ABORTION WORLDWIDE REPORT: PART IV

Methodologies for Estimating Missing Data in Country-Level Abortion Time Series

Wm. Robert Johnston, Ph.D., and Thomas W. Jacobson, M.A.

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This document explains how we produced complete data sets and cumulative totals for nations and territories included in the Abortion Worldwide Report, by estimating values for missing years. There are three categories of missing year data, plus a set of countries that are dealt with as special cases (see 4):

1. Missing data between year of abortion authorization* and first reported data;
2. Missing data intermediate to reported data (between reported years);
3. Missing data between most recent reported data and the present (2015).

For the three categories of missing data, our estimates are anchored to reported data at one or both ends of the gap. For the first years, we assumed zero abortions the year before authorization, and then anchored to the first year of reported data. For intermediate years, we anchored to the reported data on both sides of the gap. For missing data to the present, we anchored to several of the most recent years of reported data (5-14 years).

Since these three categories have different constraints we applied different methodologies. With few exceptions, the analyses described here are for abortions by country of occurrence. The exceptions are for Ireland, Malta, Isle of Man, Guernsey, and Jersey, where abortions by residents obtained in other countries (mostly the United Kingdom) are included. A few cases of specialized approaches are described also, these applying to certain years for Australia, Austria, Canada, South Africa, South Korea, the United States, and former Soviet and Yugoslav republics.

These analyses are generally based on trends in numbers of abortions rather than abortion rate (e.g., per 1000 women of childbearing age) or abortion ratio (e.g., per 1000 live births). We used trends in numbers of abortions for two primary reasons. First, in many cases reported abortion numbers are more readily available and more reliable than estimates of female population by age (needed to obtain abortion rate). Second, the methodologies we developed are generally found to be sufficiently robust when compared to actual reported numbers of abortions, often yielding estimated errors less than 10%, which is comparable to representative estimated accuracies of reported data for developed nations (see Sedgh et al., 2016).

For each of these three cases of missing data, we describe in the sections below our conclusions about relevant trends and patterns, the methodology we developed and applied for estimates

* See explanation in Laws brief for use of term “authorization” versus “legalization.”

for missing year data, and our assessment of the reliability of our methodology. In the last section we discuss several special case countries that required unique estimation methods.

1. Missing Data Between Year of Authorization and First Reported Data

A. Preliminary Analysis of Early Year Missing Data. The early period between the year of authorization and first reported data was the most problematic and poorly constrained area of missing data. We consider our estimates for missing data prior to first reported data to be our most uncertain estimates in general. Our trend analyses (discussed in the Major Findings section) showed that not only is there significant variation in how fast abortions rise in a country after authorization, but also that different stages of this rise are not accurate indicators for other stages. This also tends to be affirmed by the accuracy analysis of the intermediate gap estimates in the next section, which shows a large range of errors for estimates for long gaps when abortions are rising.

With data available from the year of authorization (or before) for half the countries, we could see that some countries were very slow to accept the idea of killing their own children, especially between the 1920s and 1940s, with a few exceptions. Yet other nations accepted abortion more quickly, especially from the 1960s forward, with some exceptions. Of the 100 nations, territories, and other regions listed in the Sacred Accounting Table:

49 have data beginning the first year of authorization or prior to that year;
5 were formerly part of Yugoslavia and their data is included in that nation for 1952-1959 (see WP12);
14 were formerly part of the Union of Soviet Socialist Republics, and we developed a special model to allocate abortions from the U.S.S.R. for 1954/55-1970 (see WP10);
32 remaining did not have reported data for 1-29 years from the year of authorization.

Of the 32 remaining countries, 16 were missing the first 1-3 years of data, 4 were missing 5 years, 3 were missing 6-10 years, and 9 were missing the first 17-29 years of abortion data. These are the groups of countries for which we developed methodologies for filling in early missing year data.

To assess the patterns for early missing year data, we reviewed countries with complete, or nearly complete, data sets, starting from the year of first authorization. The two most common early year patterns are what we call “slow-rise” or “fast-rise” after authorization.

For most nations that authorized abortion during the 1920s to 1940s, abortions remained relatively low for many years (although this was not the case in Russia, Ukraine, and Japan). Denmark is an example of such a “slow-rise” country. The government authorized abortion with restrictions in 1937, and abortions remained low for three decades (see Fig. 1.1). But abortions began rising rapidly during the late 1960s and 1970s, especially after the government authorized it on demand in 1973.

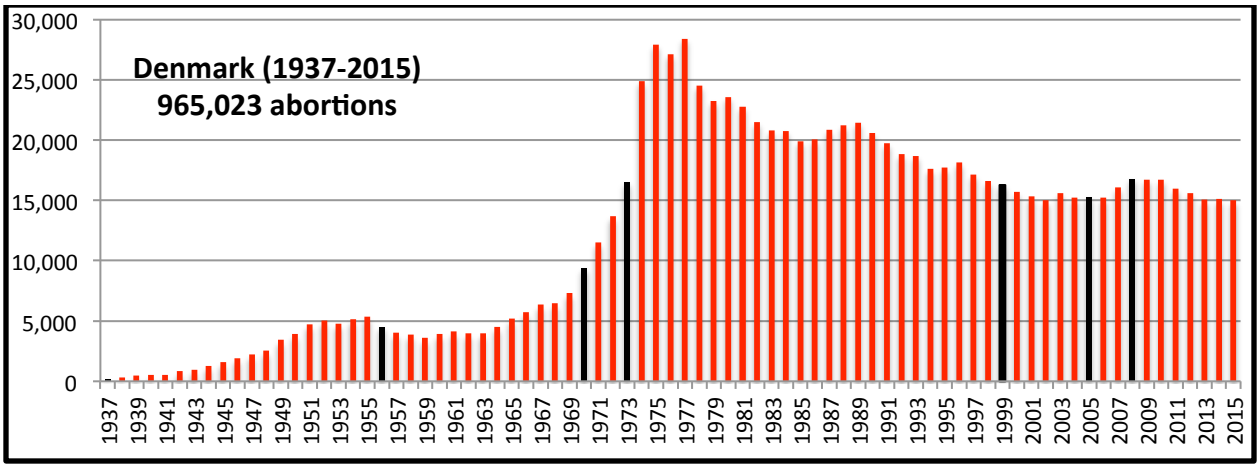


Fig. 1.1. Denmark abortions after authorizations in 1937, 1956, 1969, and on demand in 1973.

Abortions increased rapidly in other nations, promptly after governments authorized the practice. The United States is an example of a "rapid-rise" country (see Fig. 1.2). The number of abortions nationwide was very low prior to authorization. But between 1966 and 1972, 19 of the 50 states authorized abortion. When the U.S. Supreme Court arbitrarily and incorrectly ruled in the infamous 1973 *Roe* v. *Wade* case that states could not ban abortion, all the states were forced to remove their prohibitions on abortion, and within a decade abortions reached 1.6 million annually.

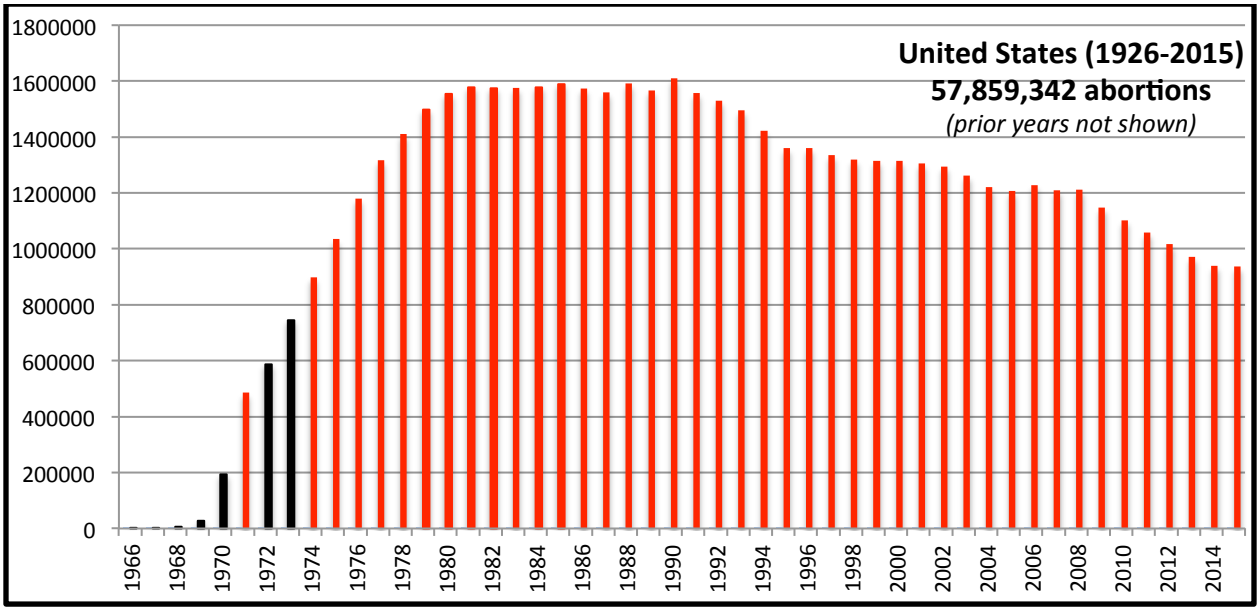


Fig. 1.2. United States after some state authorization between 1966 and 1972, and national in 1973.

