

Optimizing Care for Veterans at Risk of Cancer From Camp Lejeune Water Exposure

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Background: From 1953 to 1985, as many as 1 million Marines, Navy personnel, civilian workers, and their families stationed at Camp Lejeune were exposed to volatile organic compounds (VOCs) through contaminated drinking and bathing water. Epidemiologic studies link VOC exposure to ≥ 10 cancers. Cohort studies have shown higher cancer incidence and mortality among Camp Lejeune personnel, with up to a 3- to 6-fold increase for some cancers compared with Camp Pendleton controls. Clinical awareness of cancers associated with Camp Lejeune water contamination remains limited. Federal primary care and internal medicine clinicians are uniquely positioned to address this gap.

Observations: Camp Lejeune VOC exposure is associated with solid tumor and hematologic cancers, which present with various symptoms, examination findings, and diagnostic considerations. Primary care and internal medicine clinicians can improve outcomes by recognizing symptom patterns, conducting thorough physical examinations, and implementing

a targeted diagnostic screening panel for identified veterans who were stationed at Camp Lejeune. A proposed panel includes complete blood count with differential and peripheral smear, comprehensive metabolic panel, lactate dehydrogenase, urinalysis, low-dose chest computed tomography (CT), and CT of the abdomen and pelvis. Educating veterans and clinicians on symptom recognition, relevant physical examination findings, and the value of initial screening may help close this critical gap and reduce costs associated with advanced-stage cancer treatment.

Conclusion: Clinicians caring for veterans exposed to Camp Lejeune VOCs can improve outcomes and quality of life through increased awareness of exposure-associated symptoms, targeted physical examination, and timely use of cost-effective screening to support earlier cancer detection and reduce diagnostic delays and costs. Clinicians are central to early recognition, physical assessment, appropriate screening tools, and ongoing care for this high-risk veteran cohort.

Clinical awareness of cancers associated with Camp Lejeune water contamination exposure remains limited despite legal and policy advances. Gaps persist in early symptom recognition and timely diagnostic evaluation before a definitive cancer diagnosis among exposed personnel. This may represent missed opportunities for earlier identification of volatile organic compounds (VOCs)-related cancers and for less invasive treatment options for veterans in this high-risk population.

Federal health care practitioners (HCPs), especially those in primary care and internal medicine, are uniquely positioned to bridge this gap. By improving the recognition of symptoms, pertinent physical examination findings, and implementing a diagnostic screening panel, HCPs can support accurate diagnoses and facilitate earlier treatment to improve health and quality of life for this population.

From 1953 to 1985, as many as 1 million military personnel, civilian workers, and their families stationed at US Marine Corps Base Camp Lejeune were unknowingly exposed to toxic and carcinogenic chemicals in drinking and bathing water.¹ Three of the 8 main water sources on base were contaminated with VOCs, which are associated with multiple cancers.¹⁻³

The US Department of Veterans Affairs (VA) recognizes 15 conditions associated with Camp Lejeune contaminated water exposure for VA benefits, including 10 cancers: adult leukemia;

aplastic anemia and other myelodysplastic syndromes (MDS); bladder, esophageal, kidney, liver, breast (male and female), and lung cancers; multiple myeloma; and non-Hodgkin lymphoma (NHL).⁴

BACKGROUND

Established in 1942, Camp Lejeune is an important Marine Corps training installation. Between 1953 and 1985, multiple on-base water systems were contaminated with VOCs, including trichloroethylene (TCE), perchloroethylene (PCE), benzene, and vinyl chloride, due to improper waste disposal and industrial runoff from on- and off-base sources.⁵ Tarawa Terrace water treatment plant (WTP) was contaminated primarily with PCE from November 1957 to February 1987. Hadnot Point WTP was contaminated with TCE from August 1953 to December 1984, along with PCE, and benzene, toluene, ethylbenzene, and xylene (BTEX). Holcomb Boulevard WTP, established in 1972, was contaminated with TCE from June 1972 to February 1985.² These contaminants entered the drinking and bathing water supply over decades, and exposure often occurred concurrently across ≥ 1 VOC, compounding health risks.^{2,3} This prolonged 32-year VOC exposure window underlies current concerns regarding long-term cancer risk among affected service members, civilian employees, and family members. Epidemiologic research has found statistically significant associations

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TABLE 1. Review of Symptoms^a

