Pol J Aviat Med Bioeng Psychol 2025; 31(2): 17-27
DOI: 10.13174/pjambp.25.05.2026.02

ORIGINAL ARTICLE

SUCCESSFUL EJECTIONS IN THE POLISH AIR FORCE IN 1951-2025

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Source of support: This research received no external funding.

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Introduction: Between 1951 and 2025, there were 281 ejection incidents involving 255 aircraft in the Polish Air Force. In 60 cases, they involved two-seat aircraft. Six pilots ejected twice, and eight, despite having previously survived, later perished in aircraft accidents during continued service. The aim of this study was a comprehensive analysis of ejections in Polish military aviation, with particular emphasis on cases ending in survival and on the injuries sustained by pilots.

Methods: The analysis was conducted on the basis of materials from the Aircraft Accident Investigation Commission and Aviation Medical Records. Each case was assessed in terms of the circumstances forcing the pilot to abandon the aircraft, the course of the ejection, and the type of injuries sustained. Unsuccessful ejections were presented in statistical form only.

Results: 177 ejections were performed from subsonic aircraft and 104 from supersonic aircraft. 210 cases ended successfully. The mean age of the pilots who survived was 30 years, while 71 pilots perished during the ejection; their mean age was 29.3 years. Of the survivors, 44 pilots (21%) sustained no injuries, 40 (19%) sustained minor injuries, and 126 (60%) sustained severe injuries, mainly spinal fractures and injuries to the limbs, chest, and head. Most ejections occurred at altitudes above 500 m and at speeds exceeding 400 km/h.

Conclusions: The largest number of ejections involved the MiG-15, MiG-21, and MiG-17 aircraft, while the most injury-prone seats proved to be the KK-1, KK-2, KM-1, and KM-1M. The frequency of ejections was highest in the 1960s, 1970s, and 1980s a period associated with the size and diversity of the fleet, the introduction of new aircraft types, and the level of pilot training.

Keywords: safety, aviation, high-speed jet aircraft, ejection, injuries

Cite this article: Macander M: Successful Ejections in the Polish Air Force in 1951-2025. Pol J Aviat Med Bioeng Psychol 2025; 31(2): 17-27. DOI: 10.13174/pjambp. 25.05.2026.02

INTRODUCTION

The introduction of the ejection seat in the 1940s saved the lives of thousands of aircrew members [4,5]. Modern ejection seats are highly advanced and very effective evacuation systems, enabling the pilot to abandon the aircraft even from zero altitude and at near-zero forward speed. They are equipped with state-of-the-art mechanisms for stabilizing and immobilizing the pilot's body and limbs.

The ejection process is fully automated: once initiated, the seat travels along a programmed trajectory, and after approximately 2 seconds the pilot is already in the descent phase under a fully deployed parachute canopy. The latest designs, such as the Martin-Baker Mk-18 ejection seat used in the F-35, even allow the ejection procedure to be performed automatically without direct pilot input in situations of extreme in-flight danger [9].

In 1951, the Polish Air Force was equipped with the Yak-23 — the first jet military aircraft used in Poland and the first to be fitted with ejection seats. In the same year, the more modern MiG-15 was also acquired. Over the following decades, Poland — like other countries of the socialist bloc — procured combat aircraft exclusively from the USSR. These were primarily training and combat aircraft, bombers, and helicopters. At the same time, Polish aviation plants obtained licenses to produce the MiG-15, MiG-15bis, and MiG-17 [6,10,11]. The monopoly of Soviet equipment was not broken until 2007, with the purchase of F-16 aircraft.

This study analyzed all cases of ejection in Polish military aviation in 1951-2025, both those ending in the survival of the pilot and those in which the pilot perished. This paper is the first such detailed presentation of all ejections in Polish aviation. Issues concerning the physical injuries and mental disorders associated with such events will be presented in a separate paper.

METHODS

All cases of ejection recorded in the Polish Air Force in 1951-2025 were analyzed. Only ejections performed by military pilots in active service while carrying out combat or training missions were included in the study.

Cases involving civilians, accidental activations of the ejection seat during maintenance, and demonstration ejections performed in the late 1950s and early 1960s for television footage promoting rescue systems were excluded from the analysis. The collected material covered data on the type of aircraft, the type and generation of the ejection seat, the pilot's age, flight experience, and anthropometric characteristics, the flight parameters at the moment of the event, the type of mission performed, and the outcome of the ejection.

