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ORIGINAL ARTICLE

Dusseldorf autopsies 1914–1918

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Abstract

This article presents an evaluation of 4255 autopsy cases recorded at the Dusseldorf Pathology Institute in the years 1914 to 1918. Diagnoses were coded according to the International Classification of Diseases, 10th edition (ICD-10), and the contemporaneous history of the Pathology Institute was reviewed. We found a proportion of 54.1% adults and 45.5% children in our cohort, with a male predominance of 63.9%. Infectious diseases account for the majority of all cases (35.5%), among which tuberculosis is the most frequent, reported in 22.7% of all cases. The second largest diagnosis group is the one of respiratory diseases (16.9%), including pneumonia and influenza. Cases of perinatal conditions account for 10.5% of the collective, followed by neoplasms, injuries, intoxications, or external causes, each representing 6.6%. Cardiovascular diseases account for 5.3% of the cases. In 4.4% of the pediatric and 0.8% of adult cases, a diagnosis of the ICD-10 group "nutritional and endocrine diseases" was made. No diagnosis of hunger edema is reported. Parts of the cohort are 272 war pathology cases (6.4%), made up by soldiers who mainly had died of shotgun injuries. The whole cohort represents the disease spectrum of a German big city population at times of World War I. The data exemplify the epidemiological shift that has occurred in industrialized countries over the last 100 years, from infectious to neoplastic and cardiovascular diseases.

Keywords Autopsy · Dusseldorf · First World War · Tuberculosis · Helene Kloss

Introduction

Clinical autopsy has been worldwide in decline over the past decades [1, 2]. German university institutes of pathology, for instance, reported a median autopsy rate of 8.6% for the year 2014, and at some communal or private pathology institutes in Germany autopsy activities have ceased [3]. The significance of the autopsy in medical progress, the causes and consequences of its decline, and the possibilities for a revival of the clinical autopsy have been discussed in the medical literature [4]. An important task of the autopsy is the collection of material, such as gross specimens, photographs, histology slides, or autopsy reports. Major institutions all over the world dispose of huge collections of autopsy reports which have been an inexhaustible source for scientific studies [5]. Autopsy reports do not only represent records of individual medical cases and fates; in the collective, they are witnesses of the time. The value of autopsy reports as a medico-historical source has been exemplified in Virchow-research [6], and in investigations on the history of individual institutions [7]. Commemorating the centenary of the end of the First World War, we carried out a retrospective study on the autopsy cases performed at the Dusseldorf pathology institute in the years 1914 to 1918. With this study, we intend to contribute to the historiography of pathology, in a context of discipline history, in a biographical context, and in an epidemiological context. We make an effort to demonstrate that the autopsy is not only a specific medical or pathological issue but, beyond that, also a cultural property.

Pathological anatomy in Dusseldorf

Pathological anatomy had been established as a clinical-theoretical medical specialty in the second half of the

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nineteenth century in Germany, with constitution of academic chairs at all major universities [8–10]. In the city of Dusseldorf, often labeled as the desk of the industrial Ruhr area, a pathology institute was established relatively late, in 1907, as part of the then founded Academy of Practical Medicine. A university was founded in Dusseldorf after the Second World War, named after the most famous son of the city, Heinrich-Heine (1797–1856). Martin Benno Schmidt (1863–1949) was the first director of the Dusseldorf pathology institute. He left in 1913 to become chair of pathology at Zurich University and later in Wurzburg [11]. His successor was Otto Lubarsch (1860–1933) who was a prolific medical author, with a more encyclopedic than original focus. As a young man, he had converted from Judaism to Protestantism. He was a politically active professor, as a co-founder of the notorious Pan German League and later as founding member of the Fatherland Party. Lubarsch left Dusseldorf in 1913 to take over the pathology chair at Kiel University [12]. Later, he became Virchow's second successor in Berlin. He died peacefully in the year of the National Socialists' seizure of power.