Body system	Signs and symptoms
General	Fatigue; persistent tiredness; unintentional weight loss; unexplained fever; night sweats; sleep disturbance; recurrent infections
Blood and lymphatic	Unexplained bruising; anemia; swollen lymph nodes or lumps in the neck, axilla, or groin
Breast (male and female)	Breast shape or size changes; lump; nipple discharge
Gastrointestinal	Difficulty swallowing (dysphagia); hoarseness; speech changes; nausea; vomiting; loss of appetite; feeling full after a small meal (early satiety); abdominal pain; diarrhea; blood in stool
Musculoskeletal	Bone pain (eg, back, hips, long bones); joint pain; muscle weakness; loss of muscle mass
Neurologic	Headaches; seizures; tremors; confusion; memory issues; mood changes; speech changes; coordination and balance issues; peripheral neuropathy
Respiratory	Shortness of breath; coughing up blood; chronic cough; wheezing
Skin	New or recurrent lesions; rash; dry skin; skin color changes
Urinary	Blood in urine (painless); frequent urination; pain with urination

^aSymptoms can vary between individuals and stages of the condition.

between VOC exposure and multiple cancers, neurologic conditions, and reproductive issues.⁶ Specifically, TCE is associated with higher risks of hematologic cancers, multiple myeloma, NHL, and kidney cancer.³ PCE is linked with kidney cancer, benzene with multiple myeloma and NHL, and vinyl chloride with hepatobiliary cancers.³ A cohort mortality study compared Camp Lejeune personnel with a control group at Camp Pendleton from 1972 to 1985 and found a 3-fold higher incidence or mortality rate for kidney, esophageal, and female breast cancers, leukemia, and lymphoma among exposed Camp Lejeune personnel.⁶ Notably, personnel assigned to Camp Lejeune for as little as 6 months faced up to a 6-fold increase in cancer risk; the average military assignment between 1975 and 1985 was 18 months.^{3,6}

Honoring America's Veterans and Caring for Camp Lejeune Families Act of 2012, the Sergeant First Class Heath Robinson Honoring Our Promise to Address Comprehensive Toxics (PACT) Act of 2022, the Camp Lejeune Justice Act of 2022, and the pending Ensuring Justice for Camp Lejeune Victims Act of 2025 provide health care and legal resources for personnel and families affected by Camp Lejeune's contaminated water.⁶⁻⁸ These laws acknowledge associations between exposure and specific health conditions and expanded health care, benefits, and legal recourse for affected veterans, survivors, and their families.^{8,9}

CANCERS LINKED TO CAMP LEJEUNE

Camp Lejeune VOC-contaminated water exposure is associated with solid tumor and hematologic cancers. Symptoms, physical examination

findings, and diagnostic considerations vary by cancer type (Table 1).

Bladder Cancer

The US incidence rate of bladder cancer for both males and females is 18 per 100,000 individuals per year, with a death rate of 4.1 per 100,000 individuals per year, and a 2.1% lifetime diagnosis risk.¹⁰ Personnel exposed to VOCs at Camp Lejeune had a 9% higher risk of developing bladder cancer and a 2% increased mortality compared with an unexposed control group at Camp Pendleton.^{1,7} Other bladder cancer subtypes at increased risk are papillary transitional cell carcinoma, nonpapillary transition cell carcinoma, and urothelial carcinoma.⁷ This is consistent with prior research that found PCE exposure is associated with an increased risk for bladder cancer.^{3,7,11} Smoking and tobacco use remain significant risk factors for bladder cancer.¹²

Symptomatology. The most common symptom associated with bladder cancer is painless hematuria (gross or microscopic). Other often delayed symptoms include urinary frequency, urgency, or nocturia.^{13,14}

Diagnostics. Screening tests include urinalysis for hematuria, urine cytology, and cystoscopy with biopsy as the gold standard for diagnosis and staging.^{15,16}

Kidney Cancer

The US incidence rate of kidney cancer and renal pelvis cancer for both males and females is 17.5 per 100,000 individuals per year, with a death rate of 3.4 per 100,000, and a 1.8% lifetime diagnosis risk.¹⁷ Camp Lejeune personnel exposed to VOCs had a 6% increased risk of

developing kidney cancer and renal pelvis cancer and a 21% higher mortality risk compared with Camp Pendleton controls.^{1,7} Subtypes at risk include renal cell carcinoma and papillary carcinoma.⁷ This is consistent with prior research that found exposures to TCE and PCE are associated with a 3-fold increased risk of kidney cancer.^{3,7}