Another rapid-rise country was India, which first authorized abortion in 1972, and again in 1975. Fig. 1.3 shows that reported abortions surpassed 500,000 annually by the 10th year.

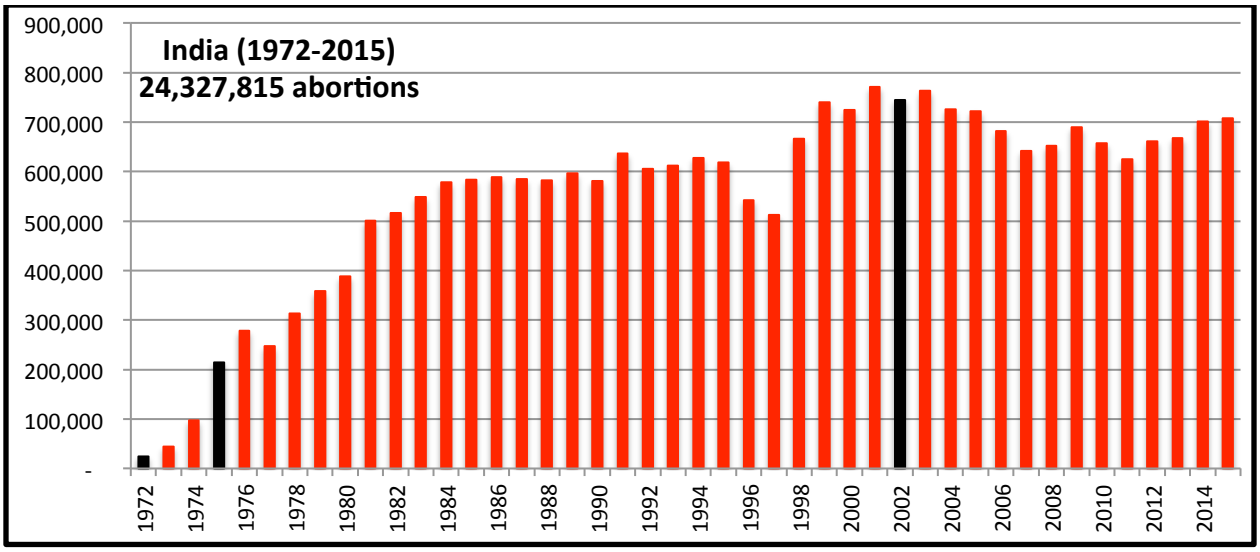


Fig. 1.3. India abortions after authorizations in 1972 and 1975.

B. Methodology Description for Early Year Missing Data. For the 32 countries with missing data from the first year of authorization, we developed two types of methodologies:

- Linear interpolation from year of authorization to first reported data – used mostly for countries missing the first 1-5 years of data (18 countries), but also for countries with longer periods where the first reported abortion figures were particularly low (Germany [17 years in the 1920s-30s]; Guam [7 years]; Qatar [10 years]).
- Two-step linear interpolation for long periods with a slow start, then rapid rise – used for countries with a longer gap of early missing years. We did one linear interpolation to reach 25% of first reported data at the mid-year gap point, followed by a second linear interpolation to the first year of reported data (e.g., Bahrain [21 years], Burundi [19 years], Comoros [25 years], Costa Rica [25 years], Greece [20 years], Puerto Rico [18 years], and Switzerland [29 years]). This is a more conservative approach (i.e., yielding lower total abortions) than straight linear interpolation. We considered and used this approach because of the possibility of a slow development of an abortion culture, which occurs in a minority of country cases where we do have more complete data.

Special Cases: For some countries, abortions were reported prior to authorization followed by a gap. If the gap went beyond the year of authorization, the last reported figure was carried forward to the year of authorization (e.g., Guyana). Otherwise data was linearly interpolated across the gap (e.g., Norway, United States).

If abortions were reported *prior to authorization*, *with no gap in reporting up to the year of authorization*, we made no assumptions about prior abortions, and thus included no estimates for that unknown period of time (e.g., Netherlands).

If we found *conflicts between early reported abortion sources*, we took this into consideration in

developing estimates (e.g., Seychelles). Seychelles was also a special case because it was missing the first 5 years, and the first reported data is 9 abortions, so we estimated 10 abortions per year for years 1 to 5.

For some countries, we carried the *linear interpolation from the year of authorization* to the first reported year, even though *longer than 5 years* (e.g., Greece).

For most of the *former Soviet Republics*, early reported abortions prior to 1954 or 1955 are included in the U.S.S.R. Similarly, for most of the *former Yugoslav republics*, early reported abortions, from 1952 to 1959, are included in Yugoslavia.

For the *People's Republic of China*, which authorized abortion in 1957, from 1957 to 1962 we took for each year the average of linear and exponential interpolation between reported figures in 1956 and 1963.

For *Spain*, which was missing the first two years of data, we estimated the first year lower than a straight linear interpolation.

For *Turkey*, we used a modification of the two-step linear interpolation method, applying a low first linear from 1965 (year authorized, but restricted) to reach 10% in 1983 (abortion on demand), and a rapid second linear to reach the first reported year of data in 1993.

C. Testing the Methodology for Early Year Missing Data.

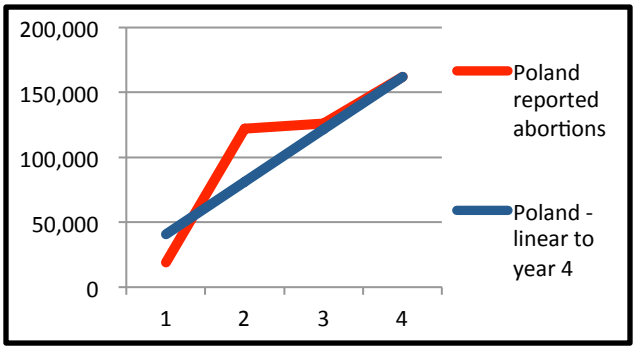
First 3 Years Linear Interpolation Gap Test: Since 16 of the 32 countries were missing 1-3 years of data beginning with the year of abortion authorization, we ran linear gap tests, assuming 0 for the year before authorization and the 4th year reported data for year 4, testing 20 countries with reported data from the year of authorization. For the isolated 3-year gap, the median linear interpolation result was 93.9% of actual reported data, but individually ranged from 59.4% to 173.1% of actual reported data. Even with this wide range of variance for the isolated gap, if the first 3 years were the only missing data, the cumulative data for the entire time series (from year of authorization through 2015) using linear interpolation for the first 3 years, resulted in a median of 98.9% of the actual reported cumulative total abortions; and ranged from 93.9% to 101.2% of the actual total.

Table 1 shows 6 of the 20 countries tested, with reported abortions in the first row, and linear interpolation to year 4 in the second row. The "4-Year Total" is the combined total for years 1 to 4. The "Gap %" shows the percent difference (from 100.00) of the linear interpolation method. The "Total" figure is the total abortions for the country from its entire data series (in the Sacred Accounting Table). The "Overall %" is the percent difference (from 100.00) of cumulative abortions with the linear test. The 4-Year Total and Gap % reveal dramatic variances from reported data when using the linear method for the first 3 years. However, the Total and Overall % reveal a small difference, if the only missing gap was the first 3 years and linear interpolation was applied.

Table 1: Linear Interpolation & Exponential Tests for First 3 Years Missing Data

Country	Year 1	Year 2	Year 3	Year 4	4-Yr Total	Gap %	Total	Overall %
India	24,300	44,800	97,756	214,332	381,188	100.00	24,327,815	100.00
linear test	*53,600*	*107,000*	*161,000*	214,332	*535,830*	*140.60*	*24,482,559*	*100.64*
New Zealand	5,800	2,700	4,100	5,945	18,545	100.00	487,781	100.00
linear test	*1,500*	*3,000*	*4,500*	5,945	*14,045*	*80.59*	*484,181*	*99.26*
Singapore	5,300	5,816	5,735	6,502	23,353	100.00	655,829	100.00
linear test	*1,600*	*3,300*	*4,900*	6,502	*16,302*	*69.81*	*648,778*	*98.92*
Tunisia	342	1,396	1,331	2,246	5,315	100.00	778,502	100.00
linear test	*600*	*1,100*	*1,700*	2,246	*5,646*	*106.23*	*778,833*	*100.04*
United Kingdom	27,200	25,207	58,632	92,013	203,052	100.00	8,555,102	100.00
linear test	*23,000*	*46,000*	*69,000*	92,013	*230,013*	*113.28*	*8,582,063*	*100.32*
United States	744,600	898,600	1,034,200	1,179,300	3,856,700	100.00	56,543,020	100.00
linear test	*295,000*	*590,000*	*884,000*	1,179,300	*2,948,300*	*76.45*	*55,634,620*	*98.39*

Of the 20 countries tested, Poland was close to the average results for the first 3-year missing gap linear test, with 94.4% of actual reported abortions (see Fig. 1.4). Of the same 20 countries, India had one of greatest variances. Fig. 1.5 compares the direct linear interpolation (40.6% over) to the slower but exponential growth of abortions in India during its first 3 years. Fig. 1.6 includes the Fig. 1.5 test, but shows that the cumulative difference for the entire data series from 1972 to 2015 was less than 1% (100.64), if the first 3 years were the only missing data and linear interpolation was applied.



