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Article

Male Twin Live Births Following Unconditional Cash Transfers in Alaska: A Time-Series Analysis

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Abstract

Prior studies report a decline in male twin live births during economically stressful periods, presumably owing to higher selection *in utero* against frail male gestations, yet no study has examined the natural corollary: whether provision of economic support increases rates of male twin births. We examined whether male twin live births increase following income gains from the Alaska Permanent Fund Dividend (PFD)—the longest running unconditional cash transfer program in the US. We obtained the monthly volume of male (and female) twin and singleton live births, from January 1980 to December 2019, from Alaska's Department of Health. Data on PFD timing and payment amounts came from Alaska's Department of Revenue. We used time-series analyses to gauge whether the odds of male twin live births increase within 2−6 months following PFD receipt, controlling for autocorrelation. Results suggest that for every $1000 increase in PFD payments, the odds of male twin live births increase by 0.002 ($p < .05$) three months following PFD disbursement. This corresponds with 50 additional (individual) male twin live births statistically attributable to the cumulative PFD amount disbursed over our study period. Income gains through the PFD may correspond with reduced male-specific selection *in utero* in Alaska.

Keywords: Male twins; selection in utero; time-series analysis; unconditional cash transfer; Alaska

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Population-level responses to external stressors may manifest as variations in birth outcomes across exposed gestational cohorts (Bruckner & Catalano, 2018). Studies examining sudden, exogenous ambient stressors such as pandemics, economic recessions and terrorist attacks provide evidence of selection *in utero* against frail male gestations, and a consequent decline in male births among conception cohorts exposed to these macro-stressors in large populations (Bruckner et al., 2023; Bruckner et al., 2010; Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023). Selection *in utero*, also known as prenatal or fetal selection, refers to the process by which certain fetal traits affect survival during pregnancy, and traits that offer a survival advantage are more likely to be passed on (Bruckner & Catalano, 2018; Lummaa et al., 1998). The male-specific nature of selection *in utero* was first theorized in 1973 by Robert Trivers and Dan Willard (the Trivers-Willard hypothesis), who posited that parents in species with high parental investment, including humans, may unconsciously bias the sex ratio of offspring based on their own condition and the expected reproductive success of each sex (Trivers & Willard, 1973). The hypothesis suggests that when a mother is in resource-rich conditions (e.g., higher availability of nutrition, low ambient threat to survival), she is more likely to produce male offspring as males have higher reproductive variance and potential success through competition for mates (Trivers & Willard, 1973). In contrast, when a mother is in resource-deprived conditions (e.g., periods of war, famine, higher mortality from diseases), she may be more likely to produce female offspring, who have more predictable reproductive success (Trivers & Willard, 1973). This strategic allocation of resources, though not consciously directed, is thought to be driven by innate biological mechanisms shaped by evolution, helping to maximize reproductive fitness and the transmission of genes across generations (Bruckner & Catalano, 2018; Trivers & Willard, 1973).

In case of twin pregnancies, the allocation of resources becomes even more critical, as the mother needs to provide for two developing fetuses (Lummaa et al., 1998). If resources are scarce or compromised due to stressful conditions, the mother may prioritize the survival and reproductive success of female offspring over male offspring (Trivers & Willard, 1973). Moreover, male twin offspring, if born during periods of resource scarcity, may fare poorly in terms of future reproductive success owing to increased competition provided by the corresponding twin (Lummaa et al., 1998; Trivers & Willard, 1973). These mechanisms of maternal conserved biology may lead to higher sex-specific spontaneous fetal loss or abortions of male fetuses, and male twin fetuses in particular, during periods of adverse circumstances (Bolund et al., 2016; Bruckner et al., 2023; Catalano et al., 2020; Forbes & Mock, 1998; Karasek et al., 2015; Lummaa et al., 1998; Singh, Gailey et al., 2023; Trivers & Willard, 1973). Multiple studies report changes in the volume of male twin live births among humans as a consistent

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marker of external circumstances, including ambient stress, economic uncertainty and optimism about the future (Bruckner et al., 2023; Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023; Stolte et al., 2024). Population-level studies in the US and Sweden show a decline in male twinning within 2 to 6 months following higher-than-expected increase in female suicides (Catalano et al., 2020; Singh, Gailey et al., 2023). Evidence from one of the most widespread stressors in recent times—the COVID-19 pandemic—also indicates consequent decline in male twin births in the US (Bruckner et al., 2023).