The study was conducted following approval by the Bioethics Committee of the Military Medical Academy in Łódź (decision no. 32/02 of 19 February 2002). The qualification scheme for the study material, comprising 210 pilots who survived the ejection process, is presented in Fig. 1.

The analysis of the material included:

a) a retrospective review of the aviation medical records of individual pilots held at the Military Institute of Aviation Medicine (WIML),
b) an analysis of the protocols of the State Aviation Aircraft Accident Investigation Commission (KBWL LP),
c) the author's own research (interviews with pilots, as well as questionnaires and psychological tests),
d) an analysis of the available specialist literature [1,2,3,8,14].

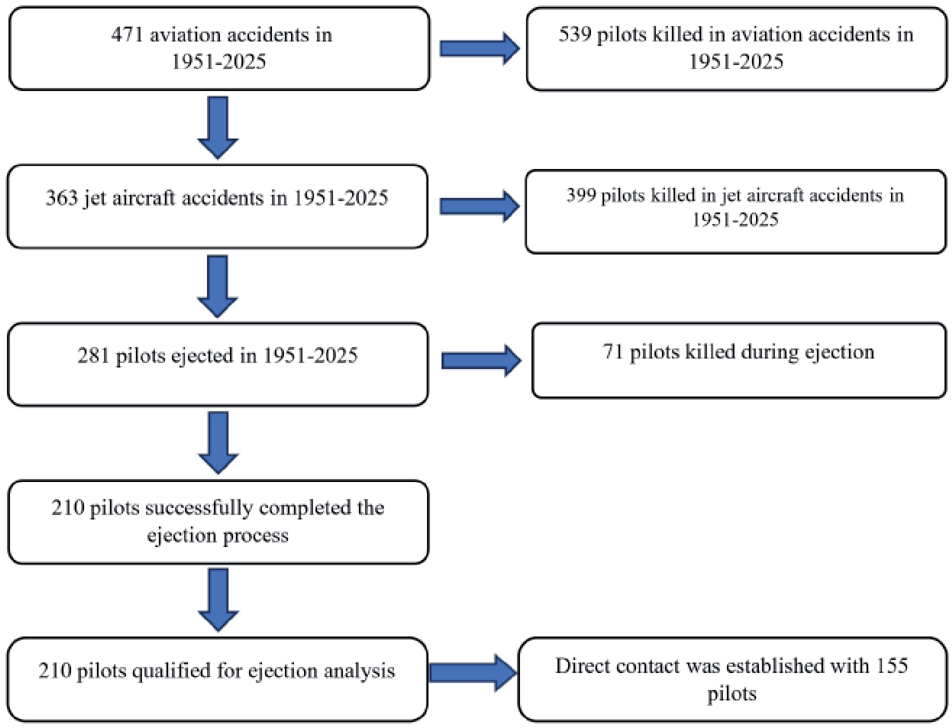
Direct contact was established with 155 pilots.

Each ejection case was analyzed in terms of the circumstances forcing the pilot to abandon the aircraft, the course of the ejection, the flight parameters, and the health-related consequences of the event. The analysis of ejections followed a causal-temporal order: first the characteristics of the pilots and the operational context, then the flight parameters (altitude/speed), next the taxonomy of ejection causes, and finally the integration with survival and injury rates as the "hard" indicators of the consequences.

The following operational definitions were adopted:

1) Pilot age: age in years at the time of the event (where available: min/mean/max).
2) Total flight hours: total number of flight hours up to the day of the event.
3) Flight hours on type: number of flight hours on the specific aircraft type from which the ejection was performed (or on a family of types).
4) Ejection altitude: above ground level or mean sea level — the literature is not always consistent; in the synthesis, the source units and context were preserved (e.g., ranges in feet).
5) Ejection speed: usually IAS (kn, km/h); less frequently TAS/Mach.
6) Subsonic vs. supersonic aircraft: classification according to design capability (fighter platforms and some attack aircraft — supersonic; advanced trainers and light attack aircraft — most often subsonic).

Fig. 1. Qualification scheme for the study material.



In accordance with the medical-board regulations in force in the PAF, injuries were classified as either minor or severe. On the basis of the assessment of the pilot's state of health, the medical board determined the period of unfitness for duty on a given aircraft type. In this paper, cases of successful ejection were subjected to detailed analysis.