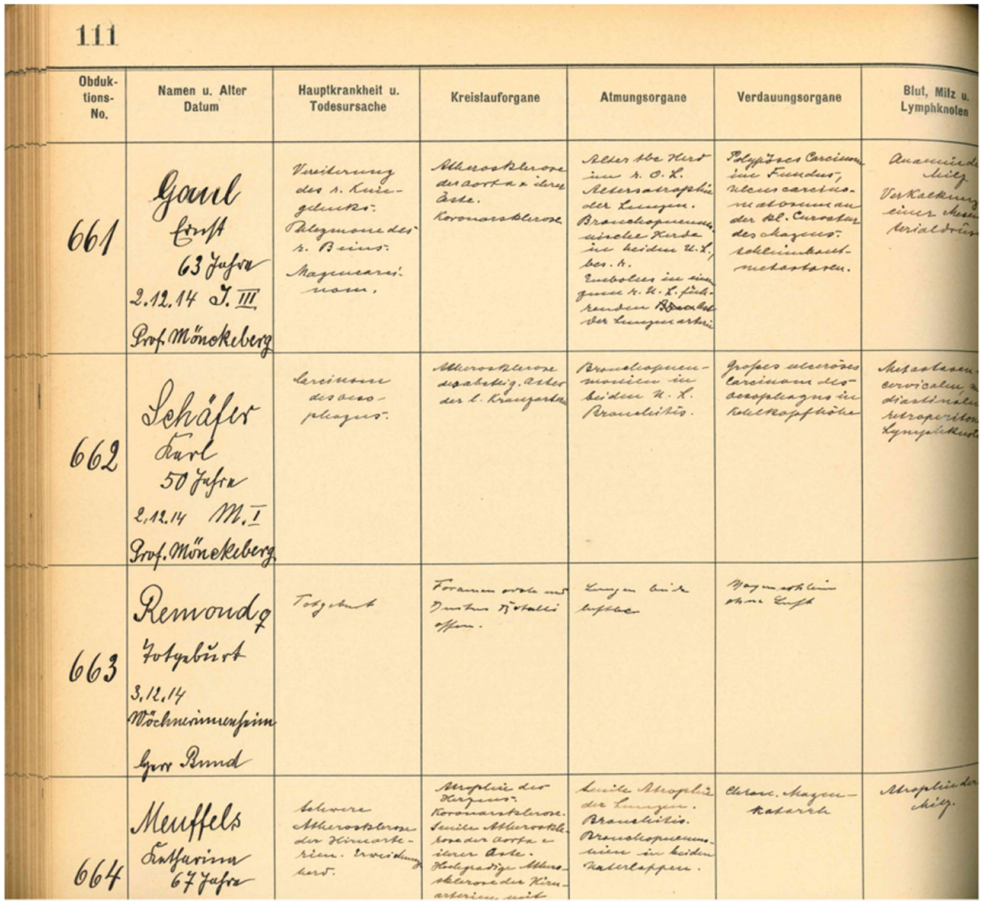
The next director of the institute of pathology in Dusseldorf was Johann Georg Mönckeberg (1877–1925). His name is used eponymously for the vascular disease known as arterial media sclerosis [13, 14]. An offspring of the Hamburg upper class, Mönckeberg, graduated in Strassburg, obtained his doctoral degree in medicine in Bonn, and started his career in pathology at Hamburg University. He left Dusseldorf in October 1916, in the midst of the Great War, to take over the pathology chair at Strassburg University. When Alsace Lorraine fell back to France in 1919, Mönckeberg continued his career in Bonn and Tübingen. Hermann Beitzke (1875–1953) became Mönckeberg's successor in Dusseldorf and started service in April 1917. He was a specialist for tuberculosis [9]. Together with Beitzke, the pathologist Helene Kloss (1887–1977) came to Dusseldorf. Kloss was Swiss, had studied medicine in Switzerland, and obtained her doctorate at the University of Bern with a dissertation she had previously worked up in Bonn. She had worked as voluntary assistant pathologist in Bonn and Berlin, then went back to Switzerland where she was a coworker of Hermann Beitzke's in Lausanne [15]. She followed him to Dusseldorf in 1917 and returned again to Switzerland in late 1919, to become chief pathologist at a communal hospital in Luzern, Switzerland [15]. In 1922, Beitzke moved to Graz, Austria, where he spent the rest of his professional career [11].