Financial resources and economic stability may alleviate stress and create conditions conducive to male twinning (i.e., male twin pregnancies carried to term). Multiple studies have previously reported decline in male twin live births following exposures pertaining to economic adversity or adverse macrosocial shocks (Bruckner et al., 2023; Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023). For instance, sharp declines in consumer confidence index correspond with a decline in male twin live births at the population level (Karasek et al., 2015). Conversely, exogenous 'positive' social exposures, such as the election of President Barack Obama in 2008, precede a proximate increase in male twin live births among Black women in the US (Stolte et al., 2024). Limited research, however, has explored whether favorable economic conditions correspond with an increase in male twinning. To test this relation, we turn to the largest population-level unconditional cash transfer program in the US—the Alaska Permanent Fund.

The Alaska Permanent Fund Dividend (PFD) is a direct cash transfer paid to residents of Alaska by the state government annually since 1982. These payments are made to all Alaska residents, including children. Residents are eligible if they are born in Alaska and stay or migrate to Alaska and meet a one calendar year residency requirement (with rare exceptions), regardless of income, employment status, or family structure (State of Alaska, Department of Revenue, Permanent Fund Dividend Division, 2021). The payments are large (annual average of $1634 in 2015 US dollars from 1982 to 2019) and vary considerably over time (Alaska Permanent Fund Corporation., 2023). New Alaska residents must complete an intensive first-time application to prove residency, but in subsequent years, the application process is minimal. Applications can be submitted January through March each year and payments are made in October. Participation rates are very high—over 90% of Alaskans receive a PFD in most years (State of Alaska, Department of Revenue, Permanent Fund Dividend Division, 2020). Parents and legal guardians may apply for dividends for their children, including newborns born during the calendar year of eligibility. The PFD is funded through investment returns from the Alaska Permanent Fund, a sovereign wealth fund created in 1976 to invest oil and mineral royalties paid to the state (Alaska Permanent Fund Corporation, 2023). While the origin of the Permanent Fund is from oil production, dividends are not tied to current oil revenues or state economic conditions broadly. The Fund is diversely invested, and the amount of the dividend each year was determined by a statutory formula between 1982 to 2015 (Alaska Permanent Fund Corporation, 2023). The formula calculates the payment as a fixed portion of the past 5 years of the Fund's investment returns. Since 2016, the size of the dividend is determined by legislative appropriation (Alaska Permanent Fund Corporation., 2023). The remaining investment returns after the dividend payout are reinvested in the principal of the Fund (Alaska Permanent Fund Corporation, 2023). The Fund continues to receive mineral royalty payments, but since 1985 the primary growth mechanism of the Fund has been re-investment of returns (Watson et al., 2019). The Alaska PFD is regarded as the largest and longest running natural experiment in unconditional cash transfers in the U.S. (Hoynes & Rothstein, 2019) and has been shown to exhibit a sizeable and sustained fertility response (with mixed evidence of improved birth outcomes) in the Alaskan population (Cowan & Douds, 2021; O'Brien & Olson, 1990; Wyndham-Douds & Cowan, 2024; Yonzan et al., 2024).

In the present study, we examine whether and to what extent male twin live births change following temporal variation in disbursement and magnitude of the Alaska PFD. We use time-series analysis to gauge whether male twin live births increase within 2 to 6 months following PFD disbursement in the Alaskan population, from January 1980 to December 2019. To our knowledge, this is the first study to empirically examine population-level responses, rooted in fundamental evolutionary biology principles, to exogenously determined unconditional cash transfer payments in a large population. Our study enhances current understanding of the link between economic policies and patterning of population-level responses driven by evolutionary biology and highlights the role of positive or beneficial exposures on male-specific selection *in utero*.