Statistical Analysis

Statistical analysis was performed using descriptive statistics. For qualitative variables, counts and percentages were calculated, and the results were presented in tables in the form of frequency distributions. Numerical variables were presented in the form of category ranges, including age, length of service, flight hours, aircraft speed, and flight altitude. The analysis was retrospective and descriptive. No modeling of cause-and-effect relationships was performed. Flight safety indicators are additionally presented on an annual basis for 1951-2025.

RESULTS

281 ejections in military aviation were recorded during the analyzed period. The following sections present the structure of the events and the characteristics of the 210 pilots who survived the ejection process (Tab. 1).

Tab. 1. Outcome of the ejection process.

Ejections	Number	Percentage
Successful	210	74.73
Unsuccessful	71	25.27
Total	281	100.00

Of the 281 ejections, 210 (74.73%) ended with the pilot's survival, while 71 (25.27%) ended in death during the ejection process (Tab. 2).

Tab. 2. Ejections by aircraft speed characteristics and outcome of the process.

Aircraft type	Number	Percentage
Successful subsonic	129	45.91
Unsuccessful subsonic	49	17.43
Successful super-sonic	81	28.83
Unsuccessful super-sonic	22	7.83
Total	281	100.00

The majority of ejections were recorded from subsonic aircraft: 178 cases (63.34%), of which 129 were successful and 49 unsuccessful. On supersonic aircraft, 103 ejections (36.66%) were recorded, of which 81 ended with the pilot's survival and 22 with death. This is presented graphically in Fig. 2.

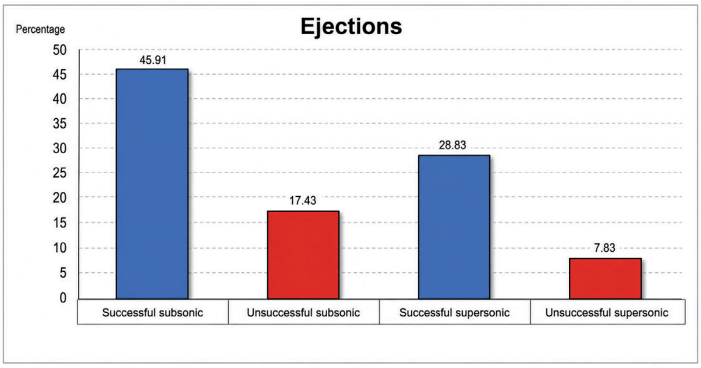


Fig. 2. Graphical breakdown of ejections by aircraft type and final outcome.

The largest number of ejections was recorded on the MiG-15 (85), MiG-21 (75), and MiG-17 (49). The highest number of deaths during ejection was found on the MiG-15 (27) and MiG-21 (18). In the analyzed material, no deaths were recorded during ejections from the MiG-19, MiG-23, or PZL-130 “Orlik”, while in the case of the PZL I-22 “Iryda” both ejections ended in death. The results of this analysis are presented in Tab. 3

Tab. 3. Successful and unsuccessful ejections by aircraft type.

Aircraft type	Number of ejections		
	Total	Successful	Unsuccessful
MiG-15	85	58	27
MiG-17	49	38	11
MiG-19	2	2	0
MiG-21	75	57	18
MiG-23	2	2	0
MiG-29	2	1	1
Su-7	8	7	1
Su-20	6	5	1
Su-22	8	7	1
TS-11 “Iskra”	32	25	7
PZL 130 “Orlik”	3	3	0
PZL I-22 “Iryda”	2	0	2
Ił-28	8	5	3
Total	281	210	71

Tables 4 and 5 present the age structure of the pilots who survived ejection. The largest group consisted of pilots born in 1930-1939 (33.8%). At the time of ejection, 127 pilots (60.48%) were 21-30 years old, and 60 (28.57%) were 31-40 years old.

Tab. 4. Age of pilots at the time of successful ejection.

Date of birth	Number of pilots	Percentage
1920-1929	17	8.09
1930-1939	71	33.80
1940-1949	48	22.86
1950-1959	47	22.39
1960-1969	20	9.53
1970-1980	6	2.85
1980-1990	1	0.48
Total	210	100.00

Tab. 5. Age of pilots at the time of successful ejection.

Age	Number of pilots	Percentage
< 20	3	1.42
21–30	127	60.48
31–40	60	28.57
41- 50	19	9.05
50 and more	1	0.48
Total	210	100.00

The military rank of the pilots at the time of successful ejection is presented in Table 6. The largest group consisted of first lieutenants (29.05%), second lieutenants (24.28%), and captains (20.47%); together, they accounted for 73.8% of the studied population.