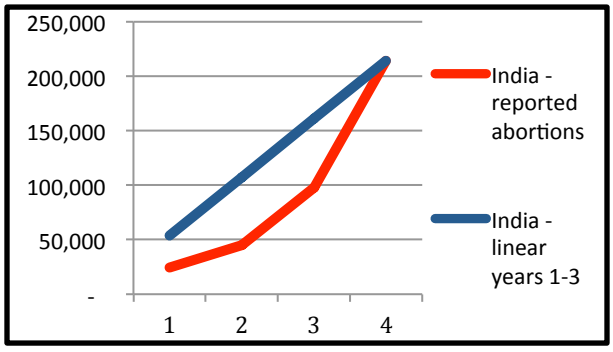


Fig. 1.4 & 1.5. Poland and India: linear gap tests for years 1-3 missing data.

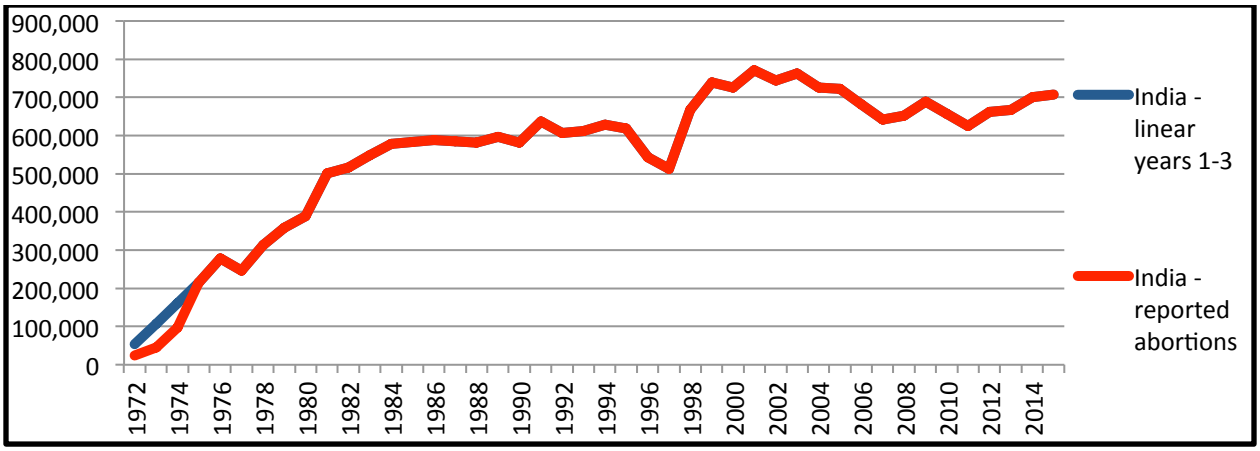


Fig. 1.6. India full data history with gap test using linear interpolation for first 3 years.

First 5 Years Linear Interpolation Gap Test: To do a linear interpolation test for the first 5 years from authorization, we used the same 20 countries. We assumed 0 for the year before authorization and used the 6th year reported data for year 6. For the isolated 5-year gap, the median linear interpolation was 82.4% of actual reported data, but individually ranged from 29.0% to 137.5% of actual reported data. Even with this wide range of variance for the isolated gap, if the first 5 years were the only missing data, the cumulative data for the entire time series (from year of authorization through 2015) using linear interpolation for the first 5 years resulted in a median of 97.8% of the actual reported cumulative total abortions; and ranged from 87.6% to 102.8% of the actual total. Table 2 shows the results for 10 of the 20 countries.

Table 2: Linear Interpolation Test for First 5 Years Missing Data

Country	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Totals	%
Canada	2,000	11,200	30,949	38,905	43,245	48,198	174,497	100.00
linear test	*8,033*	*16,066*	*24,099*	*32,132*	*40,165*	48,198	*168,693*	*96.64*
Denmark	*160*	*330*	484	522	519	824	2,839	100.00
linear test	*137*	*274*	*411*	*548*	*685*	824	2,877	*101.34*
India	24,300	44,800	97,756	214,332	278,870	247,049	907,107	100.00
linear test	*41,175*	*82,350*	*123,525*	*164,700*	*205,875*	247,049	*864,675*	*95.32*
Japan	*123,000*	246,104	489,111	638,350	805,524	1,068,066	3,370,155	100.00
linear test	*178,011*	*356,022*	*534,033*	*712,044*	*890,055*	1,068,066	*3,378,231*	*110.92*
New Zealand	5,800	2,700	4,100	5,945	6,759	6,903	32,207	100.00
linear test	*1,151*	*2,302*	*3,453*	*4,604*	*5,755*	6903	*24,168*	*75.05*
Singapore	5,300	5,816	5,735	6,502	7,175	12,873	43,401	100.00
linear test	*2,146*	*4,292*	*6,438*	*8,584*	*10,730*	12,873	*45,063*	*103.84*
Sweden	*220*	439	506	496	568	703	2,932	100.00
linear test	*117*	*234*	*351*	*468*	*585*	703	*2,457*	*83.80*
Tunisia	342	1,396	1,331	2,246	2,860	2,705	10,880	100.00
linear test	*451*	*902*	*1,353*	*1,804*	*2,255*	2,705	*9,471*	*87.05*
United Kingdom	27,200	25,207	58,632	92,013	133,190	167,555	503,797	100.00
linear test	*27,926*	*55,852*	*83,778*	*111,704*	*139,630*	167,555	*586,445*	*116.41*

United States	744,600	898,600	1,034,200	1,179,300	1,316,700	1,409,600	6,583,000	100.00
linear test	234,933	496,866	704,799	939,732	1,174,665	1,409,600	*4,933,595*	*74.94*

Two-Step Linear Interpolation Tests: To test the accuracy of our two-step linear interpolation method for early year missing data, we applied this method to all countries and territories with complete (or nearly complete) data for early years. (This included countries/territories with some years of data estimated by us, but only if the estimates were a small fraction of the total abortions for these early years.) This set included up to 35 countries/territories of which 11 are developing. We determined total abortions estimated by our method for artificial gaps of 10, 15, 20, and 25-year lengths, and compared these to actual reported abortions in each case. Table 3 summarizes the results for three sets of countries/territories: those with the best quality available data (i.e. minimal estimates by us), all those with initial years' data, and just those with developing economies.

Table 3. Accuracy Results of Tests for Two-Step Linear Interpolation Method

		10-year gap	15-year gap	20-year gap	25-year gap
Countries/ territories with best data	Number of countries	24	24	23	22
	Median error	-46.7%	-45.8%	-50.8%	-49.8%
	Percent overestimated	8%	8%	0%	5%
Countries/ territories, all data quality	Number of countries	35	35	34	32
	Median error	-46.6%	-44.7%	-50.3%	-51.8%
	Percent overestimated	11%	9%	3%	6%
Developing countries/ territories only	Number of countries	11	11	10	8
	Median error	-45.8%	-47.7%	-43.8%	-48.6%
	Percent overestimated	9%	9%	10%	13%

For all cases the median error of our method is an underestimate of total abortions by 40-50%. There are cases, however, where our method overestimates abortions. We nonetheless adopt this method as a conservative approach, estimated here (Table 3) to have about a 90% chance of not overestimating abortions for these time periods.

