columns (1) and (4), we present estimates of equation (1) that control for *in utero* rainfall as well as fixed effects for temperature points and year of birth. In columns (2) and (5), we add country-specific time trends to the fixed effects and rainfall. These trends account for the possibility that our results may be driven by differences in the trend rate of change in mental health outcomes across countries that might be correlated by chance with differential trends in climate. Finally, in columns (3) and (6), we augment this last specification by adding controls for female and urban to the fixed effects, rainfall, and trends, showing that our results are robust to the inclusion of these individual characteristics. We cluster standard errors by temperature point to account for possible serial correlation in the error term.

Table 2 clearly shows that the particular method used to aggregate the individual components of mental health into a single index does not influence the results. Nor are the results sensitive to the temperature measure used. The linear estimates of the impact of temperature shocks in Table 2 indicate that exposure to a year that is one degree warmer than the local historical average increases our measure of depression in adulthood by .02-.03 standard deviations. Being exposed to a 10 percent warmer year *in utero* increases our measure of depression in adulthood by .05-.07 standard deviations. These magnitudes are similar to the effects of early life treatments in the published literature, such as the standardized impacts of birth weight on high school graduation (Black, Devereux and Salvanes, 2007), *in utero* exposure to the 1918 flu pandemic on high school graduation (Almond, 2006), or early life malaria exposure on adult consumption (Cutler et al., 2010).

TABLE 2. Impact of In Utero Temperature on Aggregate Depression Measures

	(1)	(2)	(3)	(4)	(5)	(6)
	Depression: avg., no missing					
Temperature	0.031**	0.026**	0.027**	0.625**	0.551**	0.580**
	(0.013)	(0.013)	(0.013)	(0.295)	(0.273)	(0.275)
N	51,647	51,647	51,369	51,647	51,647	51,369
	Depression: avg. of nonmissing					
Temperature	0.032***	0.031***	0.032***	0.632**	0.690***	0.705***
	(0.012)	(0.012)	(0.012)	(0.253)	(0.244)	(0.246)
N	60,188	60,188	59,857	60,188	60,188	59,857
	Depression: m.e., no missing					
Temperature	0.031**	0.024*	0.024*	0.687**	0.543**	0.560**
	(0.014)	(0.013)	(0.013)	(0.299)	(0.272)	(0.273)
N	51,647	51,647	51,369	51,647	51,647	51,369
	Depression: m.e., avg. of nonmissing					
Temperature	0.032***	0.029***	0.030***	0.676***	0.688***	0.699***
	(0.012)	(0.011)	(0.011)	(0.258)	(0.243)	(0.244)
N	60,188	60,188	59,857	60,188	60,188	59,857
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

Table 2 shows that results are consistent in magnitude and statistical significance irrespective of how we handle respondents who failed to answer individual questions about their own mental health. As expected, the results are not dependent on using the mean effect transformations of these indices as opposed to the raw average or sum, though the mean effects provide more easily interpretable coefficients.

4.2. **Components of mental health.** We next study which specific indicators of mental health drive the response of our aggregate measures to *in utero* temperature exposure. This serves two purposes. First, we demonstrate that our aggregate results are not driven by a single indicator of mental health. Second, because the effects of *in utero* temperature present across a range of symptoms, the mechanisms underlying these results are unlikely to be narrow in scope.

Table 3 presents estimates of impacts on the measure of general depression. The outcome variable "Depression: 30 days" measures self-reported general depression in the 30 days prior to survey on a scale from 1 (none) to 5 (extreme). The result from the linear specification implies that for each additional degree Celsius of exposure during the *in utero* period, this index rises for adults by .03 points. The logarithmic specification, similarly, implies that experiencing a 10 percent warmer than average year *in utero* increases this index by .05-.06 points.

The remaining outcomes in Table 3 explore how much *in utero* temperature impacts the incidence of mild, moderate, severe, or extreme depression. The results suggest that the impacts are most apparent along the margins of mild and moderate depression. The probability of at-least moderate depression, for example, rises by 2.1 percentage points in response to a 10 percent increase in temperature in the logarithmic specification. The remainder of the impacts are seen on severe depression, while there is no evidence of an impact on the incidence of extreme depression.