Symptomatology. Hematuria, flank pain, and a palpable abdominal mass are common symptoms associated with kidney cancer. In advanced stages, other symptoms may include left-sided varicocele, anemia, weight loss, fatigue, fever, and night sweats.¹⁸

Diagnostics. Screening tests include urinalysis to assess the presence of blood, complete blood count (CBC) to assess anemia, calcium (elevated), and lactate dehydrogenase (LDH), which may be elevated. Imaging strategies include abdominal computed tomography (CT), magnetic resonance imaging (MRI), or ultrasound.¹⁹

Esophageal Cancer

The US incidence rate of esophageal cancer for both males and females is 4.2 per 100,000 individuals per year, the death rate is 3.7 per 100,000 individuals per year, and a 0.5% lifetime diagnosis risk.²⁰ VOC-exposed Camp Lejeune personnel had a 27% increased incidence and 25% increased mortality compared with the control group.^{1,7} Esophageal cancer subtypes at elevated risk include squamous cell carcinoma and adenocarcinoma. This is consistent with prior research that found Camp Lejeune water exposure is associated with a 3-fold increased risk for esophageal cancer.⁷ Additional risk factors include history of smoking and alcohol use.²¹

Symptomatology. Esophageal cancer is often asymptomatic with potential symptoms that include dysphagia, hoarseness, and weight loss in advanced disease.²²

Diagnostics. Endoscopy with biopsy is the definitive method for diagnosis.²³

Liver Cancer

The US incidence rate of liver cancer and intrahepatic bile duct cancer for both males and females is 9.4 per 100,000 individuals per year, with a death rate of 6.6 per 100,000 individuals per year, and a 1.1% lifetime diagnosis risk.²⁴ VOC-exposed personnel had a 1% higher mortality than controls.¹

Symptomatology. Liver cancer is often asymptomatic and appears in late stages.²⁵ Common symptoms include right upper quadrant pain, early satiety, nausea, vomiting, loss of appetite,

weight loss, ascites, jaundice, and abnormal bleeding or bruising.^{25,26}

Diagnostics. Diagnostic tests may include an ultrasound, CT, or MRI. Additional laboratory testing may include liver function, α -fetoprotein blood, CBC, renal function, calcium, and hepatitis panel screening for hepatitis B and C.^{27,28}

Lung Cancer

The US incidence rate of lung cancer for both males and females is 47.8 per 100,000 individuals per year, with a death rate of 31.5 per 100,000 individuals per year, and a 5.4% lifetime diagnosis risk.²⁹ VOC-exposed personnel had a 16% increased risk and 19% higher mortality.^{1,7} Subtypes include large cell, small cell, non-small cell, squamous cell, and adenocarcinoma.⁷ Smoking is an additional risk factor.³⁰

Symptomatology. Symptoms of lung cancer include cough, shortness of breath, chest pain worse with deep breathing, unexplained weight loss, fatigue, night sweats, and recurrent fevers. Advanced stages may metastasize or spread to the liver, bones, and brain.³¹

Diagnostics. Low-dose CT and chest X-ray are used for screening.³²

Breast Cancer

The US incidence rate of female breast cancer is 130.8 per 100,000 individuals per year, with a death rate of 19.2 per 100,000 individuals per year, and a 13.0% lifetime risk of diagnosis.³³ For female VOC-exposed personnel, there was an equal risk of developing breast cancer as the control group.¹ However, exposed females at Camp Lejeune had a 23% higher mortality risk compared to the control group.⁷ Breast cancer subtypes among females include ductal carcinoma, lobular carcinoma, and ductal-lobular carcinoma.¹

The US incidence rate of male breast cancer is 1.3 per 100,000 individuals per year, with a death rate of 0.3 per 100,000 individuals per year.^{34,35} The lifetime risk for males developing breast cancer is 137.7 per 100,000 and about 70 to 100 times less common in men than women.³⁶

Male personnel exposed at Camp Lejeune had a 4% increased risk for developing breast cancer compared to Camp Pendleton.⁷ However, mortality was lower in the Camp Lejeune group.¹ Although male breast cancer is rare, males at Camp Lejeune had a higher incidence, indicating a link between TCE, PCE, vinyl chloride exposures and male breast cancer.³⁷ Male breast cancer is more often diagnosed in advanced stages than female

breast cancer due to the lack of awareness or absence of routine screenings.³⁸ The most common breast cancer type in males is invasive ductal carcinoma, accounting for 85% to 90% of cases; lobular carcinoma is the second most common type.³⁹