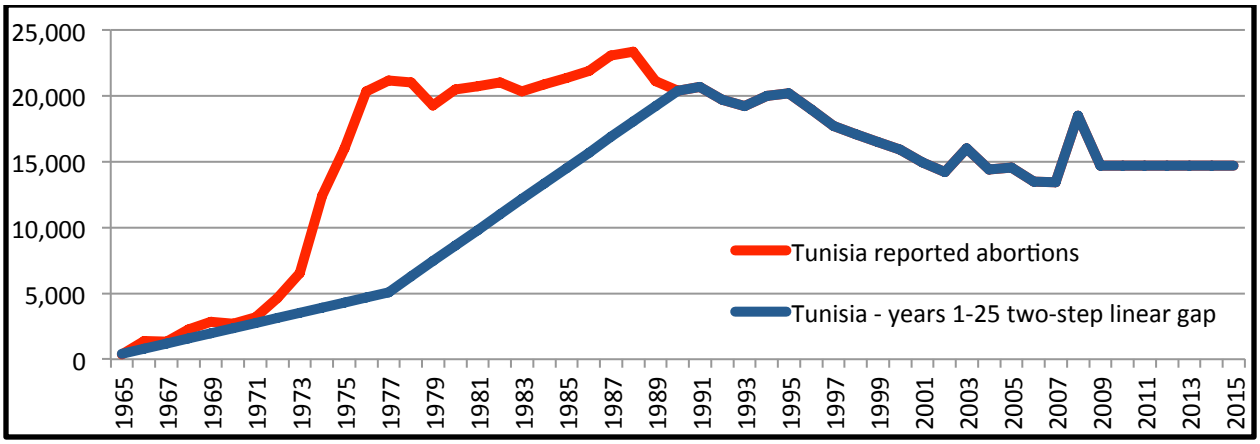


Fig. 1.8. Tunisia two-step, 25-year, linear interpolation gap test.

2. Missing Data Intermediate to Reported Data

A. Preliminary Analysis of Intermediate Year Missing Data. The majority of missing year data are intermediate to years with reported data. For the 100 nations, territories, and other regions studied in this Report, 73% of data gaps are 1 to 5 years long, with another 11% of gaps from 6 to 9 years long. In examining the available reported time series, we found that numbers of abortions tend to be relatively stable over short periods of time, that is, apart from changes in legislation or policy, or during periods immediately after authorization when abortions are rising. This is unsurprising, as the demographic and social factors driving abortion practices tend to be slow to change (i.e., female population of childbearing age, societal attitudes towards abortion, prevalence of abortion providers). Our initial examinations suggested that simple linear interpolation across gaps were reasonably accurate if pre- and post-gap annual abortions were comparable (within a factor of 2 of each other). We found generally that the narrower the gap the smaller the difference between continuous reported data series and artificial gaps. In part C below we give results of testing to assess this accuracy.

B. Methodology Description for Intermediate Year Missing Data. Based on test results, our estimates for gaps in time coverage are made using one of the following two methods:

- Linear interpolation for years in the data gap if reported figures immediately before and after the gap are within a factor of 2 of each other. If pre-/post-gap figures differ more than this, we use linear interpolation only for short gaps (less than 5 years).
- Exponential interpolation for longer gaps, or for gaps with more than a factor of 2 difference between the pre- and post-gap figures. By exponential interpolation, we mean that we used constant percentage growth or decline from year to year.

C. Testing the Methodology for Intermediate Year Missing Data. For linear interpolation, we tested for 3, 4, 5, 9, and 14-year gaps, utilizing data from 20 countries from multiple regions, with complete or nearly complete data series from year of authorization through 2015 (Belarus, Bulgaria, Canada, Czech Republic, Estonia, Finland, Iceland, Ireland, Israel, Italy, Japan, New

Zealand, Norway, Russian Federation, Singapore, Slovakia, South Africa, Sweden, United Kingdom, and United States).

3-Year Gaps: We began by testing short periods bound on either end by reported data, and applied linear interpolation. We ran the analysis on 20 countries with no less than seven (and as many as 14) 3-year gaps for each country. The results were: cumulative abortions for the artificial interpolated gaps were within 3.1% under and 1.1% over cumulative actual abortions for all 20 countries. More precisely, 19 of 20 countries were within 1.3% under and 1.1% over. Where the values at the beginning and end of a 3-year gap differed significantly, the resulting intermediate estimates can vary substantially for that individual period; but even in such cases, the cumulative difference was within the stated error range. Figure 2.1 shows results for artificial 3-year gaps for Canada, exempting the first and last 5 years, with a result of 0.8% over of linear estimated compared to reported totals.

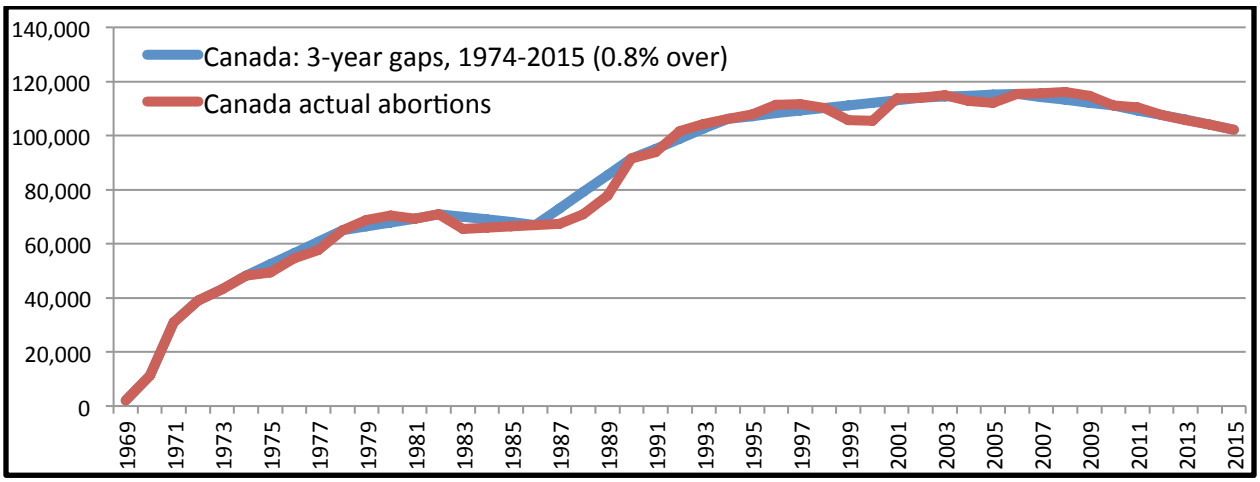


Figure 2.1. Gap analysis for Canada, successive 3-year gaps illustrated.

4-Year Gaps: Then we tested 4-year linear interpolation gaps for the same 20 countries, from 5 years after authorization to 2010. For all 20, the error range for the linear estimated total was between 1.6% under and 1.5% over total reported abortions. Figure 2.2 shows South Africa as an example, for which cumulative total estimated abortions were 0.4% over cumulative actual reported abortions.

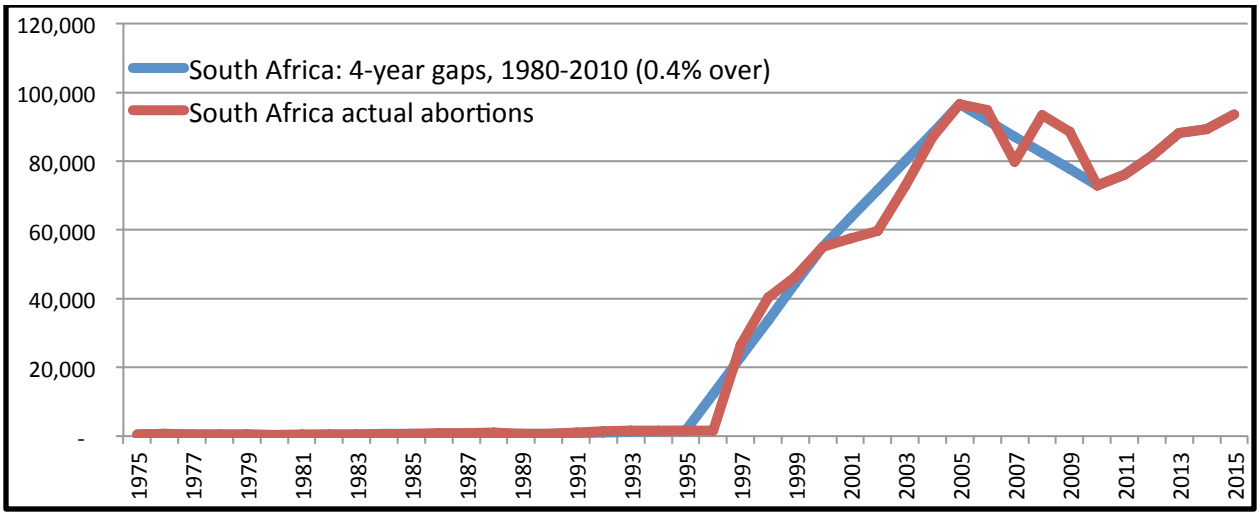


Figure 2.2. Gap analysis for South Africa, successive 4-year gaps illustrated.

5-Year Gaps: For 5-year gap tests utilizing linear interpolation for the same 20 countries, we ran the test for the middle period after initial authorization (about a decade) to the year 2000. Each country had 3 to 8 artificial gaps, depending on the length of years of data. For all 20 countries, the error rate was between 5.1% under and 1.9% over, that is, the cumulative total with artificial 5-year linear estimates compared to cumulative actual reported abortions. Fig. 2.3 shows results for artificial 5-year gaps covering a 42-year period in the Czech Republic series. During the period of rapid growth and change in abortion numbers soon after authorization, the interpolations across gaps are less accurate than for later periods, when abortion numbers are relatively stable. The graph below shows cumulative estimated abortions for 7 consecutive artificial linear 5-year gaps from 1958-2000, resulting in 96.5% of cumulative actual abortions (or a 3.5% error).

