

Supplementary Materials for

Quantifying the Holocaust: Hyperintense kill rates during the Nazi genocide

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The PDF file includes:

Section S1. Background materials and data

Section S2. Visualization of data from death camps, and materials on train deportations

Section S3. Related studies

Section S4.

Fig. S1. Number of victims deported to the death camps per month, with almost all being murdered, plotted as a function of time (months) from 1 January 1942.

Fig. S2. Reconstruction of number of people transported by train daily to Belzec death camp, all of whom were murdered with almost no exception.

Legend for film S1

References (37–40)

Other Supplementary Material for this manuscript includes the following:

(available at advances.sciencemag.org/cgi/content/full/5/1/eaau7292/DC1)

Film S1 (.mp4 format). Deportations of Jewish communities in the General Government 1942.

Section S1. Background materials and data

Dates of the Holocaust (1941-1945):

We follow Snyder (*Ref. 6*): “the term *Holocaust* signifies the final version of the Final Solution, the German policy to eliminate the Jews of Europe by murdering them. [T]he Holocaust on this definition begins in summer 1941, with the shooting of Jewish women and children in the occupied Soviet Union. The term *Holocaust* is sometimes used in two other ways: to mean all German killing policies during the war, or to mean all oppression of Jews by the Nazi regime [i.e., 1933-1945]. In this book, *Holocaust* means the murder of the Jews in Europe, as carried out by the Germans by guns and gas between 1941 and 1945.” The onset date by this definition also corresponds closely with the initiation of the Nazi mass killing programs.

We note that it is also not uncommon to define the Holocaust as “the mass murder of the Jews by the Germans during World War II (1939-1945)” (37), while it is often also dated as 1933-1945 as mentioned above.

Dieter Pohl’s statistics for the total Jewish victims of Holocaust:

According to Pohl (7; in 2012), a respected authority, the “death toll for all Jewish victims of the Shoa amounts to 5.4 to 5.8 million.” Pohl gives the following breakdown:

2.6 million murdered in concentration and extermination camps

(900,000 Auschwitz; 850,000 Treblinka; 435,000 Belzec; 160,000 Sobibor; 160,000 Kulmhof; 59,000 Majdanek)

2.2 million shot dead

100,000-200,000 in final stages of war and death marches

100,000 suffocated in mobile gas chambers

700,000 murdered individually in ghettos or forced-labor camps

In total 5.4 to 5.8 million murders

Pohl (7) believes the estimates are accurate within of $\pm 5\%$. However, there is not complete agreement amongst experts on this (see below), and the accuracy or methodological differences may sometimes be of the order of $\pm 10\%$.

Data and Data Sources

The statistics of the victims perished in the Holocaust have been highly controversial. Holocaust historians Longerich (10) and Pohl (7), in the main rely on the figures in the Höfle telegram uncovered only in 2001. Longerich (2010) writes: “By the end of 1942 precisely 713,555 people had been murdered in Treblinka. This figure appears in a telegram from Höfle that was found some years ago in the decoding reports of the radio reconnaissance department of the British Secret Service. This document provides us with the figures of the victims who had been murdered in the other Aktion Reinhardt camps. According to this report, 434,598 persons had been murdered in Belzec by the end of 1942. Since Belzec was already closed at this point, this represents the total number of murders for this extermination camp. The corresponding figures for Sobibor and Lublin-Majdanek are 101,370 and 24,733 respectively. This brings the total number of people killed in the Aktion Reinhardt camps at this point to 1,274,166.148” [i.e., to the end of 1942].”

Based on the Höfle telegram, Pohl (7) arrives at a death toll in the General Government over 1942-43 of a total of 1.35 to 1.4 million.

In contrast, Wolfgang Benz (2012) makes use of other datasources in his estimates. “Almost three million Jews were gassed in the extermination camps..... 600,000 in Belzec (between March 1942 and early 1943); 250,000 in Sobibor (May/June 1942, between October and December 1942, and between March and August 1943); 1,000,000 in Auschwitz..., 900,000 in Treblinka (between July 1942 and August 1943);.... [That is, 1.75 million at the three Belzec, Sobibor, Treblinka] These figures are the result of collaborations between historians and legal scholars; research into crimes and their perpetrators conducted for the criminal trials...; official enquiries; and of the calculations of experts on the subject, first and foremost among them Wolfgang Scheffler...”