Table 4 presents results from regressions of measures of specific symptoms of depression on the same log temperature regressors from Tables 2 and 3. Note that all of the symptom measures studied in Table 4 are measured over the 12 months prior to survey as opposed to the 30-day window measured in Table 3. The results indicate that these measures of longer-term depression also show impacts of *in utero*

TABLE 3. Impact of In Utero Temperature on Separate Depression Measures: General Depression

	(1)	(2)	(3)	(4)	(5)	(6)
	Depression: 30 days extreme					
Temperature	-0.001	0.001	0.001	0.006	0.034	0.035
	(0.002)	(0.002)	(0.002)	(0.037)	(0.034)	(0.034)
N	59,930	59,930	59,605	59,930	59,930	59,605
	Depression: 30 days severe					
Temperature	0.005	0.006*	0.007**	0.094	0.125*	0.129*
	(0.003)	(0.003)	(0.003)	(0.075)	(0.072)	(0.073)
N	59,930	59,930	59,605	59,930	59,930	59,605
	Depression: 30 days moderate					
Temperature	0.010**	0.010**	0.011**	0.181*	0.195*	0.210**
	(0.005)	(0.005)	(0.005)	(0.098)	(0.103)	(0.104)
N	59,930	59,930	59,605	59,930	59,930	59,605
	Depression: 30 days mild					
Temperature	0.014**	0.013**	0.014**	0.248**	0.265**	0.278**
	(0.006)	(0.006)	(0.006)	(0.123)	(0.127)	(0.128)
N	59,930	59,930	59,605	59,930	59,930	59,605
	Depression: 30 days					
Temperature	0.028**	0.031**	0.032***	0.530**	0.619**	0.651**
	(0.012)	(0.012)	(0.012)	(0.259)	(0.263)	(0.264)
N	59,930	59,930	59,605	59,930	59,930	59,605
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

temperature exposure. In particular, we find significant increases in the incidence of feeling sad, empty or depressed for 2 weeks or more (Feel depressed, more than two weeks); feeling sad, empty or depressed for several days in the past 12 months (Feel depressed, past 12 months); and having felt sad, empty or depressed most of

TABLE 4. Impact of In Utero Temperature on Separate Depression Measures: Symptoms

	(1)	(2)	(3)	(4)	(5)	(6)
	Slow thinking: past 12 months					
Temperature	0.004	0.003	0.003	0.058	0.058	0.057
	(0.004)	(0.004)	(0.004)	(0.089)	(0.087)	(0.088)
N	56,006	56,006	55,704	56,006	56,006	55,704
	Feel depressed most of time					
Temperature	0.010**	0.008*	0.008*	0.234**	0.212**	0.205**
	(0.005)	(0.004)	(0.004)	(0.097)	(0.092)	(0.094)
N	56,022	56,022	55,721	56,022	56,022	55,721
	Lost interest: past 12 months					
Temperature	0.005	0.007	0.007	0.139	0.190*	0.191*
	(0.005)	(0.005)	(0.005)	(0.100)	(0.097)	(0.097)
N	58,970	58,970	58,651	58,970	58,970	58,651
	Feel depressed, more than two weeks					
Temperature	0.014***	0.011***	0.011***	0.334***	0.283***	0.279***
	(0.004)	(0.004)	(0.004)	(0.090)	(0.083)	(0.084)
N	56,100	56,100	55,796	56,100	56,100	55,796
	Feel depressed, past 12 months					
Temperature	0.011**	0.011**	0.011**	0.241**	0.271**	0.274***
	(0.005)	(0.005)	(0.005)	(0.104)	(0.106)	(0.106)
N	59,050	59,050	58,738	59,050	59,050	58,738
	Decreased energy: past 12 months					
Temperature	0.009*	0.005	0.005	0.196*	0.140	0.144
	(0.005)	(0.005)	(0.005)	(0.110)	(0.103)	(0.104)
N	58,788	58,788	58,471	58,788	58,788	58,471
	Lost appetite: past 12 months					
Temperature	0.009*	0.007	0.008	0.184*	0.164*	0.173*
	(0.005)	(0.005)	(0.005)	(0.101)	(0.099)	(0.102)
N	56,036	56,036	55,734	56,036	56,036	55,734
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

the day, every day during this episode (Feel depressed most of time). We also find strong evidence of an impact on loss of appetite (Lost appetite: past 12 months) but limited evidence of impacts on energy (Decreased energy: past 12 months), interest in things the respondent normally enjoys (Lost interest: past 12 months), and speed of thinking (Slow thinking: past 12 months).

4.3. **Adaptation.** The individuals in our sample are from cohorts born between 1937 and 1986. To forecast the effects of future temperature shocks and of climate change on mental health in poor countries, it is important to test whether individuals are adapting to these effects by seeking (and gaining access to) medical care.