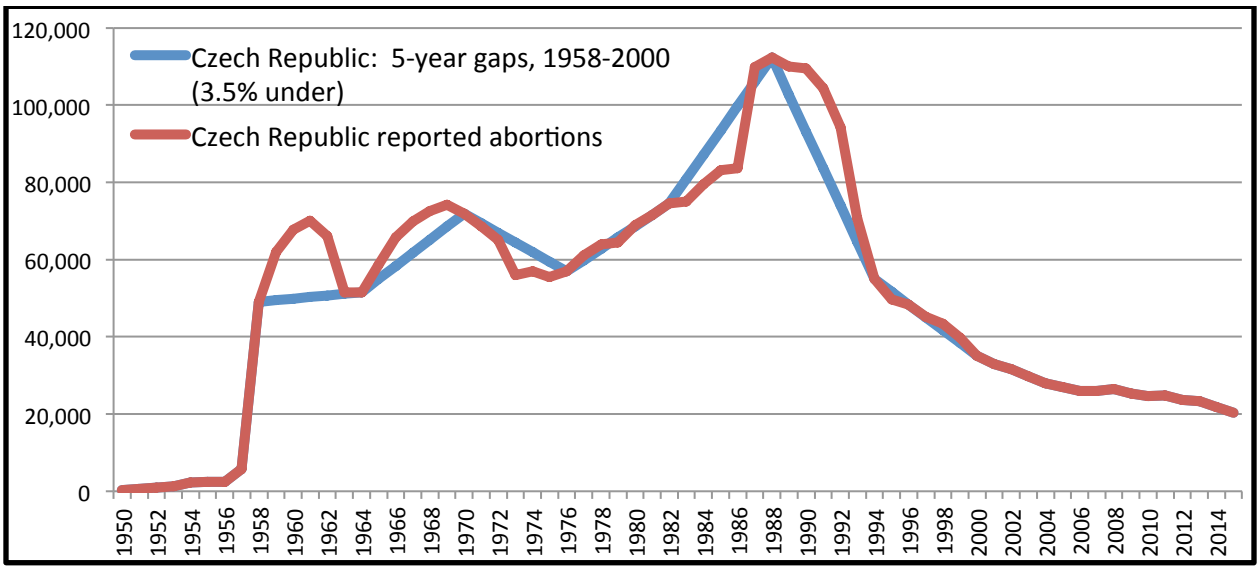


Figure 2.3. Gap analysis for Czech Republic, successive 5-year gaps illustrated.

9-Year Gaps: For the 100 countries in this Report, 11% of the data gaps in the middle years were 6 to 9-year gaps. Thus, we also ran 9-year linear interpolation gap tests on 20 countries, with two to six gaps. (To facilitate the longer gap periods we added Hungary and Serbia, and removed Italy and South Africa). The results were: cumulative abortions for the artificial interpolated gaps were within 3.6% under and 7.1% over cumulative actual abortions for all 20 countries. More precisely, 19 were within 3.6% under and 3.2% over. Figure 2.4 shows results for artificial 9-year gaps, covering a 40-year period, in the Japan series, with the result that cumulative estimated abortions were 1.0113 of cumulative actual abortions (a 1.1% error).

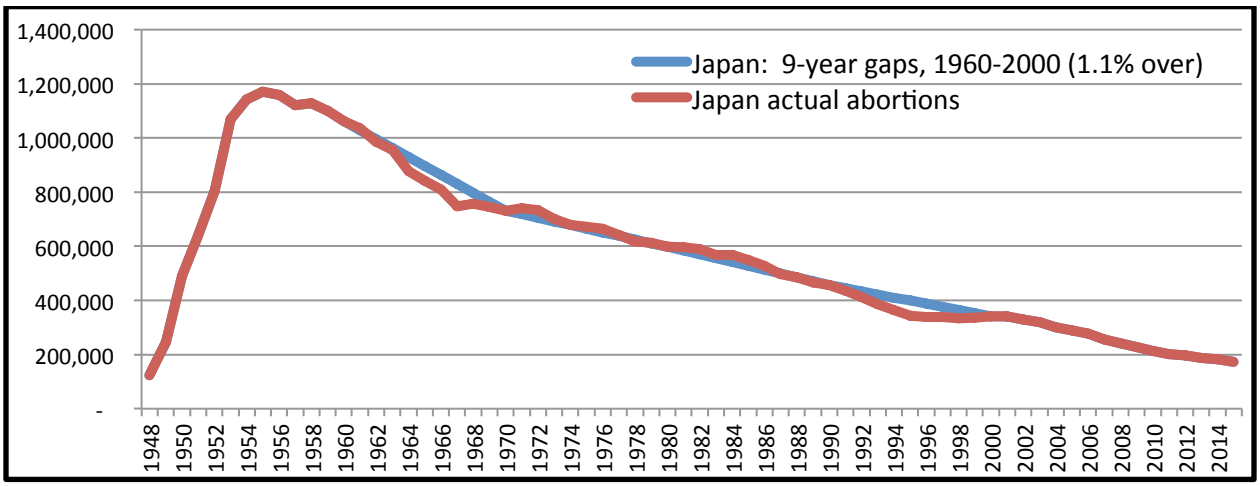


Figure 2.4. Gap analysis for Japan, successive 9-year gaps illustrated.

14-Year Gaps: We had 6 countries with 10-17 year intermediate gaps for which we did 14-year linear interpolation gap tests (covering the period after the initial rise, and up to the year 2000) for 20 countries. To include at least two gaps, we substituted nine countries with longer data series (the 20 are: Azerbaijan, Belarus, Bulgaria, Czech Republic, Denmark, Estonia, Finland, Georgia, Hungary, Iceland, Japan, Lithuania, Norway, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Sweden, Switzerland). The results were an error range between 16.2% under to 5.0% over. Of the 20, 16 were under and 4 over; 18 were between 7.2% under and 5.0% over. Georgia and Romania were the two with the greatest discrepancy, 16.2% and 15.5% under respectively; but they both experienced multiple policy changes in the tested 30-year period, and Georgia followed the exceptionally rapid decline after the fall of the Soviet Union. Again, as expected, the wider the gap, the greater the error ranges. Even so, the abortion patterns of most countries are remarkably stable after the initial exponential rise, even across the expanse of such wide gaps in data. For example, Figure 2.5 shows that Russia had an exceptionally high exponential rise in abortions after the 1955 full authorization on demand. Yet after the first and highest peak in 1965, the abortion trend was substantially consistent, with almost equal cumulative results with or without two 14-year linear gap estimates.

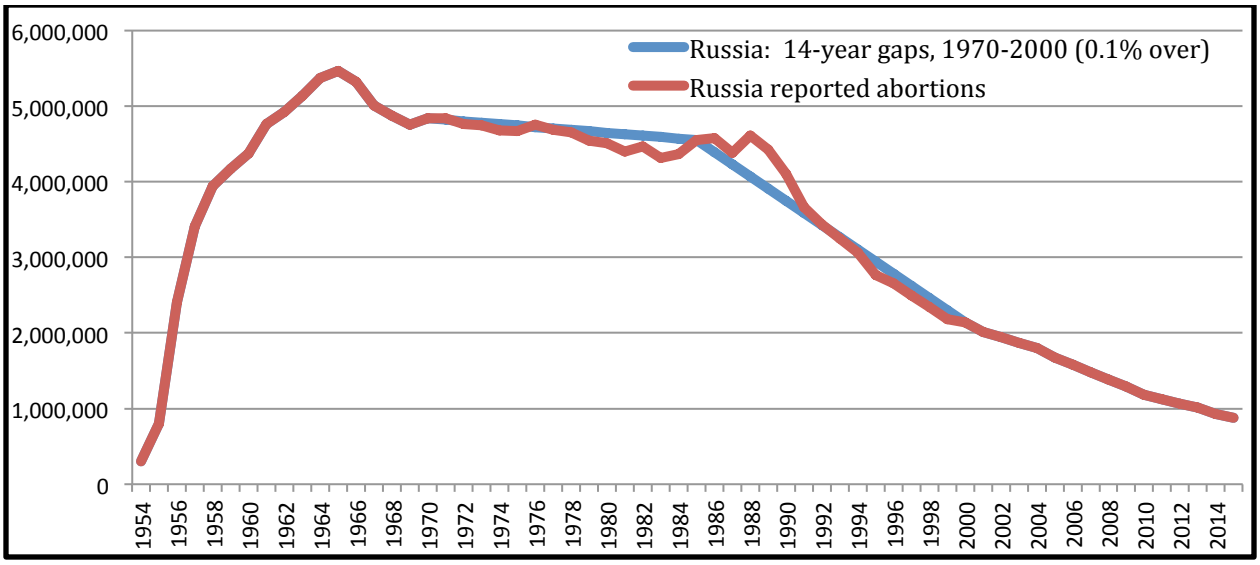


Fig. 2.5. Gap analysis for the Russian Federation, successive 14-year gaps illustrated.