Tab. 6. Military rank of pilots at the time of successful ejection.

Military rank	Number of pilots	Percentage
OCdt	20	9.53
WO	2	0.95
2Lt	51	24.28
1Lt	61	29.05
Capt.	43	20.47
Maj	19	9.05
LtCol	13	6.19
Col	1	0.48
Total	210	100.00

It is worth noting that 9.53% of the pilot population were students of the aviation academy (OSL, WOSL, WSOSP) in Dęblin and Radom.

Table 7 presents the length of service (military seniority) of the pilots who ejected. These results clearly show that more than half of the pilots (62.38%) had 1-10 years of service at the time of ejection, and 20 pilots (9.53%) had less than one year.

Tab. 7. Length of service of pilots at the time of ejection.

Length of service	Number of pilots	Percentage
< 1 year	20	9.53
1 < x <= 10	131	62.38
11 < x <= 20	52	24.76
21 < x <= 30	7	3.33
Total	210	100.00

The decade-of-commissioning range (Tab. 8) also shows that the largest number of pilots in the history of Polish military aviation ejected from the 1950-1960 commissioning cohort. This was more than 30% of all pilots.

Tab. 8. Decade-of-commissioning range of pilots at the time of successful ejection.

Commissioning	Number of pilots	Percentage
OCdt	20	9.53
1950 <= x < 1960	72	34.36
1961 <= x < 1970	48	22.82
1971 <= x < 1980	38	18.05
1981 <= x < 1990	25	11.91
1991 <= x < 2000	5	2.38
after 2000	2	0.95
Total	210	100.00

Table 9 presents the military pilot class at the time of successful ejection. The largest group consisted of pilots with class I (38.58%), followed by class III (24.76%) and class II (17.62%).

Tab. 9. Military pilot class at the time of ejection.

Pilot class	Number of pilots	Percentage
0	31	14.76
3	52	24.76
2	37	17.62
1	81	38.58
M	9	4.28
Total	210	100.00

The largest number of successful ejections was recorded under Day Visual Meteorological Conditions (DVMC) (128; 60.96%). Under nighttime conditions, a total of 54 ejections (25.71%) were performed, including 32 in Night Visual Meteorological Conditions (NVMC) and 22 in Night Instrument Meteorological Conditions (NIMC). These results are presented in Table 10.

Tab. 10. Atmospheric conditions at the time of successful ejection.

Ejection conditions	Number of ejections	Percentage
DVMC	128	60.96
DIMC	28	13.33
NVMC	32	15.23
NIMC	22	10.48
Total	210	100.00

Note. DVMC (Day Visual Meteorological Conditions); DIMC (Day Instrument Meteorological Conditions); NVMC (Night Visual Meteorological Conditions); NIMC (Night Instrument Meteorological Conditions)

Tables 11-13 present the total flight hours of pilots at the time of ejection, the flight hours on type, and the final flight hours after the end of flying service. At the time of ejection, 82 pilots (39.06%) had total flight hours of up to 500, and 58 (27.61%) had 501-1000 hours. Flight hours on type of up to 500 were found in 160 pilots (76.20%), while above 1000 hours were found in 10 pilots (4.76%).

Tab. 11. Total flight hours of pilots at the time of successful ejection.

Total flight hours	Number of pilots	Percentage
0 < x <= 500	82	39.06
501 < x <= 1000	58	27.61
1001 < x <= 2000	55	26.19
2001 < x <= 3000	14	6.66
3001 < x <= 4000	1	0.48
Total	210	100.00

Tab. 12. Flight hours on aircraft type at the time of successful ejection.

Flight hours on aircraft type	Number of pilots	Percentage
0 < x <= 500	160	76.20
501 < x <= 1000	40	19.04
1001 < x <= 1500	9	4.28
1501 < x <= 2000	1	0.48
Total	210	100.00

Final flight hours (Tab. 13) in the 1001-2000 hours range was reached by 110 pilots (52.39%), and 2001-3000 hours by 42 pilots (20.00%).

Tab. 13. Final flight hours of pilots who ejected

Final flight hours	Number of pilots	Percentage
0 < x <= 1000	35	16.67
1001 < x <= 2000	110	52.39
2001 < x <= 3000	42	20.00
3001 < x <= 4000	17	8.09
4001 < x <= 5000	3	1.42
5001 < x <= 6000	2	0.95
6001 < x <= 7000	1	0.48
Total	210	100.00

Table 14 presents the qualification of events according to the KBWL aviation event classification. The most frequently recorded categories were F (62; 29.53%) and B (59; 28.10%), followed by O (32; 15.24%) and It (31; 14.76%). Together, these four categories accounted for 87.63% of the analyzed cases.