Material and methods

The autopsy reports of the years 1914 to 1918 represent the main source of this work. They are available in the institute's archive as autopsy books and protocols. The autopsy books are in landscape format, with pre-printed columns, comprising a consecutive autopsy number, name and age of the deceased individual, "main diseases and cause of death," and the main pathological findings sorted by organ systems (Fig. 1). The autopsy protocols are pre-printed foolscap-sized four-page leaflets in upright format, one for each case, collected and bound to hard-backed books. On the front leaf of the autopsy protocol, the main pathological findings (rubric "anatomical diagnosis") are listed hierarchically (Fig. 2). All autopsy reports were systematically examined, focusing on the following parameters: gender, age, diagnosis, the pathologist who performed the autopsy, and the referring hospitals. Individuals under the age of 16 were defined as children. An explicit cause of death was not specified in the autopsy reports. Under the category "main diseases and cause of death," a disease, and in some instances more than one diagnosis, was listed. The diagnosis listed under the corresponding category in the autopsy book, which is identical to the diagnosis listed first in the autopsy protocol, was chosen as the cause of death for our evaluation. In cases with more than one diagnosis listed in the autopsy book, we referred to the diagnosis listed first in the autopsy protocol. All other pathological diagnoses were transferred into a database. Diagnoses were encoded according to the International Classification of Diseases, 10th Revision (ICD-10) [16]. We mainly refer to the following IDC-10 diagnosis groups (DG, Roman numerals): DG I: Certain Infectious and Parasitic Diseases; DG II: Neoplasms; DG IV: Endocrine, Nutritional, and Metabolic Diseases; DG IX: Diseases of the Circulatory System; DG X: Diseases of the Respiratory System; DG XVI: Certain Conditions Originating in the Perinatal Period; and DG XIX (Injury, poisoning, and certain other consequences of external causes. Following the ICD-10-guidelines, we encoded influenza and pneumonia under Diseases of the Respiratory System (DG X), although influenza is a virus disease, and pneumonia occurs in most cases due to infection. Meningitis (DG VI) or puerperal sepsis (DG XV), as other examples, is coded organ-specific as well rather than under DG I [17]. The 272 cases of military autopsies that belong to our cohort were on the one hand included in the overall evaluation and on the other hand evaluated separately in an own chapter.

Results

In the years 1914 to 1918, a total of 4255 autopsies had been performed at the Dusseldorf pathology institute. Over the course of the Great War, autopsy numbers rose from 714 cases in 1914 to 914 in 1918. At a mean rate of 851 autopsies per year, three to four autopsies were performed each day. Usually, bodies were dissected 1 day post-mortem. The dead bodies came from the huge hospital complex to which the institute still belongs today, as well as from other nearby



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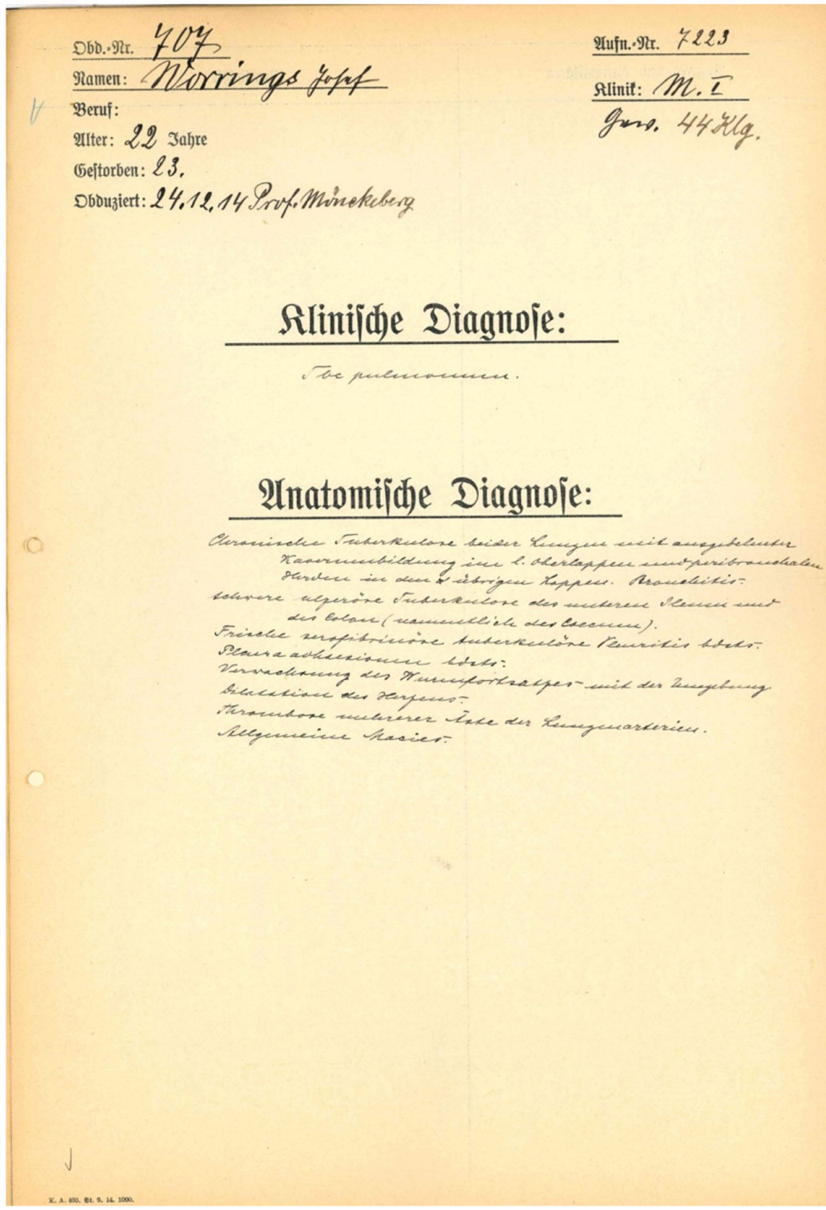
Obduktions-No.	Namen u. Alter Datum	Hauptkrankheit u. Todesursache	Kreislauforgane	Atmungsorgane	Verdauungsorgane	Blut, Milz u. Lymphknoten
661	Gaul Ernst 63 Jahre 2.12.14 J. III Prof. Mönckeberg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
662	Schäfer Karl 50 Jahre 2.12.14 M. I Prof. Mönckeberg	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
663	[illegible] Totgeburt 3.12.14 Wöchnerinnenheim [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
664	Meuffels Katharina 67 Jahre	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fig. 1 Scan of an autopsy book page