In Table 5, we explore impacts on diagnosis and treatment of depression. Despite robust, consistent evidence of strong impacts on the incidence of mild-to-severe depression and long-lasting symptoms of depression, Table 5 shows no evidence of impacts on receiving a formal diagnosis of depression in the past year; having taken medication for the treatment of depression in the past two weeks, and; ever having received treatment. We interpret the small point estimates and tight standard errors as precisely estimated zero impacts. These results hold irrespective of the inclusion of controls, fixed effects, and country-specific trends and in both the linear and log specifications. These results indicate that temperature shocks *in utero* increase the mental health disease burden, since the increased depression outcomes are not matched with increased treatment. This is expected, given the "grossly inadequate" manpower and infrastructure for mental health in Africa (Jacob et al., 2007). Given the importance of mental health for economic outcomes as well as the large mental health gap discussed in the introduction, these results imply that a higher frequency of temperature shocks might affect important socio-economic outcomes through a greater mental health disease burden.

TABLE 5. Impact of In Utero Temperature on Separate Depression Measures: Treatment

	(1)	(2)	(3)	(4)	(5)	(6)
	Depression: ever treated					
Temperature	0.001	0.001	0.001	0.019	0.035	0.028
	(0.002)	(0.002)	(0.002)	(0.042)	(0.042)	(0.042)
N	51,467	51,467	51,190	51,467	51,467	51,190
	Depression: medicated past 2 weeks					
Temperature	-0.000	0.000	-0.000	-0.013	0.001	-0.011
	(0.002)	(0.002)	(0.002)	(0.031)	(0.031)	(0.030)
N	51,044	51,044	50,771	51,044	51,044	50,771
	Depression: diagnosed past 12 months					
Temperature	-0.003	-0.002	-0.002	-0.077	-0.040	-0.042
	(0.003)	(0.003)	(0.003)	(0.056)	(0.056)	(0.056)
N	58,630	58,630	58,326	58,630	58,630	58,326
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

Finally, in Table 6 we test whether the effect of temperature shocks has become less severe over time. To do so, we interact our measure of temperature with year of birth. If the effect of temperature were weaker for more recent cohorts, we would find that the interaction term was negative. Instead all estimates are insignificant and small. The effect of *in utero* exposure to temperature shocks is as severe for early birth cohorts as it is for later ones.

4.4. **Robustness.** We report a series of robustness checks in the appendix.

TABLE 6. Impact of In Utero Temperature on Depression Over Time

	(1)	(2)	(3)	(4)	(5)	(6)
	Depression: avg., no missing					
Temperature	0.029**	0.037**	0.037**	0.654**	0.739**	0.757**
	(0.014)	(0.015)	(0.015)	(0.304)	(0.304)	(0.304)
Temp. X Y.O.B.	0.000	-0.000	-0.000	0.001	-0.005	-0.004
	(0.000)	(0.000)	(0.000)	(0.003)	(0.004)	(0.004)
N	51,647	51,647	51,369	51,647	51,647	51,369
	Depression: avg. of nonmissing					
Temperature	0.032***	0.040***	0.040***	0.736***	0.856***	0.862***
	(0.013)	(0.014)	(0.014)	(0.265)	(0.275)	(0.275)
Temp. X Y.O.B.	0.000	-0.000	-0.000	0.000	-0.004	-0.004
	(0.000)	(0.000)	(0.000)	(0.002)	(0.003)	(0.003)
N	60,188	60,188	59,857	60,188	60,188	59,857
	Depression: m.e., no missing					
Temperature	0.029**	0.031**	0.031**	0.689**	0.685**	0.692**
	(0.014)	(0.014)	(0.014)	(0.303)	(0.292)	(0.292)
Temp. X Y.O.B.	0.000	-0.000	-0.000	0.002	-0.003	-0.003
	(0.000)	(0.000)	(0.000)	(0.003)	(0.004)	(0.004)
N	51,647	51,647	51,369	51,647	51,647	51,369
	Depression: m.e., avg. of nonmissing					
Temperature	0.032***	0.036***	0.036***	0.757***	0.813***	0.810***
	(0.012)	(0.013)	(0.013)	(0.266)	(0.266)	(0.267)
Temp. X Y.O.B.	0.000	-0.000	-0.000	0.000	-0.003	-0.002
	(0.000)	(0.000)	(0.000)	(0.002)	(0.003)	(0.003)
N	60,188	60,188	59,857	60,188	60,188	59,857
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

4.4.1. *Migration.* To address possible out-migration, we use ethnicity to proxy for location of birth. The data record an individual's current place of residence. To remove individuals whose *in utero* temperatures may have been mis-coded due to migration, we discard any individuals living in locations defined by temperature grid points that are home to less than 10 percent of that ethnic group's population in the survey. Results given in table A7 are nearly identical to our baseline results.