Tab. 14. Qualification of the event according to the KBWL classification.

Qualification	Number of ejections	Percentage
B – Human Error (Human Factor)	59	28.10
E – Environment	11	5.23
O – Organization	32	15.24
D – Documentation	3	1.42
Z – Management	1	0.48
It – Other Technical (Technical/Aircraft)	31	14.76
R – Repair / Maintenance	10	4.76
F – Fatigue	62	29.53
X – Other / Unclassified	1	0.48
Total	210	100.00

The largest number of ejections was performed at aircraft speeds of 251-500 km/h (127; 60.48%), followed by 501-750 km/h (51; 24.28%), as illustrated in Tab. 15.

Tab. 15. Aircraft speed at the time of successful ejection.

Aircraft speed	Number of successful ejections	Percentage
0 < x <= 250	14	6.66
251 < x <= 500	127	60.48
501 < x <= 750	51	24.28
751 < x <= 1000	18	8.58
Total	210	100.00

Most often, ejection was initiated at altitudes of 0-500 m (55; 26.19%) and 1001-2000 m (52; 24.76%). In total, 99 ejections (47.14%) were performed below 1000 m.

Tab. 16. Aircraft altitude at the time of successful ejection.

Altitude range	Number of ejections	Percentage
0 <= x < 500	55	26.19
501 <= x < 1000	44	20.96
1001 <= x < 2000	52	24.76
2001 <= x < 3000	36	17.15
3001 <= x < 4000	13	6.19
4001 <= x < 5000	5	2.38
5001 <= x < 6000	2	0.95
6001 <= x < 8000	3	1.42
Total	210	100.00

Table 17 presents all types of ejection seats from which military pilots safely ejected. The largest number of ejections was performed using the KK-1 seat installed in MiG-15 and MiG-15bis family aircraft, followed by the KK-2 seat used in MiG-17 and MiG-19 family aircraft [12,13]. These seats accounted for almost 50% of all seats used in ejections. An important place in this list is held by the SK seat, used in the aircraft of Polish design and production — the TS-11 "Iskra". This aircraft was the basic type for the flight training of officer cadets at the aviation academy in Dęblin.

Tab. 17. Type of ejection seat used during successful ejection.

Seat type	Number of successful ejections	Percentage
KK-1	63	30.00
KK-2	40	19.04
SK-1	8	3.81
KM-1	26	12.38
KM-1M	25	11.91
KS-3	1	0.48
KS-4	11	5.23
SK	25	11.91
M-B	3	1.43
K-36	8	3.81
Total	210	100.00

Table 18 presents the types and versions of aircraft from which successful ejections were performed. Successful ejections were recorded on 28 types and versions of aircraft. Most cases involved the TS-11 "Iskra" (25; 11.91%), Lim-5 (24; 11.42%), Lim-2 (20; 9.52%), and MiG-21 PFM (15; 7.14%). When the variants are summed, the most numerous were the MiG-15/Lim/SBLim and MiG-21 families.

Tab. 18. Aircraft type from which a successful ejection was performed.

Aircraft type	Number of successful ejections	Percentage
MiG-15	12	5.71
Lim-1	6	2.85
Lim-2	20	9.52
Lim-5	24	11.42
Lim-6	14	6.66
UTIMiG-15	2	0.96
SBLim-1	5	2.38
SBLim-2	13	6.19
MiG-19	2	0.96
MiG-21 F-13	1	0.48
MiG-21 PF	4	1.90
MiG-21 PFM	15	7.14

Aircraft type	Number of successful ejections	Percentage
MiG-21M	8	3.81
MiG-21MF	12	5.71
MiG-21R	3	1.43
MiG-21Bis	10	4.76
MiG-21U, MiG-21UM	4	1.90
MiG-23	2	0.96
MiG-29	1	0.48
Su-7BM	1	0.48
Su-7BKŁ	2	0.96
Su-7U	4	1.90
Su-20	5	2.38
Su-22	5	2.38
Su-22UM3K	2	0.96
Ił-28	5	2.38
PZL-130 “Orlik”	3	1.43
TS-11 “Iskra”	25	11.91
Total	210	100.00

Table 19 presents the annual flight safety indicators for the years 1951-2025. The highest number of serious accidents (WC) was recorded in 1951 (49). High values of the serious-accident rate (WWC) were observed primarily in the first decades of the analyzed period, while no serious accidents were recorded in 2007, 2014, 2015, 2020, 2021, or 2022.