Materials and Methods

Data and Variables

We retrieved data on the monthly volume of male and female singleton and twin births in Alaska over a period of 480 months, January 1980−December 2019, from the restricted use natality data from the National Center for Health Statistics (National Center for Health Statistics, 2022) and Alaska Department of Health's Health Analytics and Vital Records division (Alaska Department of Health, 2023). We aggregated the monthly count of total live births, by sex and plurality (twins and singletons) over our study period. In keeping with prior work (Singh, Gailey et al., 2023), the monthly series of the odds of male twin live births served as our outcome (if x = number of male twin live births/number of male twin and singleton live births, then odds of male twin live births = x/(1-x)).

We retrieved information on the timing and magnitude of PFD from Alaska Department of Revenue's summary of annual PFD payments (Kueng, 2018; State of Alaska Department of Revenue, 2024). We standardized the cash transfer amounts to 2015 USD for comparability across our analytic timeframe. We defined, as our exposure, the timing and magnitude of PFD payments (in $1000 increments) over our study period (e.g., if $2500 PFD disbursement occurred in October of 1999, the exposure received a value of 2.5 for October 1999 and 0 for all other non-PFD payment months).

We determined the exposure lag or induction period between PFD payments and increased odds of male twin births based on fetal loss patterns reported in prior research (Byrne & Warburton, 1987; Hassold et al., 1983; Kline & Stein, 1987). Typically, fetal losses peak in the first trimester, decline until the 16th week, plateau for 6 weeks, and rise before birth (i.e., in the last trimester of pregnancy; Ammon Avalos et al., 2012; Goldhaber & Fireman, 1991). Most early losses result from chromosomal abnormalities, making survival unlikely regardless of maternal investment (Kline & Stein, 1987). For chromosomally normal fetuses, losses increase around the 12th week and decline until the 24th week, with more male losses (relative to female) during this period (Byrne & Warburton, 1987; Hassold et al., 1983; Kline & Stein, 1987). We

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reasoned that the impact of nonconscious maternal biological decisions on chromosomally normal male fetal loss would be most apparent between the 12th and 24th weeks of gestation (Karasek et al., 2015). Since twins are typically born earlier than singletons (average gestational age at birth among twins is around 34 to 36 weeks, relative to 40 weeks in singleton births; DiLalla et al., 2008), we expected the effects of PFD payments to first appear 8–10 weeks (i.e., 2 to 2.5 months) after PFD receipt, with observable changes in male twin birth cohorts (from potentially reduced selection *in utero*) occurring up to 6 months following PFD receipt (Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023). Based on these patterns and in alignment with prior research (Bruckner et al., 2023; Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023), we specified an exposure lag of 2 to 6 months following PFD payments for our analytic tests.