hospitals. Close to 86% of the bodies came from departments of today's Dusseldorf University Hospital, mainly from the departments of Internal Medicine, the Children's Clinic, and from the Department of Infectious Diseases. In total, 1515 (35.6%) female and 2719 (63.9%) male bodies were dissected at the Dusseldorf Institute in the years 1914 to 1918; in 0.5% of cases, gender remained unknown. Of all autopsies, 54.1% had been done on the bodies of adults, and 45.5% on the bodies of children, including 365 cases of stillbirths (8.6%); in the remaining 0.4% of cases, the age of the deceased was not reported. The children included in the cohort had died mainly during infancy or early childhood, adults mostly in their 20s. Of the deceased, 2% had reached an age of 70 to 79 years; 0.4% had died at an age over 80 years. The autopsy rate (bodies dissected/bodies admitted) at the Dusseldorf Pathology Institute was 83.3% in 1914/1915, 93.1% in 1915/1916 as well as in 1916/1917, 85.5% in 1917/1918, and 82.8% in 1918/1919 [18]. The postmortem reports do not refer to histopathological findings. A minority of all cases (0.5%) is missing or does not yield data. Mönckeberg performed 1140 autopsies from January 1914 to October 1916, being the busiest pathologist in that period. Temporarily, he was the only doctor present at the institute [11]. Heinrich Müller (1884–1972), the deputy director (prosector) of the institute, is runner-up with 949 autopsies, with a gap from July 1914 to October 1916. Then, he replaced the director at the Dusseldorf Institute until April 1917 when Herrmann Beitzke started service as Mönckeberg's successor [11]. Helene Kloss performed 797 autopsies from April 1917 to December 1918, while Beitzke did 143 autopsies at the institute in the same period. How many surgical specimens or biopsies were submitted to the institute at this time could not be determined.

Diagnosis group I: infectious diseases

Infectious diseases are the main cause of death in our cohort, comprising 35.5% of cases (Fig. 3). Among these, tuberculosis is the largest fraction (48.7%), being the cause of death in 737 cases, 535 adults, and 196 children. Together with an additional 224 cases with reported residuals of this disease, 22.7% of our cases have findings of tuberculosis. Over the course of the First World War, tuberculosis cases have increased absolutely and relatively, from 82 cases (11.6%) in 1914 to 187 (20.5%) cases in 1918, with a stepped increase from 1915 to 1917 (Fig. 4)



Obd.-Nr. 707
Namen: Worrings Josef
Beruf:
Alter: 22 Jahre
Gestorben: 23.
Obduziert: 24.12.14 Prof. Mönckeberg

Aufn.-Nr. 7223
Klinik: M. I
Gew. 44 Klg.

Klinische Diagnose:

Tbc pulmonum.

Anatomische Diagnose:

Chronische Tuberkulose beider Lungen mit ausgedehnter Kavernenbildung im l. Oberlappen und peribronchialen Herden in den übrigen Lappen. Bronchitis.
Schwere ulceröse Tuberkulose des unteren Ileum und des Colon (namentlich des Coecum).
Frische serofibrinöse tuberkulöse Pleuritis bds.
Pleura adhaesionum bds.
Verwachsung des Wurmfortsatzes mit der Umgebung.
Dilatation des Herzens.
Thrombose mehrerer Äste der Lungenarterien.
Allgemeine Macies.