4.4.2. *Standard errors.* In our baseline specifications, we cluster standard errors by the points in the Matsuura and Wilmott (2009) data in order to account for arbitrary serial correlation in the errors. In Appendix table A8, we show that results are robust to allowing for serial correlation at even broader levels. Table A8 reports standard errors clustered by primary sampling unit, or PSU, a unit roughly equivalent to districts. Results remain significant in all specifications. Note that sample sizes differ from our baseline due to missing values for PSU for some observations.

4.4.3. *Time trends.* To further rule out the possibility that out results are driven by unobserved trending variables that correlate with temperature, we have interacted each of our temperature point fixed effects with the linear variable year of birth. That is, we have included point-specific time trends. The results, reported in Table A9, are very similar to our baseline.

4.4.4. *Aggregation of monthly temperatures.* In our baseline, we have taken the log of the annual average of the raw monthly temperatures. In Table A10, we show that the results are largely unchanged if we take the log of each monthly temperature before then averaging over these in order to construct an annual temperature measure.

4.4.5. *Selective fertility and mortality.* To show that our results are not driven by selective fertility and mortality, we make the sizes of the cohorts that appear in our sample a dependent variable in Table A11. Were temperature to produce selective patterns of fertility and mortality, we would expect this to appear in the size of the surviving cohort. The number of individuals in each temperature point $\times$ year of birth cell does not, however, respond significantly to lagged temperature, either in the linear or log specification.

4.4.6. *Nonlinearities.* Following Deschenes and Greenstone (2011), we test for nonlinearities by re-estimating equation (1) replacing our continuous measure of temperature with quintiles of the observed distribution. These figures include both country trends and controls. The omitted category in each specification is the middle quintile. Coefficients and 95% confidence intervals are reported in appendix figures A1, A2, A3, and A4. Though these are less precisely estimated than our linear or logarithmic specification, there is a clearly monotonic and increasing relationship between early-life temperature exposure and adult symptoms of depression visible over the entire range of observed temperatures. It is significant for the warmest quintile.

4.4.7. *Additional robustness not reported.* Results are nearly identical if Fahrenheit temperatures are used. Since the temperature never reaches 0 degree Celsius or below in our data, the log transformation does not lead to excluding any data. The log specification has several advantages: it allows for the estimation of the impact of temperature while reducing the impacts of any outliers in the temperature data, allows for the interpretation of the coefficient as a semi-elasticity (e.g. the marginal impact of 10 percent increase in temperature), and allows the effect to be concave,

rather than linear. The results from using either the linear or log temperature are quite similar.

5. CONCLUSION

We have shown that *in utero* temperature shocks have adverse effects on adult mental health across multiple summary measures and specific symptoms in a large, nationally representative sample covering 19 African countries. In particular, we find no evidence of adaptation. There is no significant evidence from our data that greater *in utero* temperature exposure increases the chance that an individual is diagnosed with depression or receives treatment for it. Similarly, we find no evidence that the effect of temperature shocks has become less severe in more recent years. If the observed trend of unresponsiveness of health care systems continues, the effects of warmer temperatures in the future on African mental health is likely to go unmitigated. In addition to contributing to the literature on the long-run impacts of *in utero* shocks, our study has added to the growing literature on the projected impacts of climate change.

Our findings have considerable implications for countries seeking to reduce the current mental health treatment gap, as well as adapt to future climate change. Many cost-effective mental health interventions exist in developing countries, but are not implemented (Kohn et al., 2004; Patel et al., 2007). Warmer temperatures and a large treatment gap may exacerbate the incidence of depression, and consequently impact economic outcomes and wellbeing (Haines et al., 2006; McMichael, Woodruff and Hales, 2006). Reducing the mental health treatment gap through better provision of mental health facilities (Saxena et al., 2007) and policy initiatives

to reduce stigma for people seeking treatment (Saraceno et al., 2007) may thus have considerable adaptation co-benefits.

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Appendix: Not for publication

APPENDIX A. APPENDIX TABLES

TABLE A7. Robustness: Removing probable migrants

	(1)	(2)	(3)	(4)	(5)	(6)
	Depression: avg., no missing					
Temperature	0.037**	0.031**	0.032**	0.758**	0.656**	0.686**
	(0.015)	(0.014)	(0.014)	(0.325)	(0.298)	(0.299)
N	42,519	42,519	42,385	42,519	42,519	42,385
	Depression: avg. of nonmissing					
Temperature	0.036***	0.035***	0.037***	0.687**	0.767***	0.790***
	(0.013)	(0.013)	(0.013)	(0.270)	(0.260)	(0.260)
N	49,980	49,980	49,831	49,980	49,980	49,831
	Depression: m.e., no missing					
Temperature	0.038**	0.028**	0.029**	0.812**	0.632**	0.657**
	(0.015)	(0.014)	(0.014)	(0.330)	(0.297)	(0.298)
N	42,519	42,519	42,385	42,519	42,519	42,385
	Depression: m.e., avg. of nonmissing					
Temperature	0.037***	0.034***	0.035***	0.756***	0.780***	0.795***
	(0.013)	(0.013)	(0.013)	(0.284)	(0.266)	(0.267)
N	49,980	49,980	49,831	49,980	49,980	49,831
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