Analysis

Birth outcomes, including male twin live births, may exhibit temporal dependencies, such as seasonality, trends and oscillations, collectively referred to as autocorrelation (Catalano et al., 2020; Catalano et al., 2016; Karasek et al., 2015; Lummaa et al., 1998; Singh, Gailey et al., 2023). Autocorrelation violates key assumptions of correlational tests as the observed values in an autocorrelated series are not independently distributed, often exhibit nonconstant variance, and in many cases, particularly birth outcomes, are mean reverting (i.e., tend to shift to high/low values depending on past values; Box et al., 2015; McCleary et al., 1980; Shumway et al., 2000). We used Autoregressive Integrated Moving Average (ARIMA) time-series methods to account for these violations. ARIMA models work by identifying and combining three key components: autoregression (AR), differencing to achieve stationarity (I for Integrated), and moving averages (MA; Box et al., 2015; McCleary et al., 1980). Autoregression refers to using past values of the data series to predict future values, if previous observations have some influence on future observations (Box et al., 2015; McCleary et al., 1980). The differencing step helps make the time series stationary, meaning it removes any long-term trends or changes in variance (Box et al., 2015; McCleary et al., 1980). Moving averages take past forecast errors into account, smoothing out random noise or fluctuations in the data (Box et al., 2015; McCleary et al., 1980). ARIMA models have been widely used in examining the relation between exogenous exposures and changes in male twin births as they can handle complex time series patterns while allowing flexibility in fitting to various types of data (Bruckner et al., 2023; Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023). The AR, I and MA parameters form the ARIMA 'signature' of an observed series and yield the unobserved counterfactual (i.e., predicted or fitted values that would have occurred in absence of exogenous exposures) (Box et al., 2015; McCleary et al., 1980). The difference between the observed and fitted values yield the residual values (i.e., deviations from the fitted values) of a series (Box et al., 2015; McCleary et al., 1980). ARIMA-derived residuals are independently identically distributed, are free of autocorrelation, have a mean of zero and exhibit constant variance over time (Box et al., 2015; McCleary et al., 1980). These properties make ARIMA-derived outcome residuals ideal for examination of the association between exogenous exposures and consequent changes in the outcome (Box et al., 2015; McCleary et al., 1980). We used ARIMA time-series analysis to examine the relation between PFD disbursements (timing and magnitude) and the odds of male twin births in Alaska over 480 months (1980–2019). Our analytic steps comprised the following:

(1) We used Box-Jenkins iterative pattern recognition routines to identify the ARIMA signature of the monthly series of male twin odds over our study period (Box et al., 2015). We used this ARIMA signature to remove autocorrelation from the observed series and obtain the outcome residuals. Our use of male twin odds as the outcome helps account for shared seasonality, fertility trends and autocorrelation across male twin and singleton birth patterns in our data. We did not control for the concomitant series of female twin odds because male and female births exert a natural, hydraulic effect on each other in large, stable populations (Catalano et al., 2009; Forbes & Mock, 1998). Rather, motivated by the male-specific indication of the Trivers-Willard hypothesis (Trivers & Willard, 1973), we examined female twin odds as a separate dependent variable in relation to PFD payments (as described in step 5 below).
(2) We inspected the outcome residuals to determine absence of any autocorrelation.
(3) We applied the exposure (timing and magnitude of PFD disbursements) to the outcome residuals, with 2–6-month exposure lags, to determine whether the odds of male twin live births increase 2–6 months after PFD receipt. We chose this exposure lag period based on prior research that posits this induction period for exogenous economic factors to exert a change in male twinning (Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023).
(4) If results from step 3 rejected the null, we repeated steps 1–3 for examination of the raw count of male twin live births (instead of odds), controlling for the concomitant series of male singleton live births (as a covariate transfer function) to gauge consistency in results across two different formulations of the outcome.
(5) As a falsification test, we repeated steps 1–3 for the series of female twin live birth odds to check whether, per the Trivers-Willard hypothesis, any observed increase in the outcome (from step 3) appeared unique to males and not female twin births.

Robustness checks included the examination of any changes in the outcome in relation to the month-specific timing (but not magnitude) of PFD disbursements to ascertain whether results from our main analyses (step 3) were being driven by a potential 'fixed' effect of the month of PFD disbursement. We also explored the relation between the exposure and outcome series using 7- to 11-month exposure lags (i.e., months beyond our hypothesized exposure lag period until the next occurrence of PFD disbursement) to test the veracity of our prespecified exposure lags. We conducted all analyses using time-series software provided by Scientific Computing Associates.

Results

Our analytic data comprised a total of 437,247 twin and singleton births, of which 1.3% were male twin live births (Table 1). Figure 1 shows the monthly patterning of odds of male twin live births in Alaska, from January 1980 to December 2019. PFD disbursements averaged \$1634 annually and primarily occurred in October, with limited variation in monthly timing but substantial variation in magnitude over our study period (Figure 2). Supplementary Figure

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Table 1. Description of twin, singleton live births and Permanent Fund Dividend (PFD) payment in Alaska, 1980–2019

	Total count	Monthly mean	Monthly standard deviation
Male twin live births	5465	11.4	4.7
Female twin live births	5475	11.4	4.9
Male singleton live births	218,863	456	45.6
Female singleton live births	207,444	432.2	44.3
	Total amount per capita	**Annual mean per capita**	**Annual standard deviation**
PFD payment	$62,095	$1,634	$619

S1 shows the trends in twin and singleton live births (monthly count), by sex, in Alaska, from 1980 to 2019.