These figures are very close to the numbers documented by Arad who suggests that 1.7 million died at the three death camps (as detailed below). Arad writes “Of the 1.7 million Jews murdered in the death camps of Belzec, Sobibor, and Treblinka, 1,650,000 of them had been exterminated by the second half of February 1943, when Himmler came for his second visit.”

Data used in this study:

Auschwitz: Data of monthly figures of deportations to Auschwitz 1940-1945 taken from Piper (16).

Treblinka: The data for regional areas of Warsaw, Radom, Bialystok and Lublin used here are identical to numbers used in Arad (1987). Warsaw ghetto victims in Arad total to 266,700 whereas here we included 266,871 victims, as based on Gutman (3).

In addition I included deportations from Thereiseinstadt on Oct 5,8,15,19,22 (1K+1K+2K+2K+2K=8000) and Skopje in March 22,24,25 (2338+2404+2402 =7,144 which were not included in Arad (2). This is similar to the data given by HEART, although these transportations technically originate from outside the General Government.

Arad's (2) total number of victims for Treblinka summed to 881,390, while the total used here is 896,955 [896,955-881,390=15,565].

Arad (2) states that from "the beginning of the extermination activities in Treblinka, on July 23, 1942, until the end of April 1943, about 763,000 Jews from the ghettos of the General Government were murdered there (see Appendix A)" which is in accord with his tables and close to the generally accepted figure for Treblinka. The deportation of the Jews from the Bialystok district (outside the GG) to Treblinka "commenced after the deportation of most of the GG Jews had been completed" (Arad 1987).. The number of victims deported to Treblinka from Bialystok as calculated by Arad (2) are 117,970. This totals to 763,000+117,970=880,970, and is very close to the total number given by Arad (881,390).

Belzec and Sobibor: There has been many controversies over Belzec, where some scholars believe that 800,000 perished while others argue that 600,000 is more likely, and remains the accepted figure. I nevertheless use the lower figure of 515,392 given by the data in Arad (2). Arad (2) recognizes that this Belzec figure must be a lower bound, and estimates the total victims perishing at Belzec to be 600,000 similar to Pohl and Witte (38).

Arad's gives dates for transportation to Sobibor of 110,849 victims, but cannot document 30,000-40,000 from Lublin. He writes: "About 15,000 to 25,000 Jews were deported from Lvov and the other ghettos in the District of Galicia to Sobibor in the period between December 1942 and June 1943, after Belzec was closed." I have include 15,000 to make a total of 125,849. Thus to my figure for Sobibor 125,849 could be added another 40K+10K= 50,000

The court in Hagen treated the figure of 152,000 Jews having been murdered in the Sobibór camp as being the minimum (40). The research of Jules Schelvis suggested 236,000 victims perished at Sobibor (see (40)). However, Bem's (40) most recent thorough appraisal suggests 133,070 victims were murdered at Sobibor from the GG.

The final total number of victims for the three death camps is approximated in this study as Belzec+Sobibor+Treblinka=1,537,946

To this Arad indicates there were a further 100,000 undocumented victims of Belzec and, as mentioned previously, another 50,000 at Sobibor is needed, which comprises the estimated **1.7million total victims perished at the three camps.**

Einsatzgruppen data: Hilberg (1) gives the following data. "Himmler reported to Hitler on December 29, 1942, the following numbers of Jews shot in the Ukraine, South Russia, and Bialystok:

August 1942=31,246 victims; September 1942=165,282 victims;

October 1942=95,735 victims; November 1942=70,948 victims.

Total=363,211 victims over four months

These numbers were added to dataset in Figure 1 (blue curve). They correspond approximately to Gerlach's (12) assessment (p.106): "Among the German-occupied areas, Ukraine (excluding eastern Galicia) was one where the destruction of Jews was more or less completed by early November 1942. Some 300,000 Jews were shot, mostly between August and October."