TABLE A8. Robustness: Cluster by primary sampling unit

	(1)	(2)	(3)	(4)	(5)	(6)
	Depression: avg., no missing					
Temperature	0.034**	0.028**	0.029**	0.695**	0.597**	0.621**
	(0.014)	(0.014)	(0.014)	(0.296)	(0.294)	(0.295)
N	48,398	48,398	48,126	48,398	48,398	48,126
	Depression: avg. of nonmissing					
Temperature	0.032***	0.031**	0.032***	0.628**	0.680***	0.698***
	(0.012)	(0.012)	(0.012)	(0.247)	(0.255)	(0.255)
N	56,635	56,635	56,312	56,635	56,635	56,312
	Depression: m.e., no missing					
Temperature	0.033**	0.024*	0.024*	0.733**	0.557*	0.571**
	(0.014)	(0.013)	(0.014)	(0.293)	(0.289)	(0.290)
N	48,398	48,398	48,126	48,398	48,398	48,126
	Depression: m.e., avg. of nonmissing					
Temperature	0.032***	0.029**	0.030**	0.682***	0.684***	0.695***
	(0.012)	(0.012)	(0.012)	(0.251)	(0.252)	(0.253)
N	56,635	56,635	56,312	56,635	56,635	56,312
Temperature	Linear	Linear	Linear	Log	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Trends	No	Yes	Yes	No	Yes	Yes
Controls	No	No	Yes	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

TABLE A9. Robustness: Linear trends for temperature points

	(1)	(2)	(3)	(4)
	Depression: avg., no missing			
Temperature	0.031**	0.033**	0.645**	0.682**
	(0.014)	(0.014)	(0.288)	(0.287)
N	51,647	51,369	51,647	51,369
	Depression: avg. of nonmissing			
Temperature	0.034***	0.035***	0.725***	0.748***
	(0.013)	(0.013)	(0.259)	(0.260)
N	60,188	59,857	60,188	59,857
	Depression: m.e., no missing			
Temperature	0.026*	0.028**	0.595**	0.624**
	(0.014)	(0.014)	(0.290)	(0.290)
N	51,647	51,369	51,647	51,369
	Depression: m.e., avg. of nonmissing			
Temperature	0.032***	0.033***	0.722***	0.739***
	(0.012)	(0.012)	(0.257)	(0.259)
N	60,188	59,857	60,188	59,857
Temperature	Linear	Linear	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes
Point Trends	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

TABLE A10. Robustness: Average of log monthly temperature

	(1)	(2)	(3)
	Depression: avg., no missing		
Temperature	1.929**	1.630**	1.685**
	(0.829)	(0.776)	(0.776)
N	51,341	51,341	51,064
	Depression: avg. of nonmissing		
Temperature	1.621***	1.638***	1.672***
	(0.611)	(0.597)	(0.601)
N	59,849	59,849	59,519
	Depression: m.e., no missing		
Temperature	2.108**	1.639**	1.665**
	(0.838)	(0.774)	(0.773)
N	51,341	51,341	51,064
	Depression: m.e., avg. of nonmissing		
Temperature	1.601**	1.525**	1.543**
	(0.641)	(0.615)	(0.620)
N	59,849	59,849	59,519
Temperature	Log	Log	Log
Fixed Effects	Yes	Yes	Yes
Country Trends	No	Yes	Yes
Controls	No	No	Yes