Fig. 2 Scan of a front page of an autopsy protocol. Mönckeberg performed an autopsy on Christmas Eve 1914, the day of the "small truce in the Great War"

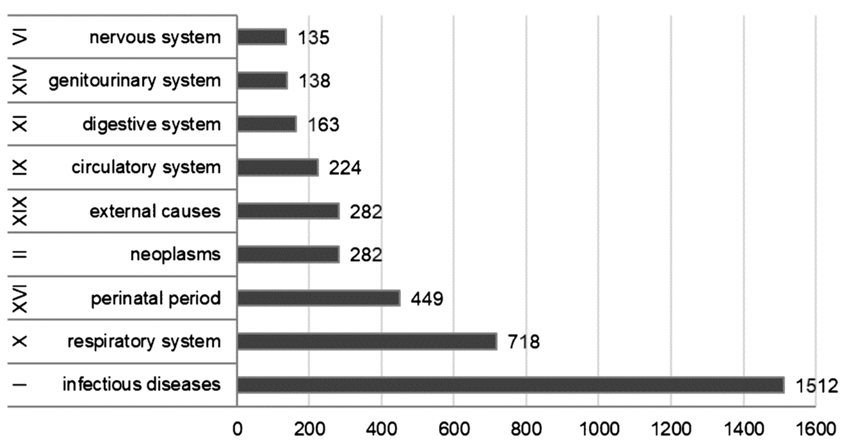


Fig. 3 The autopsy cohort subdivided into the ICD-10 diagnosis groups

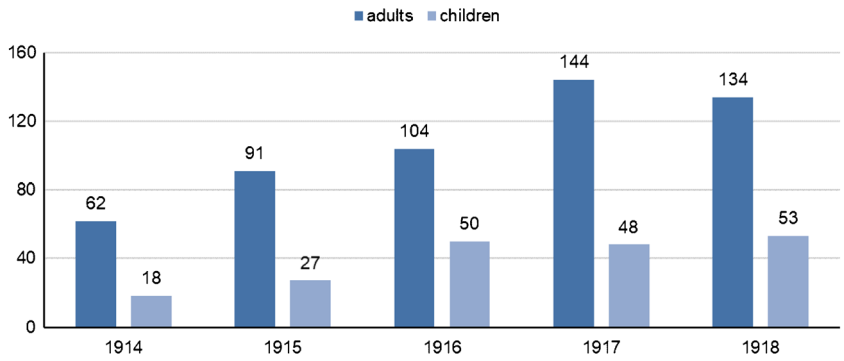


Fig. 4 Tuberculosis as cause of death

and practically stagnation between 1917 and 1918. In the vast majority (95.3%) of tuberculosis cases, affection of the lung is reported, in 70% lymph node affection; in 60.8% of tuberculosis cases, involvement of the gastrointestinal tract is recorded; and in 40.5% urogenital involvement including the kidneys. Few cases (0.5%) of cutaneous tuberculosis are reported. The average age of adults who had died of tuberculosis was 35.5 years; children had died of tuberculosis at an average age of 5.4 years. Diphtheria is second among infectious diseases in our cohort (13.4%), followed by scarlet fever and pertussis. Gastrointestinal infections make up 11.2% of the cases in diagnosis group I, including two cases of typhoid fever in soldiers. Venereal diseases, mainly syphilis, are reported in 6.7% of cases, virus diseases in 3.5%.

Diagnosis group II: neoplasms

Two hundred eighty-two cases of neoplastic diseases are reported, with 260 malignancies; 183 occurred in males and 77 in females. Among the malignancies, gastrointestinal neoplasms are the most frequent (47.7%), followed by neoplasms of the female reproductive organs (9.2%) and hematopathology cases (8.5%). Tumors of the central nervous system (CNS) and the eye account for 5.4% in diagnosis group II, at the same level as oropharyngeal tumors. Malignancies of the respiratory/intrathoracic organs and of the urinary system represent 5% each. Breast cancer was diagnosed in 2.3% of the tumor cases. Furthermore, malignant neoplasms of the soft tissues (2.3%), the male genital organs (1.9%), bones and joints (1.5%), the endocrine system (1.2%), and of the skin (0.8%) are reported. In females, 31.2% of the malignancies relate to the genital system, 29.9% to the digestive organs, and 10.4% to the CNS/eye. Breast cancer and urinary tract cancer comprise 9.1% of malignant tumors in females. In males, 55.2% malignancies of the digestive tract are documented, besides 11.4% hematopathological cases, followed by oropharyngeal tumors (6.5%) and intrathoracic tumors (5.5%).