Symptomatology. In both females and males, breast cancer symptoms include painless, firm mass or lump in the breast (left breast slightly more common than right), skin changes or dimpling, nipple retraction or turning inward, and nipple discharge. Breast cancer can spread to the lymph nodes and can be appreciated in axilla or clavicular regions.⁴⁰

Diagnostics. The diagnostic evaluation for breast cancer is similar for females and males. It includes a clinical breast examination, diagnostic mammogram, and ultrasound.⁴¹ Mammograms can distinguish between gynecomastia and cancer, especially in males.⁴² A core or fine needle biopsy is needed to confirm diagnosis.⁴¹

Adult Leukemia

The US incidence rate of leukemia for both male and female was 14.4 per 100,000 individuals per year, with a death rate of 5.8 per 100,000 individuals per year, and a 1.5% lifetime diagnosis risk.⁴³

VOC-exposed personnel had a 7% higher risk of developing leukemia and a 13% increased mortality risk compared with the control group.^{1,7} Subtypes of leukemia at risk included a 38% increased incidence of acute myeloid/monocytic leukemia (AML) and a 2% increased incidence of chronic lymphocytic leukemia (CLL).¹ Benzene and TCE exposures are known risk factors for AML and other leukemias.⁷ Personnel at Camp Lejeune had 3 times the incidence or mortality for leukemia, specifically AML mortality at 20%.⁷ Smoking is an additional risk factor for certain leukemias, especially AML.³⁰

Symptomatology. Symptoms associated with leukemia are often nonspecific and may include fatigue, pallor, easy bruising or bleeding (skin or gums), recurrent infections secondary to neutropenia, fever, night sweats, pain or feeling full after a small meal due to enlarged spleen or liver, and weight loss.^{44,45}

Diagnostics. An initial screening includes a CBC with differential, a peripheral smear to detect the presence of blast cells, as well as Auer rods in myeloid blast cells in AML or smudge cells in CLL. Confirmatory tests may include bone marrow biopsy or flow cytometry. A referral to a hematologist is recommended for any suspected leukemia.^{46,47}

Myelodysplastic Syndromes

Aplastic anemia and MDS are considered rare disorders.⁴⁸ Aplastic anemia is a nonmalignant bone marrow failure disorder with pancytopenia and hypocellular bone marrow due to the loss of hematopoietic stem cells.⁴⁸ MDS is a type of hematopoietic cancer where the bone marrow produces abnormal blood cells or does not make enough healthy cells.⁴⁹ This can lead to an increased risk for infection, cytopenias, neutropenia, refractory anemia, and thrombocytopenia, and progression to AML in some patients.⁴⁹

The reported US incidence of MDS from 1975 to 2013 was 6.7 per 100,000 for males and 3.7 per 100,000 for females.⁵⁰ Benzene exposure is linked to MDS and a known cause of AML.¹ VOC-exposed personnel had a 68% increased risk of developing MDS and a 2.3-fold increased mortality risk compared to controls.^{1,7}

Symptomatology. Some patients are asymptomatic at diagnosis.⁵¹ Symptoms related to cytopenia include fatigue, pallor, purpura, petechiae, bleeding of skin, gum, or nose, recurrent infections, fever, bone pain, loss of appetite, and weight loss.^{50,51}

Diagnostics. Initial workup includes a CBC with differential to assess for anemia, white blood cell and absolute neutrophil counts (low), and thrombocytopenia.⁵² A peripheral blood smear may show myeloid blast cells. A bone marrow aspiration and biopsy, flow cytometry, and cytogenetic or molecular testing may be performed. If MDS is suspected, a referral to a hematologist should be considered.⁵²

Multiple Myeloma

The US incidence rate of multiple myeloma for both males and females is 7.3 per 100,000 individuals per year, with a mortality rate of 2.9 per 100,000 individuals per year, and a 0.8% lifetime diagnosis risk.⁵³ VOC-exposed personnel had a 13% increased risk of developing multiple myeloma and an 8% increased mortality risk compared to unexposed personnel.^{1,7}

Symptomatology. Multiple myeloma may be asymptomatic in early stages. The most common presenting symptom is bone pain, especially in the back, hips, and long bones, due to hypercalcemia from increased reabsorption, plasma cell tumor overgrowth in the bone marrow, and lytic lesions.⁵⁴ Additional symptoms include fatigue and pallor related to anemia, leukopenia, thrombocytopenia, recurrent infections, extreme thirst, frequent urination, dehydration, confusion associated with hypercalcemia, peripheral neuropathy, loss of appetite, weight loss, and renal impairment or failure.⁵⁴