Box-Jenkins pattern recognition routines identified autoregressive (AR) parameters at 4, 5, 6 lags as the ARIMA signature of the monthly series of male twin odds (outcome). Supplementary Figure S2 shows the expected or fitted values (i.e., the ARIMA signature) of our outcome series. We removed the autocorrelation identified by this ARIMA signature from the observed series of male twin odds to obtain the residuals of our outcome series (shown in Supplementary Figure S3, overlaid with the timing and magnitude of PFD payments). Next, we inspected the ARIMA-derived outcome residuals to confirm absence of autocorrelation (Supplementary Figure S4).

Results from time-series analyses indicate an increase in the odds of male twin live births for every additional $1000 increase in PFD payments 3 months after the exposure, controlling for autocorrelation (Table 2, coefficient of exposure lag 3 = .002, $p <$ .05). In terms of absolute outcome counts, we observe 0.8 (or ~1) additional male twin live births per $1000 increment in PFD payment three months after PFD disbursement (Table 3, coefficient of exposure lag 3 = .8, $p < .05$).

We do not observe any change in the odds of female twin live births in relation to the exposure (Supplementary Table S1). We also do not observe any relation between the odds of male twin births and the timing of PFD disbursements, which helps rule out a potential ‘October’ effect on the patterning of male twinning in Alaska (Supplementary Table S2). Exposure lags of 7–11 months do not exhibit statistically detectable relations with the outcome (Supplementary Table S3). Lastly, re-examination of our main test using a reduced-form specification with only exposure lag 3 (excluding all other exposure terms) supports our original inference (Supplementary Table S4). Our estimates also align with those reported in prior time-series research on population-level male twin live births (Supplementary Table S5). Taken together, our results indicate a modest increase in male twin live births in relation to the magnitude of PFD disbursements in Alaska. Application of coefficient of exposure lag 3 from Table 3 to the cumulative PFD payment amount ($62,095) yields 50 additional (individual) male twin live births (62,095 * 0.8/1000 ≈ 50) statistically attributable to the cumulative amount disbursed through the PFD over our study period.

Discussion

A substantial body of work supports the inverse relation between adverse economic, macrosocial exposures and male twinning-specific selection *in utero* (Bruckner et al., 2023; Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023). However, evidence of the association between positive income shocks on male twin births remains scarce. We examined whether income gains through the largest and longest running unconditional cash transfer program in the US—the Alaska Permanent Fund Dividend (PFD)—corresponds with a proximate increase in male twin live births in the Alaskan population. The PFD disbursements began in 1982 following operationalization of the Trans-Alaska oil Pipeline System, with annual payments ranging from $600 to $2500 every year, and continue to the present day (State of Alaska Department of Revenue, 2024). Results from time-series analyses indicate higher than expected male twin live births following $1000 increment in PFD payments from 1980 to 2019. We do not observe this relation among female twin live births, and sensitivity tests suggest that our observed relation is driven by the generosity of PFD amounts, rather than the month-specific timing of PFD payments.