Diagnosis group IV: nutritional and endocrine diseases

A percentage of 2.35 belong to this diagnosis group, with a proportion of 0.8% among adults and 4.1% among children. In children, the main diagnosis in this group is "atrophy" or "paidatrophy," followed by "rachitis" (rickets) and "nutritional disorder," without further specification. In five cases, a diagnosis of "status thymicolymphaticus" was made in children. In adults, cases of diabetes and adrenal disorders fall under this category. Emaciation, cachexia, and similar findings are reported frequently, particularly in adults, mainly in connection with infectious diseases like tuberculosis or in the context of neoplastic diseases, like stomach cancer.

Diagnosis group IX: cardiovascular diseases

With a proportion of 86.1% adults, 224 cases (5.3%) belong to this diagnosis group, most of them men (67.5%). The average age of adults in this group is 48 years. The most common diagnoses are heart failure (22.7%), arteriosclerosis (16.5%), and endocarditis (13.9%).

Diagnosis group X: respiratory diseases

Seventeen percent of our cases belong to the group of respiratory diseases. Pneumonia and influenza are listed here, comprising 87% of these cases, with eleven cases of influenza in 1918. Among respiratory diseases, 6% were diagnosed as purulent, and 0.3% of cases were attributed to exogenous substances. Victims of chemical warfare are not included in this cohort, neither are plausible cases of occupational lung diseases.

Diagnosis group XVI: conditions originating in the perinatal period

There are 10.6% of cases referring to conditions originating in the perinatal period. Among these, stillbirth, premature birth, or asthenia was diagnosed. In comparison with autopsy reports on adult bodies, pediatric autopsies are not nearly as

elaborately documented. In most pediatric cases, autopsy reports are limited to a diagnosis; sometimes, the heart and lung are described. A detailed report, however, is not given in most pediatric cases.

Auxiliary findings and comorbidities

Significant secondary diagnoses in the four largest DGs (DG XVI excluded) are listed in Table 1. Incidental malignomas are reported in five cases: one case in DG I, DG IX, and DG X each and two cases in DG XI (digestive system).

First World War

The city of Dusseldorf served as a military hospital base in the First World War, with huge capacities of the municipal hospital and other hospitals in town transformed to military hospitals. Parts of our cohort are 272 cases of military autopsies on exclusively male bodies, with an average age of 26.8 years at death. Mönckeberg worked as a civilian consulting pathologist to the military authorities until October 1916 and performed 246 autopsies as such. In August 1916, war pathology was institutionalized on highest orders, and Army Pathologists with military rank were deployed to each of the German armies [19]. Aims and scopes of war pathology had been outlined authoritatively by Ludwig Aschoff (1860–1942), who set out a concept of "constitutional pathology," at a war pathology meeting in Berlin [20, 21]. Herman Beitzke was deployed as Army Pathologist of the Seventh Army. As such, he spent much time at the communication zones of the Western Front and performed autopsies in field hospitals. Beitzke worked on tuberculosis and on other infectious diseases like M. Weil [22]. In our collection of war pathology autopsies, 51.7% of the individuals died from gunshot injuries (34.3% shots to the head, 21.4% to the lower limbs, and 12.9% to the thorax). The remaining cases of gunshot injuries are distributed to the spinal column, the abdomen, to the pelvis, and few other locations. The actual number of gunshot injuries is even higher, since cases with distinct infections were encoded in diagnosis group I (infectious diseases), even if the infection was a sequel of injury. Date of injury is not evident in most cases. Obviously, they had mainly taken a protracted course, and many of them had been transported some 300 km from the Western Front to Dusseldorf where they later died. Among the military cases, 11.4% prevalence of tuberculosis is documented. Mönckeberg published his findings on tuberculosis in combatants in 1915 in Robert Kochs renowned Journal of Tuberculosis [23]. We encountered 23 cases of tetanus and 10 cases of gas gangrene. We furthermore came across two cases of typhoid fever. No occurrences of epidemic typhus are reported in our cohort.

Discussion

We have introduced a study on autopsy cases at a German big city academic institution in the years of the First World War, 1914 to 1918, one century in hindsight.

Tuberculosis is the "Captain of Death" [24] in our study. In 1914, 11.5% of the cases were of fatal tuberculosis, in 1918 20.5%. These figures give realistic images: in 1914, the death rate for tuberculosis was 142/100,000 in Germany; in 1918, it rose to 229/100,000. In 1918, 54,817 more cases of fatal tuberculosis occurred in Germany compared with 1914. In the years from 1914 to 1920, tuberculosis killed 800,000 people in Germany [25], mainly among the civilian population. About half of these deaths have been attributed to the Great War, epitomizing the going along of war and plague. In the city of Dusseldorf, with about 400,000 inhabitants in 1915, increase of tuberculosis mortality was dramatic, with escalation of 113% over the war years [26]. In accordance with known facts, we found predilection of tuberculosis for younger adults, with an overrepresentation of adults compared with children in our cohort and an average age of 35.5 years among adult tuberculosis victims. Prevalence of tuberculosis was higher among civilians of our cohort than in soldiers, as one would expect. Parts of our cohort were probably males unfit