TABLE 2. Physical Examination Findings

Body system	Findings	Associated disorders/cancers
General inspection	Pallor; jaundice; signs of distress	Anemia in leukemia; lymphoma; liver cancer
Vital signs	Weight—document and assess for weight loss compared with prior visits; pulse—tachycardia	Increased likelihood of advanced-stage cancer and metastasis
Head, eyes, ears, nose, and throat	Inspect for conjunctival pallor; examine oral cavity for ulcers, bleeding gums, abscesses, or infections	Anemia in leukemia; myelodysplastic syndromes
Skin	Purpura; petechiae; bruising; infections; delayed wound healing	Leukemia; myelodysplastic syndromes
Lymphatic	Lymph nodes—perform thorough palpation for enlarged, firm, nontender nodes in the cervical (anterior/posterior) and supraclavicular regions; axillae; inguinal regions	Lymphoma
Chest	Inspect and palpate the chest and chest wall for masses or lumps	Lung cancer; breast cancer; metastases
Breast (male and female)	Perform a complete breast examination; observe for asymmetry, skin changes, dimpling, nipple retraction, nipple discharge; palpate for firm masses or lumps; enlarged axillary lymph nodes	Breast cancer
Cardiac	Tachycardia	Anemia
Respiratory	Auscultate for decreased breath sounds; wheezing; rhonchi; crackles	Lung cancer
Abdominal	Evaluate for ascites (fluid wave); palpate for right upper quadrant tenderness, hepatomegaly, splenomegaly, abdominal masses, suprapubic tenderness, bladder distension	Liver cancer; bladder cancer
Musculoskeletal	Inspect the back, ribs, sternum, pelvis, and long bones for deformities, swelling, or tenderness with palpation	Multiple myeloma; metastasis
Renal	Costovertebral angle tenderness	Kidney cancer

Diagnosics. Testing considerations include a CBC with a peripheral blood smear to evaluate anemia and rouleaux formation of red blood cells (seen in > 50% of patients with multiple myeloma), comprehensive metabolic panel (CMP) to assess kidney function, calcium levels (elevated), serum and urine protein electrophoresis with immunofixation to detect monoclonal protein (detected in > 80% of patients with multiple myeloma) and Bence-Jones proteins, serum free light chain assay, and a bone marrow biopsy for diagnosis.^{55,56}

MRI of the spine and pelvis is the most sensitive to detecting bone marrow involvement and focal lesions before lytic lesion progression occurs and for assessing spinal cord compression.⁵⁷ PET/CT is more sensitive at detecting extramedullary disease, outside of the spine, and for patients that cannot undergo MRI.⁵⁷ A whole-body low-dose CT, either alone or with PET, is more sensitive than an X-ray at detecting lytic lesions, fractures, or osteoporosis associated with multiple myeloma.⁵⁷

Non-Hodgkin Lymphoma

The US incidence rate of NHL for both males and females are 18.7 per 100,000 individuals

per year, the death rate is 4.9 per 100,000 individuals per year, and a 2% lifetime diagnosis risk.⁵⁸ VOC-exposed personnel had a 1% higher risk of developing NHL and a decreased mortality risk compared to the control group.^{1,7} Specific NHL subtypes with increased risk in the exposed cohort are mantle cell (26%), follicular (7%), Burkitt (53%), and marginal zone B-cell (45%).⁷

Symptomatology. NHL often presents with painless lymphadenopathy or enlarged lymph nodes involving the cervical, axillary, inguinal regions.^{59,60} Other symptoms include frequent infections, unexplained bruising, weight loss, and “B symptoms,” such as fever and night sweats.^{59,60} Some patients develop a mediastinal mass in the thorax, which if large may lead to cough or shortness of breath.⁵⁹

Diagnosics. The initial diagnostic workup includes CBC with differential and LDH, which may be elevated.^{60,61} Imaging may begin with a chest X-ray to assess for a mediastinal mass; however, CTs of the chest, abdomen, and pelvis provide more detail to better assess for NHL. Whole body PET/CT is considered the gold standard for assessing and staging systemic involvement. If enlarged