DISCUSSION

The aim of this study was to describe all cases of ejection in Polish military aviation in 1951-2025, both those ending in pilot survival and those resulting in death. In line with this objective, the discussion of the results focuses primarily on the scale of the phenomenon, the characteristics of the aircraft, the profile of the pilots, the flight parameters, and the qualification of the events.

Tab. 19. Flight safety indicators for the Aviation of the Polish Armed Forces from 1951.

Year	Flight hours, total	Number of serious accidents (WC)			Indicator Serious-accident rate (WWC)
		Catastrophe (K)	Incident (A)	Total	
1951	90505	11	38	49	54.14
1952	82757	14	19	33	39.88
1953	94340	15	16	31	32.86
1954	99500	18	12	30	30.15
1955	116015	14	17	31	26.72
1956	115652	15	9	24	20.75
1957	118347	17	18	35	29.57
1958	129462	18	14	32	24.72
1959	151865	17	19	36	23.71
1960	156500	14	12	26	16.61
1961	175784	19	18	37	21.05
1962	178032	13	14	27	15.17
1963	146430	15	14	29	19.80
1964	135943	17	8	25	18.39
1965	140515	13	5	18	12.81
1966	144752	14	10	24	16.58
1967	148437	10	9	19	12.80
1968	138387	14	9	23	16.62
1969	153846	11	8	19	12.35
1970	134744	5	9	14	10.39
1971	139654	5	11	16	11.46
1972	155602	9	10	19	12.21
1973	159491	6	7	13	8.15
1974	158594	4	4	8	5.03
1975	162491	7	17	24	14.77
1976	156717	8	12	20	12.76
1977	151922	8	9	17	11.19

Year	Flight hours, total	Number of serious accidents (WC)			Indicator Serious-accident rate (WWC)
		Catastrophe (K)	Incident (A)	Total	
1978	173483	9	7	16	9.22
1979	170731	4	8	12	7.02
1980	170344	4	11	15	8.81
1981	159781	12	8	20	12.52
1982	182376	7	13	20	10.97
1983	170897	7	5	12	7.02
1984	163608	5	8	13	7.95
1985	165232	6	10	16	9.68
1986	170272	8	9	17	9.98
1987	162858	6	8	14	8.60
1988	162841	5	7	12	7.37
1989	138037	3	7	10	7.24
1990	115415	4	9	13	11.26
1991	94873	1	9	10	10.54
1992	85510	2	3	5	5.85
1993	88083	0	3	3	3.41
1994	97120	2	3	5	5.15
1995	86860	3	4	7	8.06
1996	73517	2	7	9	12.24
1997	70635	3	3	6	8.49
1998	65343	3	1	4	6.12
1999	68244	0	4	4	5.86
2000	67870	1	1	2	2.94
2001	57677	3	3	6	10.38
2002	46823	0	1	1	2.14
2003	46646	1	2	3	6.43
2004	47603	1	1	2	4.24
2005	49009	1	1	2	4.08
2006	50763	1	2	3	5.91
2007	53866	0	0	0	0
2008	57968	1	1	2	3.45
2009	54641	2	2	4	7.32
2010	54231	2	3	5	9.22
2011	63174	0	2	2	3.17
2012	63079	0	1	1	1.58
2013	64403	0	2	2	3.10
2014	64542	0	0	0	0
2015	64714	0	0	0	0
2016	65607	1	0	1	1.52
2017	63470	1	3	4	6.30
2018	61402	1	2	3	4.88
2019	59883	0	2	2	3.34
2020	61593	0	0	0	0
2021	59828	0	0	0	0
2022	62930	0	0	0	0
2023	62401	0	1	1	1.60
2024	52534	1	0	1	1.90
2025	54547	1	0	1	1.83

281 ejections were recorded in the analyzed material, of which 210 ended in pilot survival (74.73%) and 71 in death during the ejection process (25.27%) (Tab. 1). These data confirm the high effectiveness of the rescue procedure, but at the same time indicate that ejection remains a borderline event burdened with a substantial risk of fatal failure.