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

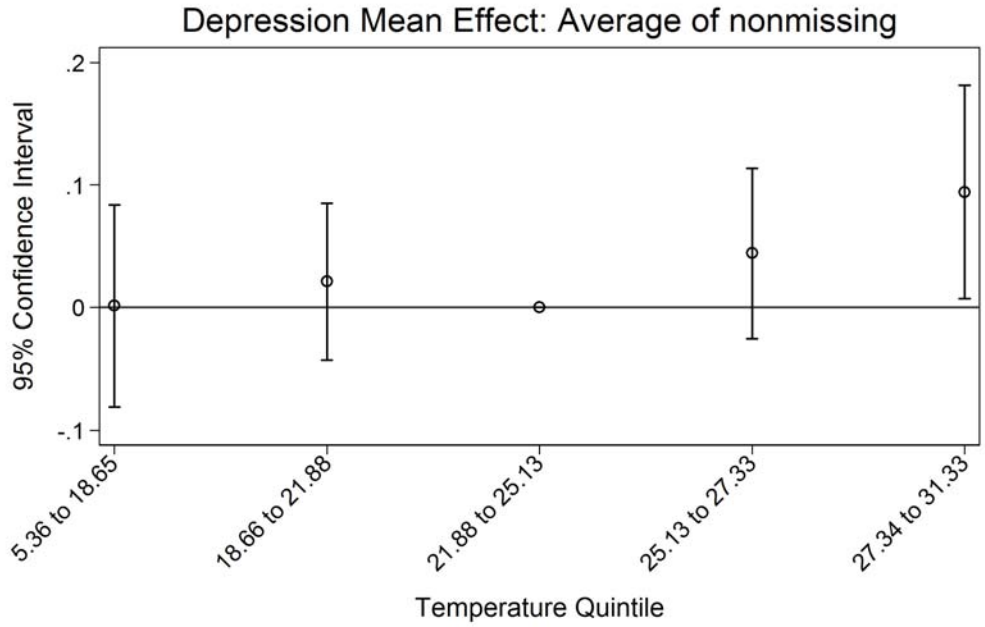
TABLE A11. Robustness: Cohort size

	(1)	(2)	(3)	(4)
	Cohort size			
Temperature	0.061	-0.093	2.159	-1.461
	(0.077)	(0.066)	(1.627)	(1.291)
N	24,082	24,082	24,082	24,082
Temperature	Linear	Linear	Log	Log
Fixed Effects	Yes	Yes	Yes	Yes
Country Trends	No	Yes	No	Yes
Controls	No	No	No	No

Notes: ***Significant at the 1 percent level, **Significant at the 5 percent level, *Significant at the 10 percent level. All regressions estimated by ordinary least squares. Standard errors are clustered by temperature point in parentheses unless otherwise indicated. Fixed effects are for year of birth and temperature point. All specifications include a constant and rainfall or log rainfall. Additional controls where included are female and urban.