Strengths of our analyses include rigorous time-series methods that control for autocorrelation and establish temporal order (i.e., the exposure precedes the outcome). Our use of vital statistics natality data also permits independent verification and replication of our work. Use of theoretically relevant, proximate exposure lags limits confounding from other longer running factors (such as changes in assisted reproductive technology) that may influence the temporal patterning of male twin births in Alaska over our study period. Furthermore, our estimated coefficient (magnitude) and exposure lag coheres with other studies that have examined the relation between ambient exposures and male twin births in diverse populations (Catalano et al., 2020; Karasek et al., 2015; Singh, Gailey et al., 2023). For our observed relation between PFD payment amounts and increase in male twin live births to arise from a factor other than the PFD, such a factor would have to: (1) be causally independent of the magnitude and timing of PFD payments but exhibit identical variation to this exposure, (2) increase the odds of male twin live births within 2–6 months post exposure, (3) not correspond with any changes in the odds of female twin live births, and (4) be independent of any downstream effects of PFD transfers on birth outcomes. We know of no such factor. Our results align with expectations from PFD receipt, motivated by evolutionary biological mechanisms pertaining to male-specific selection *in utero* (Trivers & Willard, 1973).

Prior work on the relation between macroeconomic conditions and male twinning reports a decline in the odds of male twin live births by 0.0012 two months after sudden drop in consumer confidence index (indicative of increased population-level financial risk aversion) in the Swedish population (Karasek et al., 2015). Results from our analyses align with these estimates (in the opposite direction) at a similar temporal lag. We contend that our discovered statistical detection at exposure lag 3 suggests that any putative effect of the Alaska PFD may have reduced male-specific selection *in utero* among persons who were already pregnant and in the second trimester of gestation at the time of PFD receipt. We do not find evidence of increased male twinning in potentially ‘new’ or early conceptions immediately following every $1000 increment in PFD receipt as the coefficients for 6–11 month exposure lags in our analyses do not indicate higher than expected odds of male twin live

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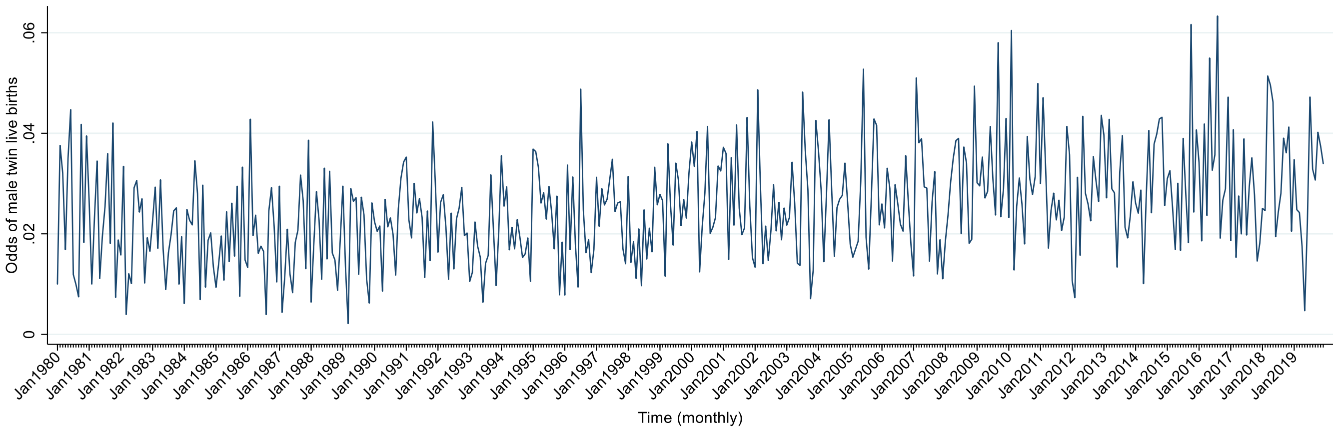

Figure 1. Monthly trends in odds of male twin live births in Alaska, January 1980 to December 2019.