For the 100 days of killing, the death by bullets left 292,260 (August, Sept., Oct.) +9460 (four days of November) =301,720 murdered.

Kill-rate targets during Operation Reinhard

According to Gerstein's report (see 2) the practical target set for Operation Reinhard was a kill-rate of $K_r(\text{Reinhard})=60,000$ victims per day, based on $K_r(\text{Belzec})=15,000$, $K_r(\text{Sobibor})=20,000$, and $K_r(\text{Treblinka})=25,000$ victims per day. That is, in theory the Nazis believed they were capable of liquidating $K_r = 6,000,000$ victims per 100 days, which is a rate

nearly 800% higher than the Rwanda massacre. The target could quite possibly have been achieved if the Nazis had more time to perfect their system before annihilating and thus exhausting almost all of their supply of victims.

Section S2. Visualization of data from death camps, and materials on train deportations

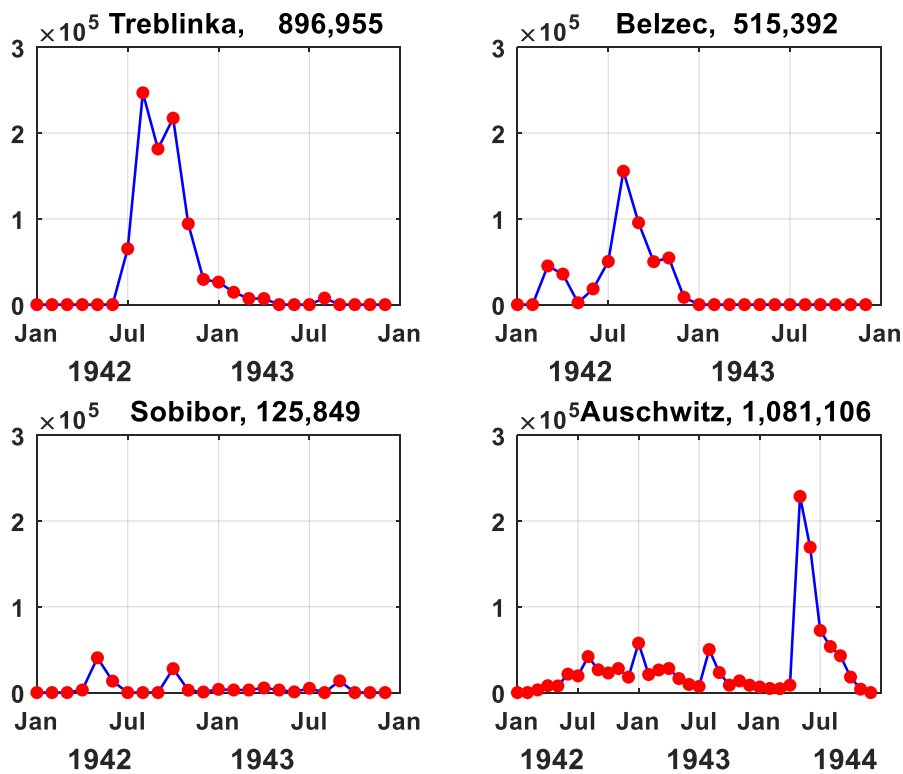


Fig. S1. Number of victims deported to the death camps per month, with almost all being murdered, plotted as a function of time (months) from 1 January 1942. At the top right hand corner of each panel, the total number of deaths per camp is given. While the sum total murders at Belzec is indicated as 515,392, Arad (2) suggests the figure should be closer to 600,000 given that there are missing records.