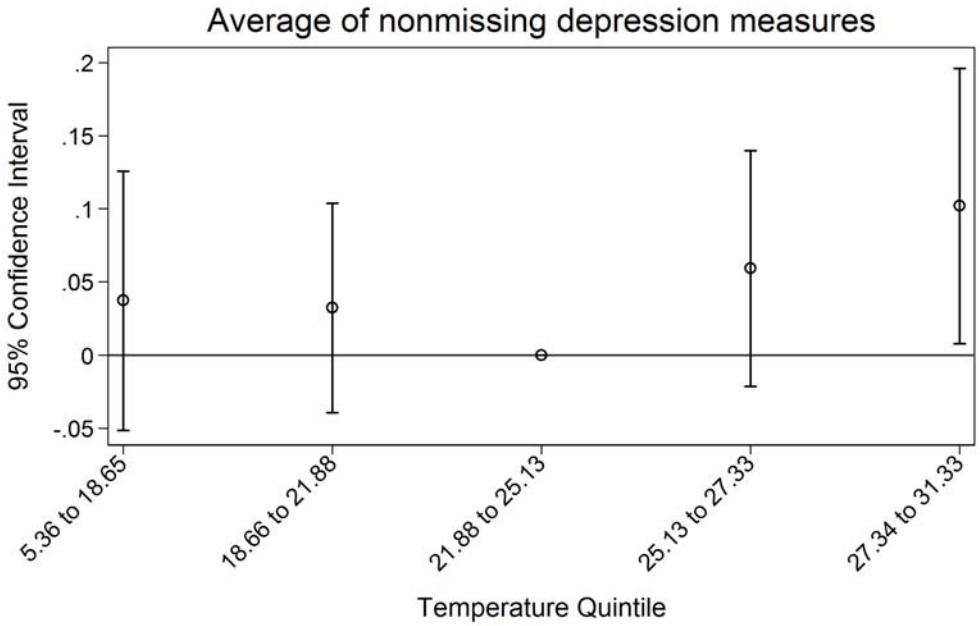
APPENDIX B. APPENDIX FIGURES

FIGURE A1. Robustness: Quintiles of temperature 1



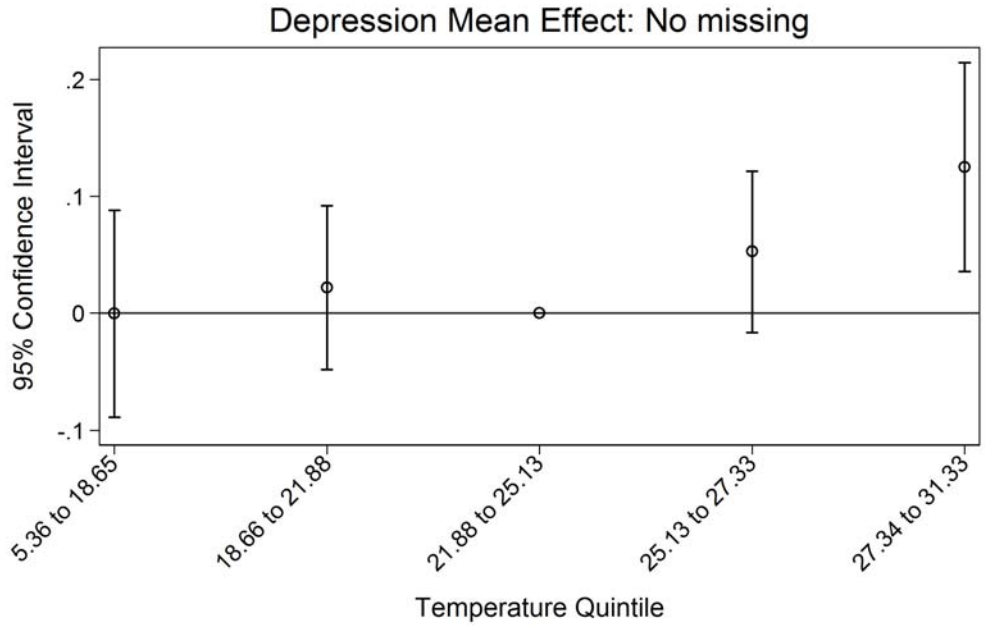
This figure reports coefficient estimates and 95% confidence intervals from estimating (1) with country trends and year fixed effects, replacing the continuous measure of temperature with quintiles of the observed distribution. The middle quintile is the omitted category.

FIGURE A2. Robustness: Quintiles of temperature 2



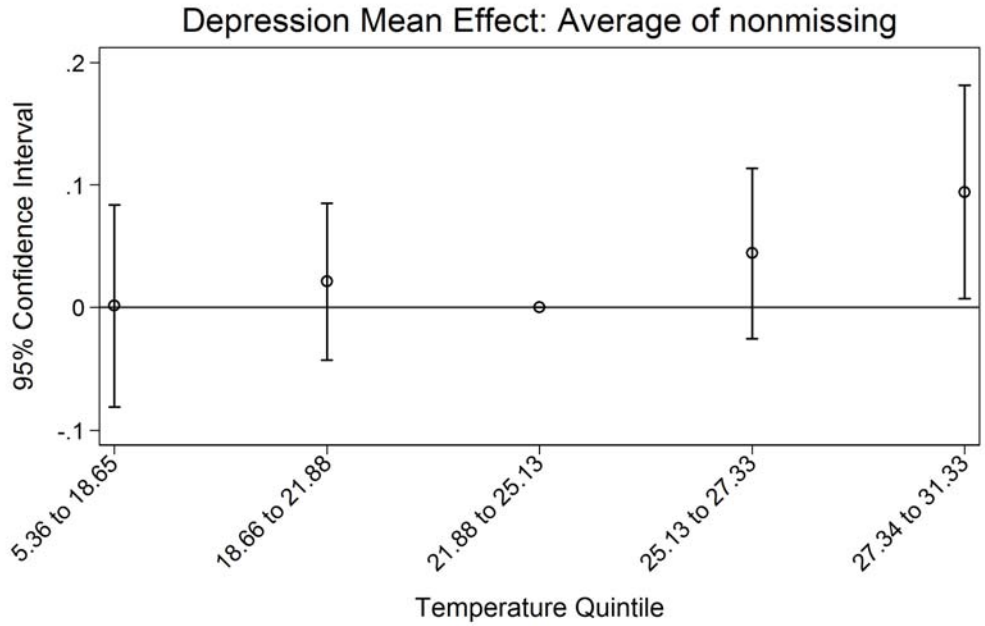
This figure reports coefficient estimates and 95% confidence intervals from estimating (1) with country trends and year fixed effects, replacing the continuous measure of temperature with quintiles of the observed distribution. The middle quintile is the omitted category.