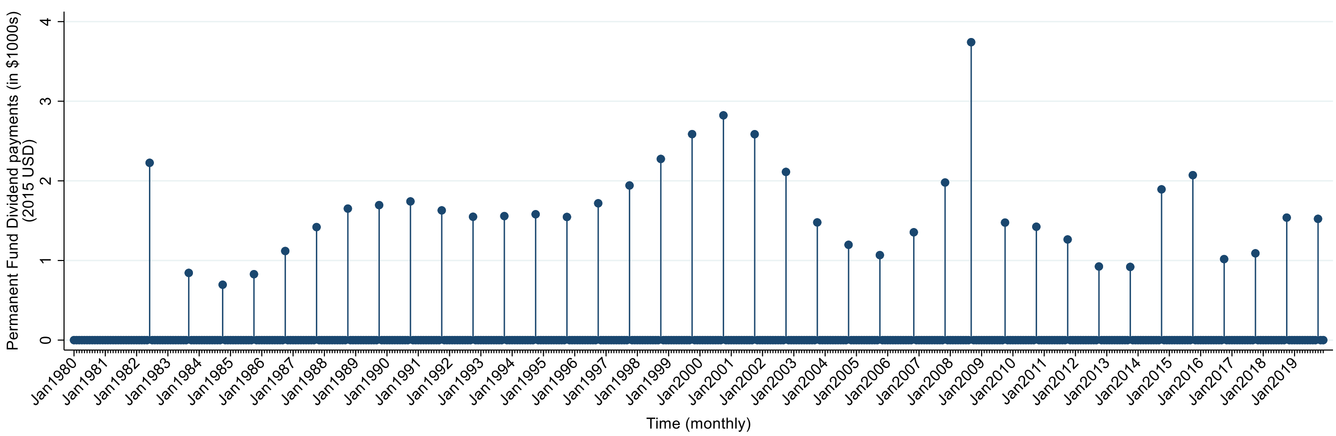

Figure 2. Trends in Permanent Fund Dividend payments (in $1000s, 2015 USD) in Alaska, January 1980–December 2019.

births. This observation, along with results reported by prior research, suggests that male-specific selection *in utero* may be sensitive to (positive or negative) economic shocks in the second or early third trimester of pregnancy on average, relative to other gestational periods. We acknowledge the speculative nature of this proposition as we do not examine responses by conception or gestational cohorts in this study, and we encourage future research to use more refined data to examine trimester-specific changes in male twinning following exogenous economic exposures.

Limitations include that we do not examine conception cohort-specific patterning of male twinning in relation to PFD receipt. The vital statistics natality data files used in this study provide gestational age at birth in bins of 3–4 weeks, which diminishes our ability to create precise conception cohort arrays of twin and singleton births. We are also unable to distinguish between monozygotic versus dizygotic twins and we do not have consistent information on use of assisted reproductive technology for all live births over our study period. Whereas our exclusion of higher order births (i.e., triplets, quadruplets) and our analysis of female twin births following PFD disbursements may address concerns regarding potential confounding from rapid changes in adoption of assisted reproductive technology between 1980 to 2019, we encourage future research to use more detailed data (if available) to examine the validity of our findings after accounting for these factors.

Unconditional cash transfers have attracted increasing attention in recent years, with hundreds of local pilot programs throughout the US (Elliott et al., 2023), some of which particularly focus on birth outcomes (Bridge Project, 2024; California Preterm Birth Initiative, n.d.; RxKids, 2024). The last time unconditional cash transfer programs garnered this much attention in high income countries was during the Nixon administration in which multiple cities in the US and Canada tried small-scale Negative Income Tax experiments (Widerquist, 2005). The cash payments in these experiments showed mixed effects on birth outcomes. In Gary, Indiana researchers found that the program increased birth weight, but the sample size was small and not diverse (Kehrer & Wolin, 1979), while the larger experiment in Manitoba showed no effect on newborn health outcomes (Forget, 2011). More recently, studies in the US show increased fertility (Cowan & Douds, 2022; Singh, Gemmill et al., 2023) but offer mixed evidence of improved birth outcomes (like preterm births, low birthweight) following unconditional cash receipt (Wyndham-Douds & Cowan, 2024). Other large-scale cash transfer (or cash-adjacent) programs such as the Earned Income Tax Credit, food stamps and Child Tax Credit policies correspond with reductions in preterm or low birth-weight births (Almond et al., 2011; Hamad & Rehkopf, 2015; Hoynes et al., 2015; Markowitz et al., 2017), while some of these policies also correspond with a counterintuitive increase (or no change) in low birthweight in exposed cohorts (Bruckner et al., 2013; Currie & Cole, 1993; Margerison et al., 2023). If resource gains from these