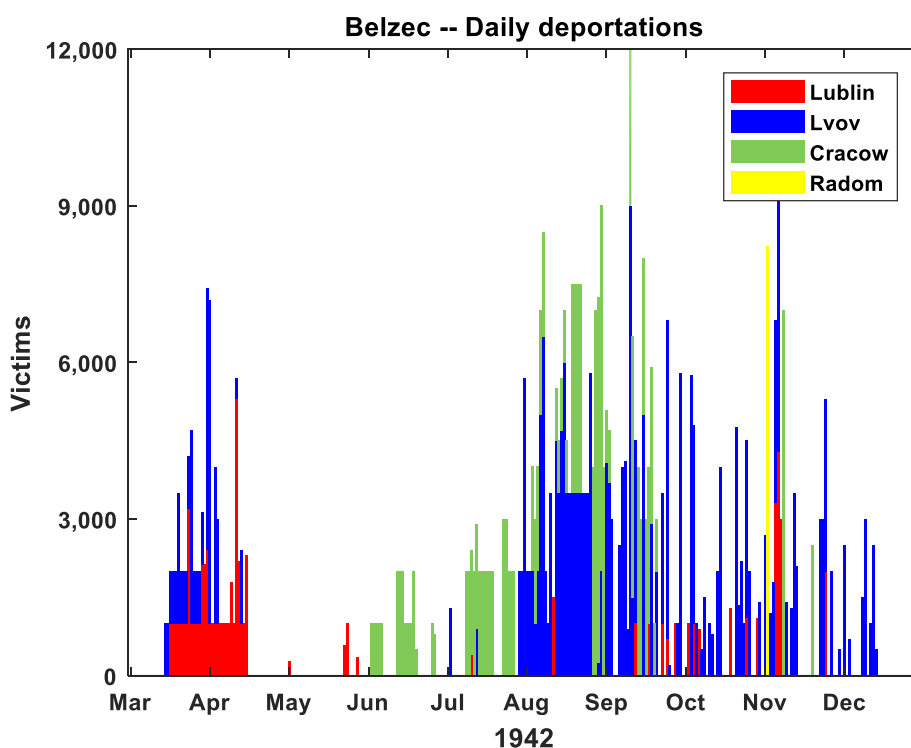


Fig. S2. Reconstruction of number of people transported by train daily to Belzec death camp, all of whom were murdered with almost no exception. First deportation from District of Lvov on March 15 1942. Belzec ceased operations after December 11 1942. District of Lublin (red) = 71,282 transported in total. District of Lvov (dark blue) = 279,080. District of Radom =8,230 (yellow). District of Cracow (green)= 156,800 .

Train records

Arad's dataset (2) is based on train records of which there are only partial details. With regards to deportations to Treblinka, Martin Gilbert (39) wrote the following: "For every deportation, a precise time-table was devised, and copies sent to every station en route.... For the Wloszczowa deportation ... an intricate timetable, typical of hundreds more, was devised:

Wloszczowa		depart	16.38
Kielce	arrive	19.06	depart 19.55
Skarzysko	arrive	21.41	depart 22.43
Radom	arrive	0.03	depart 0.13
Deblin	arrive	2.00	depart 3.10
Lukow	arrive	5.17	depart 6.08
Siedlce	arrive	6.58	depart 8.34
Treblinka	arrive	11.24	(depart empty) 15.59

Following the empty train's despatch from Treblinka, an equally intricate timetable was devised, to return it to the next deportation point."

Constant number of train carriages and linearity of Figure 2

The linearity of the graph in Figure 2 may in part be attributed to the Nazis efficiently utilising an allocated number of train carriages over the three month period as the following documentation indicates. Arad (2) writes: "To work out the transportation requirements for the deportation ... a conference was held at the Ministry of Transport in Berlin on September 26 and 28, 1942. At this conference, attended by Eichmann or Rolf Giinther ... the following was decided:

"Evacuation of the Polish Jews

Urgent transports as proposed by the Chief of the Security Police and the SD:

2 trains daily from the Warsaw district to Treblinka

1 train daily from the Radom district to Treblinka

1 train daily from the Cracow district to Belzec

1 train daily from the Lvov district to Belzec

These transports will be carried out with the 200 freight cars already made available for this purpose by order of the Directorate of the German railways in Cracow, as far as this is possible. Upon completion of the repair of the Lublin-Chelm line, about November 1942, the other urgent transports will also be carried out. These are:

1 train daily from the Radom district to Sobibor

1 train daily from the north Lublin district to Belzec

1 train daily from the central Lublin district to Sobibor

insofar as this is practicable and the required number of freight cars are available. With the reduction of the transport of potatoes, it is expected that it will be possible for the special train service to be able to place at the disposal of the Directorate of the German railway in Cracow the necessary freight cars. Thus the train transportation required will be available in accordance with the above proposals and the plan completed this year." These details may be found in Arad (2).