In terms of aircraft speed characteristics, most events involved subsonic aircraft: 178 cases, or 63.34% of the total, including 129 successful and 49 unsuccessful ejections (Tab. 2; Fig. 2). On supersonic aircraft, 103 ejections were recorded, or 36.66% of the total, including 81 successful and 22 unsuccessful (Tab. 2; Fig. 2). When recalculated within both groups, survival applied to 72.47% of ejections from subsonic aircraft and 78.64% of ejections from supersonic aircraft (Tab. 2). The mere classification of an aircraft as subsonic or supersonic should therefore not be interpreted as a stand-alone risk indicator, since the outcome of an ejection was also influenced by the operational era, seat type, mission profile, altitude, speed, and the nature of the emergency situation.

An analysis of the aircraft types shows a concentration of ejections in aircraft families intensively operated in successive decades of Polish military aviation. The largest number of events was recorded on the MiG-15 (85), MiG-21 (75), and MiG-17 (49), while the highest number of deaths was found on the MiG-15 (27) and MiG-21 (18) (Tab. 3). Among successful ejections, the most numerous were the TS-11 “Iskra” (25), Lim-5 (24), Lim-2 (20), and MiG-21 PFM (15) (Tab. 18). These results should be interpreted with caution, since the number of ejections from a given aircraft type is not equivalent to the per-unit risk without reference to the number of operated aircraft, the global flight hours of the given type, and the profile of the missions performed.

The age structure of the pilots who survived ejection indicates that these events primarily concerned the age range typical of active operational service. The largest group consisted of pilots aged 21-30 (127; 60.48%), followed by those aged 31-40 (60; 28.57%); together, these groups comprised 187 pilots, i.e. 89.05% of the survivors (Tab. 5). In terms of birth cohorts, the largest share consisted of pilots born in 1930-1939 (71; 33.80%), reflecting the historical structure of personnel during the periods with the highest number of events (Tab. 4). These data do not justify the claim that ejection concerns only the youngest or least experienced pilots; rather, they indicate a concentration of events in the group most intensively involved in training and operational flying.

The results regarding military rank and length of service confirm the link between ejections and the early and middle stages of an aviation career. First lieutenants, second lieutenants, and captains together accounted for 155 individuals, i.e. 73.80% of the pilots who survived ejection (Tab. 6). In addition, 131 pilots (62.38%) had 1-10 years of service, and 20 (9.53%) less than one year (Tab. 7). This observation has training implications: the greatest emphasis should be placed on reinforcing emergency procedures, recognizing the limits for further attempts to save the aircraft, and making the decision to eject — among pilots in the first years of service, but without overlooking more experienced pilots. As Kubiak [7] notes, experienced pilots, fearing a “loss of face,” do not admit their own weaknesses, which can lead to tragic consequences. An ideal example of this situation is the crash of the Su-22M3K on 30 January 1990 in Mirosławiec, piloted by the regiment commander [3,14].

Military pilot class does not indicate that ejections were limited to personnel with low qualifications. The largest group consisted of class I pilots (81; 38.58%), followed by class III (52; 24.76%) and class II (37; 17.62%) (Tab. 9). This distribution should be interpreted in connection with exposure to flights and missions, rather than as a simple measure of the susceptibility of a given pilot class to ejection.

Data on flight hours are particularly important for interpreting pilot experience. At the time of successful ejection, 82 pilots (39.06%) had total flight hours of up to 500, and 58 (27.61%) had 501-1000 hours; thus, a total of 140 pilots (66.67%) fell within the up to 1000 total flight hours range (Tab. 11). An even more pronounced concentration concerned the flight hours on type: 160 pilots (76.20%) had up to 500 hours on type, and 40 (19.04%) had 501-1000 hours; in total, 200 pilots (95.24%) had no more than 1000 hours on type (Tab. 12). This result supports the conclusion that preparation for emergency situations should be strongly profiled to a specific aircraft type, especially during the pilot’s initial period of operating that type.

Final flight hours show that ejection did not necessarily mean the end of an aviation career. After ending their service, 110 pilots (52.39%) achieved a final flight-hour count of 1001-2000 hours, and 42 (20%) of 2001-3000 hours (Tab. 13). These data indicate that a significant proportion of pilots continued training or flying service after ejection, which underscores the importance of proper aviation medical qualification, psychophysical monitoring, and a gradual return to flying duties.