Comprehensive Evaluation: Now we present a more exhaustive evaluation of the accuracy of our estimates for intermediate gaps, based on the complete time series of available reported data. Similar to the examples above, we artificially inserted gaps in time series of complete recorded data. We compared estimates of total abortions for the years in the artificial gap (using linear interpolation) to the actual total during these years, obtaining error estimates. For each such comparison, we also took the ratio of the annual abortions in the year before the gap to the annual abortions in the year after the gap. This ratio is an estimate of the stability of abortion numbers for this time period. By obtaining these two values for every possible artificial gap we could insert in the complete recorded data, we obtained hundreds of data points. We used these to evaluate not just the typical accuracy of our interpolations, but also how much this accuracy depends on whether abortions were higher, lower, or similar before and after the gap.

Figure 2.6 illustrates these results for gaps of 4 years' length: the horizontal axis is the ratio of pre- to post-gap abortions, and the vertical axis is the error of the estimated total abortions in the gap relative to the actual reported total. When we examined available recorded data from 89 countries, we came up with 2,800 possible 4-year gaps (1-80 data points from each country), which are the red points plotted in the figure. The majority of points form a horizontal spread, representing estimate errors generally less than 20% above or below the actual total (small vertical spread), for a wide range of pre-/post-gap ratios (larger horizontal spread). The blue line is a moving average of the estimate errors, showing that on average the linear interpolation yields very low error (particularly if the pre- and post-gap abortions are within a factor of 2 of each other). When annual abortions before the gap are much smaller than after the gap (left side of plot), there is a much greater spread in errors, meaning that linear interpolation is less reliable for gaps during periods of dramatic increases in abortions. Interpolation is more reliable when abortions are decreasing (right side of plot), though not as reliable as when they are stable.

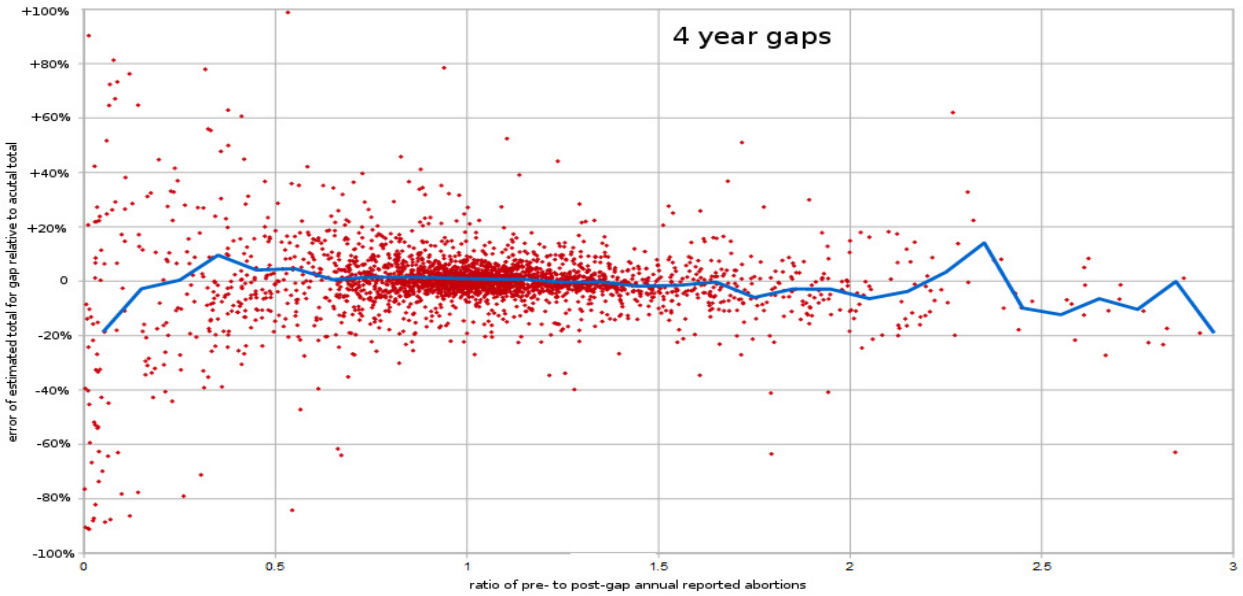


Figure 2.6. Estimate accuracy for 4-year artificial gaps versus pre- to post-gap abortion levels (red) with running average (blue).

We conducted these analyses for gaps with lengths of 4, 9, and 14 years. Figures 2.7 and 2.8 show the results for 9- and 14-year gaps, respectively, similar to Figure 2.6. Table 4 gives statistics on the accuracy of the estimates for these gaps when the pre- and post-gap annual abortions are within a factor of 2 of each other. Results are in terms of what percentage of the samples have errors less than 5% (high or low), 10%, or 20%.

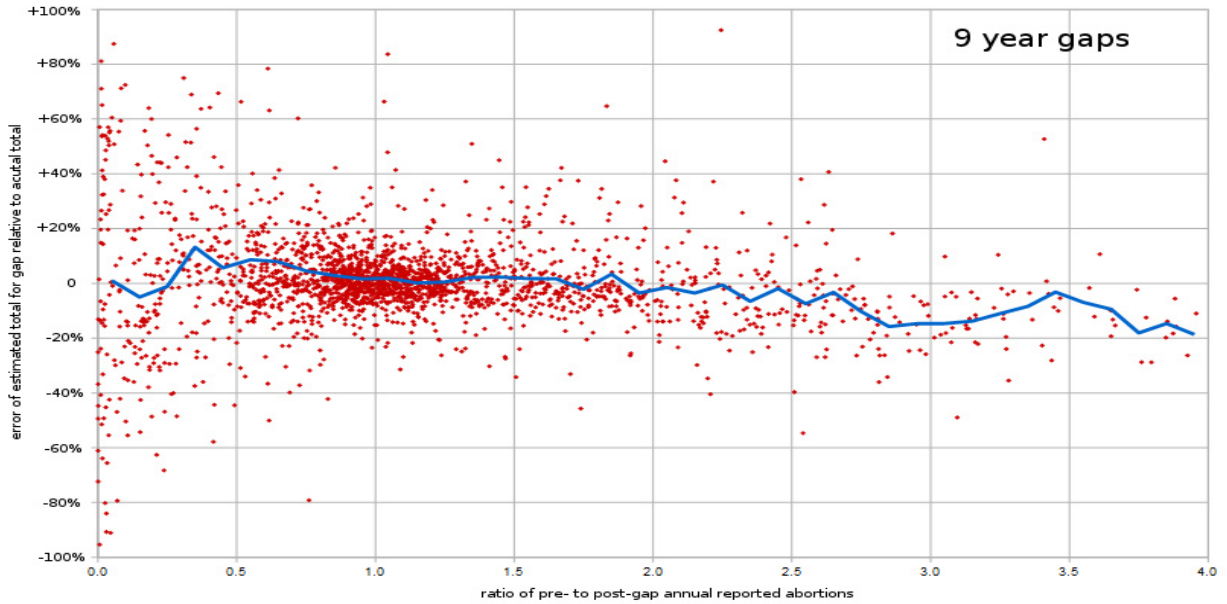


Figure 2.7. Estimate accuracy for 9-year artificial gaps versus pre- to post-gap abortion levels (red) with running average (blue).