Section S3. Related studies

Arad (2) pointed out that: “Of the 1.7 million Jews murdered in the death camps of Belzec, Sobibor, and Treblinka, 1,650,000 of them had been exterminated by the second half of February 1943.” However, this and similar broad summary descriptions of events that extend for over a year make it impossible to isolate the extreme months of August to October 1942, as quantified and visualised here. Martin Gilbert was aware and quite shocked when he estimated that August 1942 alone had more than 400,000 murders, and was the basis for a whole chapter in his book (5).

Recent renewed historical interest in Operation Reinhard over the last five years indicates a finer awareness of the kill-rate amongst some modern scholars (12,13), but again this still lacks more careful substantiation in terms of accuracy and sources. Only in 2016, was it understood and presented by Gerlach (12) when he wrote: “by June 1942 Himmler had adopted a plan to murder all of the Jews within one year, i.e., by the middle of 1943. By the end of 1942, the great majority of Jews within the German sphere of influence had been murdered. About 3 million Jews perished from May to December 1942, 2 million in the four horrible months from July to October 1942 alone.” Gerlach (12) does not appear to give the full calculations that led to these conclusions, nor to the reference to the four month period explaining where he obtains this information.

Later Gerlach (12) refers to a ten week period, rather than 4 month period, as the peak of mass murders: “As a horrible consequence, more than 750,000 Jews were murdered in the General Government between late July and the end of September 1942. And nearly 400,000, mostly from the district of Radom, were killed in the last three months of 1942. Those ten weeks in the summer and fall of 1942 were the peak of mass murder in the General Government.” Again, it is not clear where Gerlach (12) obtained his data to make this claim, and how he arrives at a ten-week period which leaves confusion since Figure 2 above shows the peak of mass murder runs for three months, or slightly more, in the GG. Given Gerlach’s (12) verbal descriptions are not completely consistent and the sources of the numbers vague, Figures 1 and 2 help clarify exactly what happened with the aid of Arad’s dataset.

At another point in his book Gerlach (12) gives figures exclusively for the GG: “In the General Government about 160,000 Jews were gassed in the first half of 1942 (close to 50,000 per month from mid-March onwards) and 110,000 in July; but from August to October 1942 it was close to

900,000 (or 300,000 per month) plus 200,000 in the last two months of the year combined.” According to a footnote, the numbers used by Gerlach are taken from Berger’s doctoral thesis (13), whose estimates are also derived from Arad independently. But Gerlach’s (12) numbers here do not include Auschwitz or the mass shootings, nor are there graphical plots that help relate to the other months of the year. Gerlach’s (12) and Berger’s (13) approximate assessments complement the results found here for the GG region. Berger’s doctoral thesis (13; published in German) became known to the author only after early pre-review of this manuscript, and comes close to some of the findings here (for the GG) by providing graphs of Arad’s data (2) on a camp-by-camp basis.

Section S4.

Film S1. Deportations of Jewish communities in the General Government 1942.

The spatio-temporal video visually reconstructs the sequential deportations listed by Arad (2) from towns across the GG over 1942 and 1943. The video shows the rounding up of the Jewish populations beginning with those rounded up for Belzec (blue) which became operational on March 15, followed by Sobibor (green) which became operational on May 3, and lastly followed by Treblinka (red) which opened on July 22. The last main communities in Bialystok were rounded up in November and December 1942 (top right corner of mapping, on the periphery of the GG). Sometimes there were several transportations from a single town or station at different times of the year, which are visualized here as the same single point. The structure of the railway network (green lines) itself can be seen in these data, where communities are transported sequentially along long stretches of the rail-line.

The right hand panel gives a graph showing the increase in the cumulative number of deaths as the genocide proceeded in time. In late December 1942 the graph plateaus and an approximate ~1.5 million cumulative murders are observed. Approximately 200,000 murders in Belzec and Sobibor went unrecorded in Arad’s dataset, which would raise the total number of deaths to 1.7 million (section S1).