Table 1 Auxiliary findings/comorbidities in the four largest diagnosis groups (DG XVI excluded)

Auxiliary findings/comorbidities	(I) Infectious diseases	(II) Neoplasms	(X) Respiratory diseases	(XIX) External causes
Sclerosis of the aorta	198; 13.1%	118; 41.8%	110; 15.3%	43; 15.2%
Sclerosis of the coronary arteries	155; 10.3%	94; 33.3%	56; 7.8%	59; 20.1%
Myocardial hypertrophy	50; 3.3%	10; 3.5%	44; 6.1%	5; 1.8%
Endocarditis	42; 2.8%	16; 5.7%	23; 3.2%	7; 2.5%
Pulmonary embolism	25; 1.7%	13; 4.6%	7; 1.0%	8; 2.8%
pneumonia	490; 32.4%	66; 23.4%	44; 6.1%	51; 18.1%
Tuberculosis	31; 2.1%	37, 13.1%	23; 3.9%	26; 6.4%
Active tuberculosis	23; 1.5%	17; 6.0%	8; 1.1%	11; 3.9%
Residual tuberculosis	8; 0.5%	20; 7.1%	15; 2.1%	15; 5.3%

for military service with higher than average morbidity and mortality.

Among children, diphtheria was the most deadly infectious disease. From 1914 to 1915, we observed a steep rise in diphtheria cases. In many of these, doctors had tried to save the children by performing tracheotomy; whether an anti-diphtheria serum was administered is not evident. Possibly, there was shortage of anti-diphtheria serum due to preferred production of anti-tetanus serum for the army.

Tetanus, in our cohort, had exclusively befallen soldiers. There was a peak of tetanus cases in the early phase of the war, while in the year 1918, no cases of tetanus are listed in our collection. This is congruent to official data and has been credited for success of consequent application of anti-tetanus serum to wounded soldiers. Only 0.8 to 0.9‰ of soldiers (4000 to 5000 cases) [27] in the German Army who underwent medical treatment fell ill with tetanus. Twenty-three of these cases are included in our collective. There were no fatalities due to epidemic typhus, reflecting the fact that epidemic typhus was not an issue at the Western Front. In accordance with official data, most of the soldiers in our cohort who died of shotgun injuries had been hit to the head [26]. More than 20% of shotgun injuries in our collective apply to the lower limbs. In the logic of war, the "best" one could do to the enemy was to hit him with a shot to the thigh. This would not kill a soldier instantly, though render him unfit for combat most likely forever, and it would absorb remarkable manpower to save the wounded and to take care of him [28]. In the concept of War Pathology, as it was outlined by Ludwig Aschoff in 1916, which was an ideologically freighted concept, issues of constitutional pathology were a stronghold. In the autopsy reports of our cohort, typical vocabulary like "status thymicolymphaticus," considered a constitutional anomaly, is quoted only in five instances. There are no further references to constitutional pathology, neither in the context of tuberculosis.

In late 1918 and early 1919, an influenza pandemic ravaged the world, with a bigger death toll than the war [29]. Eleven cases in our collection are a rather small part of that and we assume that influenza was underdiagnosed.

Cardiovascular and neoplastic diseases play subordinate parts in our cohort, with a proportion of fewer than 10% each. Set against the high proportion of fatal infectious diseases, this exemplifies the fundamental epidemiological shift that has occurred in industrialized countries over the course of the twentieth century: while people 100 years ago died of infectious diseases as children or as adults in their 30s or 40s, today, child mortality is low and adults die more often in their 70s or 80s, mainly of cardiovascular or neoplastic conditions [30]. Bearing in mind that for example pneumonia or puerperal sepsis according to the ICD-10 are listed as respiratory respectively diseases of the female genitals, the actual prevalence of lethal infections was even higher in our cohort.