FIGURE A3. Robustness: Quintiles of temperature 3



This figure reports coefficient estimates and 95% confidence intervals from estimating (1) with country trends and year fixed effects, replacing the continuous measure of temperature with quintiles of the observed distribution. The middle quintile is the omitted category.

FIGURE A4. Robustness: Quintiles of temperature 4



This figure reports coefficient estimates and 95% confidence intervals from estimating (1) with country trends and year fixed effects, replacing the continuous measure of temperature with quintiles of the observed distribution. The middle quintile is the omitted category.

APPENDIX C. SURVEY INSTRUMENTS

- *Variable*: Depression: 30 days.

  Question Number: $q2090$.

  Pre-question: Now I would like to review different functions of your body. When answering these questions, I would like you to think about the last 30 days, taking both good and bad days into account. When I ask about difficulty, I would like you to consider how much difficulty you have had, on an average, in the past 30 days, while doing the activity in the way that you usually do it. By difficulty I mean requiring increased effort, discomfort or pain, slowness or changes in the way you do the activity. Please answer this question taking into account any assistance you have available.

  Literal question: Overall in the last 30 days, how much of a problem did you have with feeling sad, low or depressed?

  Valid answers: 1, None; 2, Mild; 3, Moderate; 4, Severe; 5, Extreme.

- *Variable*: Worry or anxiety in last 30 days.

  Question Number: $q2091$.

  Pre-question: Now I would like to review different functions of your body. When answering these questions, I would like you to think about the last 30 days, taking both good and bad days into account. When I ask about difficulty, I would like you to consider how much difficulty you have had, on an average, in the past 30 days, while doing the activity in the way that you usually do it. By difficulty I mean requiring increased effort, discomfort or pain, slowness or changes in the way you do the activity. Please answer this question taking into account any assistance you have available.

  Literal question: Overall in the last 30 days, how much of a problem did

you have with worry or anxiety?

Valid answers: 1, None; 2, Mild; 3, Moderate; 4, Severe; 5, Extreme.

- *Variable*: Feel depressed, past 12 months.

  Question Number: $q6028$

  Pre-question: For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time frames used in this section (such as "ever" and "the last 2 weeks").

  Literal question: During the last 12 months, have you had a period lasting several days when you felt sad, empty or depressed?

  Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.

- *Variable*: Lost interest: past 12 months.

  Question Number: $q6029$.

  Pre-question: For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise

a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time frames used in this section (such as "ever" and "the last 2 weeks").

Literal question: During the last 12 months, have you had a period lasting several days when you lost interest in most things you usually enjoy such as hobbies, personal relationships or work?

Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.

- *Variable*: Decreased energy: past 12 months.

  Question Number: $q6030$

  Pre-question: During the last 12 months, have you experienced any of the following... For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time frames used in this section (such as "ever" and "the last 2 weeks").

  Literal question: During the last 12 months, have you had a period lasting

several days when you have been feeling your energy decreased or that you are tired all the time?

Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.

- *Variable*: Feel depressed, more than two weeks.

  Question Number: $q6031$.

  Pre-question: During the last 12 months, have you experienced any of the following... For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time frames used in this section (such as "ever" and "the last 2 weeks").

  Literal question: Was this period [of sadness/loss of interest/low energy] more than 2 weeks?

  Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.

- *Variable*: Feel depressed most of time.

  Question Number: $q6032$.

  Pre-question: During the last 12 months, have you experienced any of the following... For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms

in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time frames used in this section (such as "ever" and "the last 2 weeks").

Literal question: Was this period [of sadness/loss of interest/low energy] most of the day, nearly every day?

Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.

- *Variable*: Lost appetite: past 12 months.

  Question Number: $q6033$.

  Pre-question: During the last 12 months, have you experienced any of the following... For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time

frames used in this section (such as “ever” and “the last 2 weeks”).

Literal question: During this period, did you lose your appetite?

Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.

- *Variable*: Slow thinking: past 12 months.

  Question Number: $q6034$.

  Pre-question: During the last 12 months, have you experienced any of the following... For this set of questions, the interviewer must read out a series of symptoms and determine if the respondent had any of those symptoms in the last 12 months. The point of asking symptom-related questions is to screen those individuals who might have a specific health condition or disease. Because there could be a number of symptoms that characterise a given health condition, and because some symptoms may be common to different conditions, it is important that the interviewer probe for each symptom to see whether the respondent may have an active disease. It is also important that the time period for the symptoms (in the last 12 months) be clearly understood by the respondent and not confused with other time frames used in this section (such as “ever” and “the last 2 weeks”).

  Literal question: During this period, did you notice any slowing down in your thinking?

  Valid answers: 1, Yes; 5, No. We have recoded 5 as 0.