TABLE 3. Diagnostic Testing by Cancer

Test or imaging	Associated cancers
Urinalysis	Bladder; kidney
Cystoscopy	Bladder
Complete blood count	Kidney; liver; leukemia; aplastic anemia/myelodysplastic syndromes; multiple myeloma; non-Hodgkin lymphoma
Peripheral smear	Leukemia; aplastic anemia/myelodysplastic syndromes; multiple myeloma; non-Hodgkin lymphoma
Serum calcium	Kidney; liver; multiple myeloma
Renal function tests	Kidney; liver; multiple myeloma
Liver function tests	Liver
Lactate dehydrogenase	Kidney; non-Hodgkin lymphoma
α -fetoprotein	Liver
Serum/urine protein electrophoresis	Multiple myeloma
Plain radiographs	Multiple myeloma
Chest radiograph	Lung; non-Hodgkin lymphoma
Computed tomography	
Low-dose, chest	Lung; non-Hodgkin lymphoma
Low-dose, whole-body	Multiple myeloma
Abdomen	Kidney; liver
Abdomen and pelvis	Non-Hodgkin lymphoma
Positron emission tomography	Multiple myeloma; non-Hodgkin lymphoma
Ultrasonography	Kidney; liver
Magnetic resonance imaging	Kidney; liver; multiple myeloma
Endoscopy	Esophageal
Mammography	Breast
Bone marrow biopsy	Leukemia; aplastic anemia/myelodysplastic syndromes
Flow cytometry	Leukemia; aplastic anemia/myelodysplastic syndromes

lymph nodes are present, a biopsy can confirm the subtype of NHL.^{60,61}

PHYSICAL EXAMINATION

A focused physical examination may aid HCPs in early detection of the cancers associated with Camp Lejeune (Table 2). The physical examination can guide diagnostic testing and imaging for further assessment and workup for VOC-related cancers.

Proposed Diagnostic Screening Panel

Primary care and internal medicine HCPs have the opportunity to improve patient health outcomes by implementing a targeted diagnostic screening panel for identified veterans previously stationed at Camp Lejeune. Early identification of cancers associated with VOCs

exposure can facilitate earlier treatment interventions and improve health and quality of life outcomes. The following diagnostic screening panel outlines a potential cost-effective strategy for evaluating and detecting the 10 cancers associated with VOC exposure in Camp Lejeune water.

Baseline Screening

Implementing a diagnostic screening panel in this high-risk cohort can lead to earlier diagnosis, reduce mortality, and improve patient outcomes through early intervention, which in turn may result in less invasive treatment. This approach may also reduce health care costs by avoiding costs associated with delayed diagnosis and advanced-stage cancer care (Tables 3 and 4).

TABLE 4. Proposed Diagnostic Screening Panel for Cancers Associated With Camp Lejeune Water^a

Test or imaging	Associated cancers
Urinalysis	Bladder; kidney
Complete blood count	Kidney; leukemia; aplastic anemia/myelodysplastic syndromes; multiple myeloma; non-Hodgkin lymphoma
Peripheral smear	Leukemia; aplastic anemia/myelodysplastic syndromes; multiple myeloma; non-Hodgkin lymphoma
Comprehensive metabolic panel	Kidney; liver; multiple myeloma
Lactate dehydrogenase	Kidney; non-Hodgkin lymphoma
Low-dose computed tomography	
Chest	Lung
Abdomen and pelvis	Kidney; liver; non-Hodgkin lymphoma

^aIncludes calcium, liver function, and renal function.

A baseline panel of tests for exposed veterans could include:

- A CBC with differential and peripheral smear to assess for anemia, leukemia, thrombocytopenia, and blast cells associated with leukemias, MDS, multiple myeloma, and NHL.^{19,46,47,52,55,56,60,61}
- CMP evaluates calcium, total protein, renal and liver renal function. Elevated test results may indicate kidney or liver cancer or multiple myeloma.^{19,27,28,55,56}
- LDH testing may reveal levels that are elevated from tissue damage or high cell turnover in kidney cancer, multiple myeloma, and NHL.^{19,55,56,60,61}
- Urinalysis with microscopy may detect hematuria, proteinuria and cellular casts in bladder and kidney cancers.^{13,24,19}
- Low-dose CTs of the chest, abdomen, and pelvis are recommended for early identification of any masses or lymphadenopathy in lung, kidney, liver cancers, and NHL.^{19,27,28,32,60,61}

COST EFFICIENCY

Screening Panel Cost

According to the Medicare Clinical Laboratory Fee Schedule payment cap for 2018, the mean cost for the proposed blood workup was \$35 (CBC, \$10; CMP, \$13; LDH, \$8; urinalysis, \$4).⁶² Medicare procedure price schedule for 2025 includes \$351 for a CT of the abdomen and pelvis with and without contrast (*Current Procedural Terminology [CPT] code 74177*) and \$187 for a CT of the chest with and without contrast (*CPT code 71270*).^{63,64} The total proposed diagnostic screening panel payment cost about \$572.