Concerning neoplasms, we have encountered a distribution of malignancies one would not expect today, with few cases of lung and oropharyngeal cancers among males and less than 10% of breast cancer among the malignancies in females. In females, cervical cancer played a bigger part than it would play today. Our findings suggest decline in stomach cancer prevalence, with cases in severity and number among our cohort, one would probably not see at autopsy today. Incidentally, diagnosed malignomas are exceptionally rare in our collective, including one case of stomach carcinoma in a tuberculosis case. Emaciation or cachexia is reported frequently in the autopsies, mainly in a context of consumption. Most of these cases are listed in the diagnosis groups of their underlying diseases. The diagnoses "hunger edema" or "inanition" are not reported, and body mass indexes are documented only very occasionally. At the dissection table, it would be difficult to determine starvation as the cause of death since starving people would mainly die of intercurrent diseases like pneumonia or gastrointestinal infections. Thus, we can only speculate about whether and, if yes, how many individuals of our collective actually had starved to death. We do suppose though that there were instances of fatal starvation, especially among the children listed in diagnosis group IV. Besides old people, infants are particularly vulnerable to malnutrition. In a retrospective study on autopsies at a City Hospital in the USA from 1908 to 1911, paid atrophy has been connected to child neglect, which means malnutrition, starvation, and exposure. In that study on autopsies at Newark City Hospital, comparable with our findings, low prevalence (5%) of malignancies has been reported in contrast to high prevalence (159/537 cases) of infections, including tuberculosis. It has been commented that pathologists saw "proportionately fewer cancers" 100 years ago [31]. On the other hand, rising frequency of cancer had been stated already at the beginning of the twentieth century in Germany, when the first official bills of mortality were issued for the Reich, which considered also autopsy findings [32]. The distribution of cancer was comparable to our results in a contemporaneous autopsy study on cancer cases in the city of Kiel in the years 1914 to 1918. In that study, 59.28% of cancers were primarily of the digestive system, with predominance of stomach cancer [33]. In a recent retrospective study on autopsy cases in the city of Köln (Cologne), 40 km from Dusseldorf, the mortality spectrum was also compatible with our findings [34]. As mentioned before, a considerable part of the tuberculosis fatalities can be put into context with malnutrition. In a total war, the civilian population was an explicit target, be it through the hunger blockade, unrestricted U-boat warfare, or rather primitive air raids. In Germany, a big city population like the one in Dusseldorf was plagued by deprivation and hunger, as civilians were second in line when insufficient resources were distributed. With progress of the war, shortages prevailed everywhere at the increasingly undernourished "home front." At

the Dusseldorf pathology institute, at times, the director or his deputy was the only doctors to do the work. The constantly high autopsy rates under these circumstances reflect immense individual workloads [18].

The Great War has been celebrated not only as father of medical science but also of female emancipation. When shortage had a grip on the country, females increasingly replaced male workers, taking over more and more formerly pure male duties. After the war, women were granted the right to vote, but they had to step back again in many fields and leave work posts to the returning men. Dr. Helene Kloss (Fig. 5) worked as pathologist in Dusseldorf from 1917 to late 1919. Before the Great War, a young female like her had studied medicine in Switzerland, a country that played a pioneering role in university training of women. At a German university, a female physician 100 years ago, at best, would have got hold of a post as voluntary assistant, without salary; as such, Helene Kloss was trained in pathology before the war in Bonn and Berlin. In 1917 and 1918, she temporarily replaced the director, Hermann Beitzke, in Dusseldorf when he was on duty as Army Pathologist. At that stage of her career, she would certainly not have worked without payment. She later became chief pathologist at a communal hospital in Luzern, Switzerland [15]. To our knowledge, she was the first female chief pathologist in the German-speaking world. Today, women are well represented in German medicine, although it took until 2003 for a female to take over a pathology chair at a German university. Helene Kloss, the pioneer of emancipation in pathology, furthermore represents a typical case of occupational disease among pathologists and autopsy technicians, since she was herself later affected by tuberculosis.

Fig. 5 Helene Kloss in 1916; with kind permission of Professors Aldo Colombi and Joachim Diebold, Luzern, Switzerland

In conclusion, this study shows how autopsy reports vividly illustrate the disease spectrum of a city population in its historical context. With this analysis, we could gain insights not only into causes of death of the civil population but also on the patterns of injury in casualties of World War I. We take the view that autopsy reports and autopsy archives have a cultural role, as witnesses of the time and medico-historical sources.

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Author's contributions All the authors met the criteria listed in the ICMJE recommendations for the qualification of authorship.

Janßen and Winand had full access to all the data and take responsibility for the integrity and accuracy of the data.

Concept and design: All authors.

Acquisition, analysis, interpretation of data: Janßen, Winand, Babaryka.

Drafting of the manuscript: Janßen, Häberle, Babaryka.

Revision of the manuscript: All authors.

Statistical analysis: Janßen, Winand.

Supervision: Esposito, Babaryka.

Compliance with ethical standards

This study was approved by the ethics committee of the Heinrich-Heine-University Dusseldorf (study number 5870R).

Conflict of interest The authors declare that they have no conflict of interest.

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