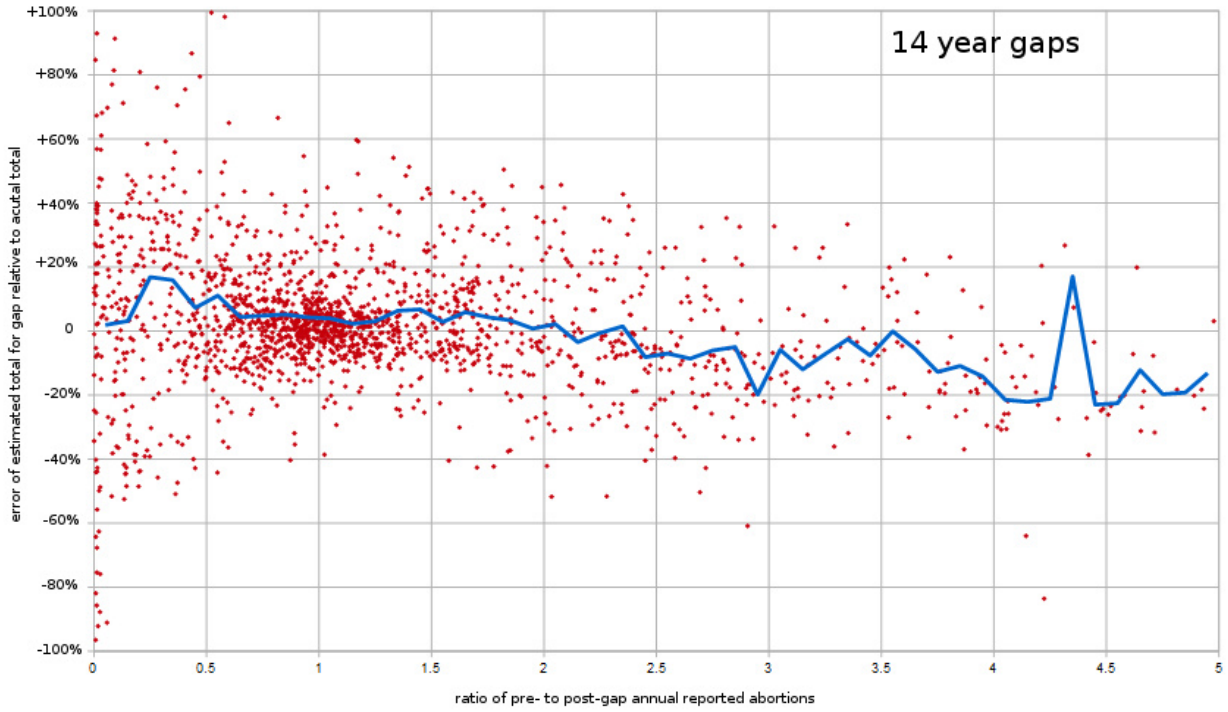


Figure 2.8. Estimate accuracy for 14-year artificial gaps versus pre- to post-gap abortion levels (red) with running average (blue).

Table 4. Fraction of estimates with given levels of accuracy, for 4-, 9-, and 14-year gaps, assuming similar pre- and post-gap abortion levels (within a factor of 2)

Gap length	Estimate accuracy (high or low)			Number of cases with pre- to post-gap abortions within a factor of 2	Number of cases, all
	<5%	<10%	<20%		
4 year gap	65.2	84.4	95.6	2,474	2,850
9 year gap	50.5	75.8	93.1	1,715	2,337
14 year gap	40.6	66.2	84.9	1,185	1,917

If pre- and post-gap annual abortions differ by more than a factor of 2, then linear interpolation performs less well. Table 5 shows test results for such cases for the 14-year gap test for different ranges of pre- to post-gap annual abortions. If this ratio is less than 0.5, abortions are rising significantly; if it is greater than 2, abortions are dropping significantly; and the intermediate range of 0.5-2 indicates the somewhat stable range discussed above. In the table, the median error is shown for each range (positive for overestimate, negative for underestimate). The table also shows the range from underestimates (negative) to overestimates (positive) spanned by the middle 80% of cases. Thus, 10% of the cases had lower underestimates, 10% had higher overestimates, but 80% were within the range shown in the table.

Table 5: Statistics of linear interpolation accuracy in 14-year gap test, for different ranges of ratio of pre- to post-gap abortions.

Pre/post ratio	0 to 0.1	0.1 to 0.2	0.2 to 0.333	0.333 to 0.5	0.5 to 2	2 to 3	3 to 5	5 to 10	>10
# of cases	95	70	66	90	1,185	212	133	45	21
median	+8%	+5%	+23%	+5%	+2%	-6%	-14%	-18%	-41%
80% of cases	-66% to +59%	-42% to +43%	-35% to +48%	-15% to +40%	-10% to +22%	-27% to +24%	-28% to +16%	-37% to +8%	-90% to +17%

For the cases of interpolation over gaps with rising or dropping abortion numbers (pre-/post-gap ratio is either less than 0.5 or more than 2, respectively), the table illustrates two results. First, the accuracy range spanned by 80% of cases is larger than for similar pre-/post-gap ratios, which is why we assess the accuracy of some of our interpolated estimates as between 20% and a factor of 2 (Tier 2 in the tables). Second, the median accuracy results show that linear interpolation tends (more often than not) to somewhat overestimate for gaps when abortions are rising, and underestimate when abortions are dropping. Our choice of exponential interpolation in cases of long gaps and large pre-/post-gap abortion levels is thus conservative (i.e. unlikely to overestimate abortions).

Special Case: Soviet-Era Estimates for U.S.S.R. Republics. Total U.S.S.R. abortion data is available from 1954 to 1991 (and for some earlier years). From 1955, when the U.S.S.R. reauthorized abortion and made it available on demand, abortion data for individual Soviet republics is limited through 1970. For the balance of the Soviet-era, from 1971 to 1991, abortion data at the individual republic level is available. We modeled the abortion levels in each republic for 1954 to 1970 by estimating trends in abortion percentage (abortions as a percentage of total live births plus abortions) for each republic, and then applying these to each republic's reported annual live births to obtain annual abortion estimates. Fig. 2.9 shows these abortion percentage trends (without estimations for gaps), revealing that the abortion percentage varies by a factor of three across the republics, but also showing similarities including an early peak (in the 1960s to 1970s), and for some republics a second peak following around 1990. The timing of the early peak shows some correlation with level of urbanization, occurring earlier in the more urbanized republics. (Details are provided in WP10, 2016.)

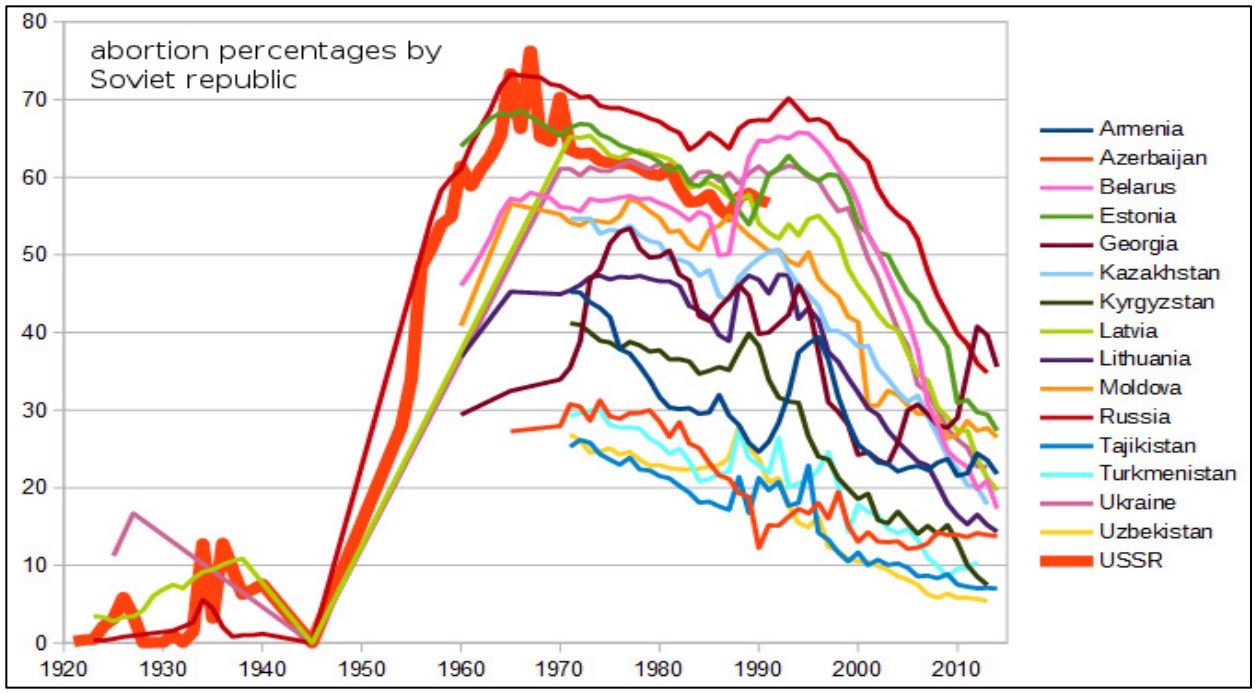


Fig. 2.9. Abortion percentages by Soviet republic/successor states and for the U.S.S.R. overall.

3. Missing Data Between Most Recent Reported Data and the Present

A. Preliminary Analysis of Recent Year Missing Data. For most recent years to 2015: 36 nations in this Report had data for 2015; 34 were missing 1 year (2015); 7 were missing 2 years (2014-2015); 10 were missing 3-6 years; and 8 were missing 9 years of data or more. (Three former nations and two with insufficient data are not included.) As we discussed in 2-A above, numbers of abortions tend to remain relatively stable over a few years at a time, unless there is a change in policy.

B. Methodology Development and Description for Recent Year Missing Data. Table 6 below shows the year-to-year fluctuations for 12 of the 87 countries we analyzed for the post-2000 time period. The change is expressed as an annual ratio change (relative to the prior year). A ratio of 1.0 would be no change; a ratio of 1.1 would be 10% increase; and a ratio of 0.9 would be 10% decrease.