Cancer Care Cost

The average cost for initial cancer care across all cancer sites from 2007 to 2013 was \$43,516 per patient; Camp Lejeune-associated can-

cers ranged from \$26,443 for bladder cancer to \$89,947 for esophageal cancer care.⁶⁴ Further, the last year of life cost across all cancer sites averaged \$109,727, and Camp Lejeune-associated cancer types ranged from \$76,101 for breast cancer to \$169,588 for leukemia.⁶⁵

CONCLUSIONS

From 1953 to 1985, up to 1 million military personnel, civilian workers, and their families stationed at Camp Lejeune were unknowingly exposed to toxic and carcinogenic VOCs, which are associated with ≥ 10 cancers, including bladder, kidney, esophageal, liver, lung, breast, and hematologic malignancies.¹⁻⁴ Some veterans may be asymptomatic, whereas others present with subtle or specific symptoms that can vary by individual and the type and stage of cancer. HCPs have an opportunity to improve patient outcomes through awareness in identifying symptoms associated with Camp Lejeune water exposure and performing a thorough baseline physical examination, especially noting lymphadenopathy, unexplained weight loss, or masses, which can guide further diagnostic evaluation.

Timely screening can identify cancers earlier, reducing delays in care, mitigating the cost burden associated with advanced-stage cancer treatment, improving survival outcomes, and enhancing quality of life. Primary care and internal medicine HCPs specifically play a crucial role in early recognition, physical assessment, and appropriate screening tools. A proposed panel includes CBC with differential and peripheral smear, CMP, LDH, urinalysis, and low-dose CTs of the chest, abdomen and pelvis. Implementation should be guided by clinical judgment and patient-specific risk factors. The proposed diagnostic screening panel is a small price to pay for those who served in any capacity at Camp Lejeune.