Table 2. Results from ARIMA time-series analysis of monthly odds of male twin live births as a function of PFD month and amount (in $1000s) and autocorrelation, Alaska, 1980–2019

Variables	Coefficient	Standard error
PFD month and amount (in $1000s)		
Lag 2 (2 months post PFD disbursement)	.001	0.0008
Lag 3 (3 months post PFD disbursement)	.002*	0.0008
Lag 4 (4 months post PFD disbursement)	.0004	0.0008
Lag 5 (5 months post PFD disbursement)	.0003	0.0008
Lag 6 (6 months post PFD disbursement)	−.0004	0.0008
Autocorrelation parameters		
AR 4	.122*	0.045
AR 5	.146**	0.045
AR 6	.134**	0.045
Constant	.025***	0.0008

Note: AR, autoregression. *$p < .05$, **$p < .01$, ***$p < .001$; two-tailed test.

Table 3. Results from ARIMA time-series analysis of monthly count of male twin live births as a function of PFD month and amount (in $1000s), monthly count of male singleton live births and autocorrelation, Alaska, 1980–2019

Variables	Coefficient	Standard error
PFD month and amount (in $1000s)		
Lag 2 (2 months post PFD disbursement)	0.47	0.37
Lag 3 (3 months post PFD disbursement)	0.80*	0.37
Lag 4 (4 months post PFD disbursement)	0.20	0.37
Lag 5 (5 months post PFD disbursement)	0.20	0.37
Lag 6 (6 months post PFD disbursement)	−0.10	0.37
Male singleton live births	0.024***	0.0006
Autocorrelation parameters		
AR 4	0.124*	0.045
AR 5	0.15**	0.045
AR 6	0.14**	0.045

Note: AR, autoregression. *$p < .05$, **$p < .01$, ***$p < .001$; two-tailed test.

programs increase fetal viability, any consequent reduction in selection *in utero* should correspond with higher than expected male twin live births in these populations. Reduced selection *in utero* could also help explain counterintuitive findings of higher preterm births among recipients of income/cash transfer programs, as birth cohorts with higher than expected male twin live births would presumably comprise a higher proportion of frail births that were not spontaneously aborted in the peri-viable fetal stage and were converted into viable, albeit frail, live births following maternal exposure to cash transfers. Thus, examination of the incidence of male twin live births may offer a way to resolve debates around mixed evidence of improved birth outcomes following cash/resource transfers. We caution that population-level changes in male twinning and selection *in utero* responses may not be detectable in small sample sizes. Stable signals of evolutionary mechanisms are typically observable in large populations as any changes in the patterning of evolutionarily determined birth outcomes may be too weak, noisy or unstable for rigorous analysis in small samples.

Birth cohorts responding to increased economic resources may convert peri-viable gestations to viable fetuses and yield relatively more frail live births (that may have otherwise been aborted *in utero*; Bruckner & Catalano, 2018). This potential conversion may hold implications for birth cohort composition and fitness (Catalano et al., 2020; Karasek et al., 2015). It is plausible that birth cohorts with higher-than-expected male twin live births (indicating lower selection *in utero*) may exhibit relatively higher volume of infants with birth defects, higher neonatal mortality and other genetic conditions (Bruckner, Catalano et al., 2021; Bruckner, Gailey et al., 2021; Bruckner et al., 2015; Singh et al., 2017). We encourage future research to examine the relation between exposures that increase resources and economic certainty and birth cohort fitness in large populations.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/thg.2024.50.

Data availability statement. Data used in this study are available upon request from the Alaska Department of Health's Health Analytics and Vital Records department: https://health.alaska.gov/dph/VitalStats/Pages/data/default.aspx

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Competing interests. All authors declare no competing interests.

Ethics standard. This study used de-identified, aggregate data and was deemed exempt from IRB review.

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