Meteorological conditions and the time of flight indicate that most successful ejections took place under daytime visual conditions (DVMC) (128; 60.96%) (Tab. 10). Nighttime ejections covered a total of 54 cases, including 32 under NVMC and 22 under NIMC, i.e. 25.71% of the studied group (Tab. 10). This does not automatically mean a lower risk during the day, since this distribution may reflect the structure of flight hours and the larger number of flights performed under daytime conditions.

The qualification of events according to KBWL points to the multifactorial nature of the situations leading to ejection. The most frequently indicated factors were fatigue F (62; 29.53%) and human error B (59; 28.10%); together, these two categories covered 121 cases, i.e. 57.63% of the studied group (Tab. 14). A significant share was also held by organization O (32; 15.24%) and other technical factors It (31; 14.76%) (Tab. 14). In total, categories F, B, O, and It accounted for 184 cases, i.e. 87.63% of the analyzed events (Tab. 14). These results argue in favor of a systemic approach to safety, in which the pilot's decision is only one of the elements in the sequence leading to ejection.

The flight parameters at the moment of ejection confirm the importance of time pressure. The largest number of successful ejections was performed at speeds of 251-500 km/h (127; 60.48%), followed by 501-750 km/h (51; 24.28%) (Tab. 15). At the same time, 99 ejections (47.14%) were performed below 1000 m, and 151 (71.91%) below 2000 m (Tab. 16). This means that in many situations the pilot made the decision under conditions of limited altitude and a short time available to assess the effectiveness of further attempts to save the aircraft.

The distribution of ejection seat types is consistent with the historical structure of the operated aircraft. The most frequently used seats were the KK-1 (63; 30%) and KK-2 (40; 19.04%); together they accounted for 103 successful ejections, i.e. 49.04% of the analyzed group (Tab. 17). Other significant groups consisted of the KM-1 (26; 12.38%), KM-1M (25; 11.91%), and SK (25; 11.91%) seats (Tab. 17). However, without data on the number of flights, the number of installed seats, and the period of operation, these values should not be treated as a direct measure of the effectiveness of the individual designs.

The annual results indicate a clear change in the state of flight safety over a long historical perspective. The highest number of serious accidents was recorded in 1951 (49), and high accident-rate values occurred mainly in the first decades of the analyzed period, e.g. 54.14 in 1951 and 39.88 in 1952 (Tab. 19). In 2007, 2014, 2015, 2020, 2021, and 2022, no serious accidents were recorded, which indicates an improvement in systemic safety, although isolated events in subsequent years confirm that the risk has not been entirely eliminated (Tab. 19).

In summary, the material presented is epidemiological in nature, and its greatest value lies in its historical completeness and in the ability to identify areas requiring continuous improvement: type-specific training, the decision to eject, fatigue management, the control of organizational factors, and the documentation of event parameters.

CONCLUSIONS

Based on the analysis conducted, the following conclusions were formulated:

1. In 1951-2025, 281 ejections were recorded in Polish military aviation; 210 ended in pilot survival and 71 in death, which confirms the high effectiveness of ejection as a rescue procedure but also the substantial risk of fatal failure;
2. Ejections were concentrated in aircraft types intensively operated historically, especially the MiG-15, MiG-21, and MiG-17. However, the interpretation of risk for individual aircraft types requires referencing the number of events to flight hours, the number of operated aircraft, and the period of use;
3. The largest group of pilots who survived ejection consisted of pilots aged 21-40, holding the ranks of second lieutenant, first lieutenant, and captain, and with 1-10 years of service. This result indicates the need for particularly intensive decision-making training and emergency procedures during the first years of operational service;
4. Most pilots had relatively few flight hours on aircraft type: 160 individuals, i.e. 76.20%, had up to 500 hours on type. For this reason, training in emergency aircraft egress and in special-situation procedures should therefore be strongly linked to the specific aircraft type and to the pilot's stage of adaptation to that type;
5. The dominant parameters of successful ejections were speeds of 251-500 km/h and altitudes below 1000 m or 2000 m. These data indicate that pilot preparation should

emphasize the rapid recognition of no-escape situations, unambiguous decision thresholds, and action under time pressure at low altitude;

6. The most frequent KBWL event qualifications concerned fatigue, human error, organization, and technical factors. For this reason, the prevention of ejections and their consequences should encompass — in parallel — fatigue management, decision-making training, organizational oversight, technical maintenance, and the standardization of event-parameter documentation.

AUTHORS' DECLARATION

Study Design: Marian Macander. **Data Collection:** Marian Macander. **Manuscript Preparation:** Marian Macander. The author declares that there is no conflict of interest.

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