Table 6: Year-to-Year Change Ratios in Recent Abortion Data

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Belarus	0.832	0.887	0.892	0.894	0.902	0.905	0.791	0.912	0.852	0.925	0.963	0.894	1.090	0.795	
Burundi	0.925	1.250	0.982	1.116						0.991	0.566	0.871	1.021		
China PR	0.944	1.084	1.059	0.990	0.995	1.029	1.044	1.202	0.666	1.041	1.042	1.009			
Cuba	0.912	1.018	0.927	1.025	0.929	1.086	0.972	1.135	1.131	0.843	1.176	0.997	1.008		

Hong Kong	0.947	0.922	0.934	0.912	0.894	0.952	1.000	0.977	0.911	0.934	1.056	0.952	0.943		
Israel	1.048	0.974	1.051	0.980	0.978	0.995	0.985	1.005	1.014	0.983	0.982	1.044	0.965	1.006	
Italy	0.961	0.992	1.013	1.033	0.943	0.973	1.006	0.959	0.963	0.987	0.966	0.962	0.959	0.949	
Japan	1.001	0.964	0.971	0.943	0.958	0.956	0.929	0.944	0.936	0.937	0.950	0.973	0.947	0.977	
Spain	1.096	1.104	1.035	1.065	1.079	1.108	1.104	1.033	0.963	1.014	1.049	0.956	0.958	0.872	
Russia	0.989	0.920	0.959	0.964	0.932	0.944	0.935	0.937	0.933	0.918	0.948	0.952	0.945	0.919	

From the above analysis, we obtained the minimum, median, and maximum changes for the most recent 15-year period, as well as the median for the last 5 years, shown in Table 7.

Table 7: Summary of Year-to-Year Change Ratios for Recent Abortion Data

Country	Year-to-year changes, 2000 to 2015			Median change during last 5 years	Adopted annual change
	minimum	median	maximum		
Belarus	0.791	0.894	1.090	0.925*	-7.5 %
Burundi	0.566	0.986*	1.250	N/A	-1.4 %
China PR	0.666	1.035*	1.202	1.041	+3.5 %
Cuba	0.843	1.008*	1.176	1.008	+0.8 %
Hong Kong	0.894	0.943*	1.056	0.943	-5.7 %
Israel	0.965	0.990*	1.051	0.983	-1.0 %
Italy	0.943	0.964*	1.033	0.962	-3.6 %
Japan	0.929	0.953*	1.001	0.950	-4.7 %
Spain	0.872	1.042*	1.108	0.958	-4.2 %
Russia	0.918	0.941*	0.989	0.945	-5.9 %

* Indicates ratio used for annual changes for the particular country.

We examined these results on a country-by-country basis, and used the following methods:

- If a country's trend was consistent after 2000, the median trend was used for estimates for years missing data up to 2015;
- If the trend was not consistent for the full time period, we considered the trend for the last 5 years of reported data;
- If the median trends were different (post 2000 years vs. last 5 years only), we used the trend for the last 5 years to produce recent year estimates;
- Otherwise we used the trend for the full period after 2000.

Overall we preferred the post-2000 trends for 63 countries, and the last 5 years' trends for 20 countries.

Four countries (Greece, Malta, Tunisia, Vietnam) did not have consistent trends for either of the recent time periods examined above. In these cases we carried the last reported annual abortion figures forward as our estimates for recent years. The same was done for the 9 countries or territories without sufficient data after 2000, except for Trinidad and Tobago where reported abortion numbers are so low that we do not make any estimate for years after the last reported data. Finally, we addressed estimates for several countries on a special case-by-case basis as described in the next section.

C. Testing the Methodology for Recent Year Missing Data. To assess the accuracy of these estimates, we applied the method without using the latest one or two years' of data and compared the resulting estimates to the reported data for those years. We did this testing for 87 countries, including 36 with reported data all the way to 2015. Median and average percentage errors were 3% and 6-7%, respectively, for estimates for countries where we preferred the median trend for all years after 2000. For countries where we only used the last 5 years' trends, the median and average percentage errors were 6-9% and 12-18%, respectively. Overall, 88% of these test estimates had errors less than 20%, and 70% of the estimates had errors less than 10%.

4. Developing Estimates for Special Case Countries.

For several countries we developed estimates on a case-by-case basis due to their unique situations regarding abortion reporting. Australia, Canada, South Africa, and the United States do not mandate complete abortion reporting at the national level, do have varying reporting practices at the state or province level, and have demonstrated inconsistency in degree of underreporting over time. The same was true for Yugoslavia in practice. Thus for these countries we develop estimates by applying variations of the methods discussed above at the sub-national level, combined with well-grounded academic work addressing estimates for incomplete reporting. Little data are reported for South Korea but we do use estimates based on periodic government surveys that are robust in sample size and diversity in comparison to most published sample-based estimates. For Austria we develop conservative estimates of abortion to separate available data for abortions and miscarriages combined.

Australia: At the national level Australia only reported Medicare-funded abortions. Chan and Sage (2005) estimate these are incomplete by about 14% for 1985-2003. Complete data is available for South Australia for 1970-2011 (Scheil et al., 2013), and for Western Australia for 1999-2012 (MCHU, 2013). The Chan and Sage estimates for 1985-2003 were used as a starting point; their analysis is based on Medicare item 35643 reports that include most abortions, but not item 16525 reports that include additional abortions. After adjusting 1985-2003 estimates to include item 16525 reports, the underreporting ratio found by Chan and Sage was applied to post-2003 national figures. For 1970-1984, limited national estimates were supplemented by interpolation. (Details are provided WP4, 2016; the working papers [WP] are posted on www.GlobalLifeCampaign.com)

Austria: Available data for Austria is limited to abortions for 1989-2001 and combined

abortions and miscarriages for 1960-1988 (Council of Europe, 2004). Combined abortions and miscarriages increased 75% within a year of authorization of abortion (in 1974). By assuming miscarriage rates declined steadily from 1974 to 1988, abortions and miscarriages were separately estimated for this period. For 2002-2015, abortions were assumed to decline at the same rate as in 1996-2001, similar to the extrapolation method described above. (Details are provided in WP5, 2016.)

Canada: Reported abortion statistics for Canada have become increasingly incomplete since the late 1980s, and significantly more so since 2012 (EFC, 2012). Specifically, national data from 2002-2006, 2008-2010, and 2012-2014 are incomplete. To correct these figures, province (or territory) level data was linearly interpolated across years of incomplete data; this occurs for British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nunavut, Ontario, and Yukon Territory. For 2015, the approach described above for extrapolating national figures to 2015 was applied to Canada as a whole and to the provinces/territories individually, with both giving consistent results. The results imply about 22% underreporting in 2012-2014. (Details are provided in WP6, 2016.)

South Korea (Republic of Korea): Available abortion data for South Korea is mostly limited to estimates based on periodic government surveys. These surveys are broad-based relative to surveys often used in family planning studies, and we consider the South Korea estimates to be credible estimates. The last available estimate is for 2010. From 2005 to 2010, available estimates (Ahn et al., 2012; Kim, 2011) imply a 10-12% annual decrease in abortions, excepting 2009 which saw a 22% decrease and was a year of new legal restrictions on abortion. For 2011-2015 estimates, we assume a 22% decrease in 2012, a year of additional abortion restrictions, and 11% decreases the remaining years. (Details are provided in WP8, 2016.)

South Africa: South Africa abortions have been reported by province from 1997 to 2014, but with inconsistent reporting years and varying levels of underreporting (Health Systems Trust, 2016). National Department of Health figures are by calendar year from 1997 to between 2005-2009, depending on the province. District Health Information System figures are by fiscal year (April to following March) from 2005-2014. Figures were compiled from these and supplementary sources for each province and each year, converted to estimates for calendar years for all years. Given the persistent problems of underreporting, the highest credible figures were adopted in each case. For 2015, the approach described above for extrapolating national figures to 2015 was applied to South Africa as a whole and to the provinces individually, with both giving consistent results. (Details are provided in WP9, 2016.)

United States: National-level figures for the United States were also handled as a special case. The most reliable national-level abortion time series are Alan Guttmacher Institute (AGI) estimates, last reported for 2011. Individual states follow variable practices and reporting cycles for reporting state-level data. We compiled state level data for all available states and years from 2000 to the present. Then we calculated trends for all states up to the latest year available in each case, and compared to the 2000-2011 trends in the AGI data. We used these to identify states with trends that tend to match the national trends, and used them to estimate post-2011 national-level trends. (Details are provided in WP13, 2016.)

Yugoslavia and successor states: Available data for Yugoslavia, its constituent regions, and the corresponding successor states is inconsistent across regions, years and whether abortions are separated from miscarriages. Estimates were developed separately for each of the following regions: Bosnia and Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, Serbia, and Slovenia. Interpolation across data gaps was linear for short gaps and exponential for large gaps, and miscarriages were separately estimated as needed to separate these from abortions for combined reported figures. (Details are provided in WP12, 2016.)

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