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References

- Bove FJ, Greek A, Gatiba R, et al. Cancer incidence among Marines and Navy personnel and civilian workers exposed to industrial solvents in drinking water at US Marine Corps Base Camp Lejeune: a cohort study. *Environ Health Perspect*. 2024;132:107008. doi:10.1289/EHP14966
- Maslia ML, Aral MM, Ruckart PZ, Bove FJ. Reconstructing historical VOC concentrations in drinking water for epidemiological studies at a US military base: summary of results. *Water (Basel)*. 2016;8:449. doi:10.3390/w8100449
- Rosenfeld PE, Spaeth KR, McCarthy SJ, et al. Camp Lejeune Marine cancer risk assessment for exposure to contaminated drinking water from 1955 to 1987. *Water Air Soil Pollut*. 2024;235(2). doi:10.1007/s11270-023-06863-y
- US Department of Veterans Affairs, Veterans Health Administration. Camp Lejeune: past water contamination. Updated April 15, 2025. Accessed March 3, 2026. <https://www.publichealth.va.gov/exposures/camp-lejeune/>
- Jung K, Khan A, Mocharnuk R, et al. Clinical encounter with three cancer patients affected by groundwater contamination at Camp Lejeune: a case series and review of the literature. *J Med Case Rep*. 2022;16(1):272. doi:10.1186/s13256-022-03501-9
- Honoring America's Veterans and Caring for Camp Lejeune Families Act of 2012, Pub L No. 112-154. Janey Ensminger Act. Congress.gov. Accessed April 15, 2026. <https://www.congress.gov/bill/112th-congress/house-bill/1627>
- Bove FJ, Greek A, Gatiba R, et al. Evaluation of mortality among Marines, Navy personnel, and civilian workers exposed to contaminated drinking water at USMC Base Camp Lejeune: a cohort study. *Environ Health*. 2024;23(1):61. doi:10.1186/s12940-024-01099-7
- Honoring our PACT Act of 2022 (Pub L No. 117-168): expansion of health care eligibility and toxic exposure screenings. Congress.gov. Accessed March 3, 2026. <https://www.congress.gov/bill/117th-congress/house-bill/3967>
- Ensuring Justice for Camp Lejeune Victims Act of 2025. Congress.gov. Accessed March 24, 2026. <https://www.congress.gov/bill/119th-congress/house-bill/4145>
- SEER. Cancer stat facts: bladder cancer. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/urinb.html>
- Agency for Toxic Substances and Disease Registry. ATSDR assessment of the evidence for the drinking water contaminants at Camp Lejeune and specific cancers and other diseases. Published January 13, 2017. Accessed March 3, 2026. https://www.atsdr.cdc.gov/camp-lejeune/media/pdfs/2024/10/ATSDR_summary_of_the_evidence_for_causality_TCE_PCE_508.pdf
- National Cancer Institute. What is bladder cancer? Updated February 16, 2023. Accessed March 3, 2026. <https://www.cancer.gov/types/bladder>
- National Cancer Institute. Bladder cancer symptoms. Updated February 16, 2023. Accessed March 3, 2026. <https://www.cancer.gov/types/bladder/symptoms>
- American Cancer Society. Bladder cancer signs and symptoms. Updated March 12, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/bladder-cancer/detection-diagnosis-staging/signs-and-symptoms.html>
- National Cancer Institute. Bladder cancer screening. Updated April 27, 2023. Accessed March 3, 2026. <https://www.cancer.gov/types/bladder/screening>
- American Cancer Society. Tests for bladder cancer. Updated March 12, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/bladder-cancer/detection-diagnosis-staging/how-diagnosed.html>
- SEER. Cancer stat facts: kidney and renal pelvis cancer. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/kidrp.html>
- American Cancer Society. Kidney cancer signs and symptoms. Updated May 1, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/kidney-cancer/detection-diagnosis-staging/signs-and-symptoms.html>
- American Cancer Society. Tests for kidney cancer. Updated May 1, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/kidney-cancer/detection-diagnosis-staging/how-diagnosed.html>
- SEER. Cancer stat facts: esophageal cancer. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/esoph.html>
- Engel LS, Chow WH, Vaughan TL, et al. Population attributable risks of esophageal and gastric cancers. *J Natl Cancer Inst*. 2003;95(18):1404-1413. doi:10.1093/jnci/djg047
- American Cancer Society. Signs and symptoms of esophageal cancer. Updated March 20, 2020. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/esophagus-cancer/esophagus-cancer/detection-diagnosis-staging/signs-and-symptoms.html>
- American Cancer Society. Tests for esophageal cancer. Updated March 20, 2020. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/esophagus-cancer/detection-diagnosis-staging/how-diagnosed.html>
- SEER. Cancer stat facts: liver and intrahepatic bile duct cancer. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/livibd.html>
- American Cancer Society. Signs and symptoms of liver cancer. Updated February 11, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/liver-cancer/detection-diagnosis-staging/signs-symptoms.html>
- National Cancer Institute. What is liver cancer? Updated May 15, 2024. Accessed March 3, 2026. <https://www.cancer.gov/types/liver/what-is-liver-cancer>
- American Cancer Society. Tests for liver cancer. Updated February 11, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/liver-cancer/detection-diagnosis-staging/how-diagnosed.html>
- National Cancer Institute. Liver cancer screening. Updated May 15, 2024. Accessed March 3, 2026. <https://www.cancer.gov/types/liver/what-is-liver-cancer/screening>
- SEER. Cancer stat facts: lung cancer. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/lungb.html>
- US Department of Health and Human Services. *The Health Consequences of Smoking: A Report of the Surgeon General*. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2004. Accessed March 3, 2026. https://www.ncbi.nlm.nih.gov/books/NBK44695/pdf/Bookshelf_NBK44695.pdf
- American Cancer Society. Lung cancer signs and symptoms. Updated February 27, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/lung-cancer/detection-diagnosis-staging/signs-symptoms.html>
- American Cancer Society. Tests for lung cancer. Updated January 29, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/lung-cancer/detection-diagnosis-staging/how-diagnosed.html>
- SEER. Cancer stat facts: female breast cancer. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/breast.html>
- SEER. SEER*Explorer breast incidence and mortality comparison. Updated July 2, 2025. Accessed March 3, 2026. <https://seer.cancer.gov/statistics-network/explorer/application.html>
- Susan G. Komen. Male breast cancer. Updated June 3, 2025. Accessed March 3, 2026. <https://www.komen.org>

- /breast-cancer/facts-statistics/male-breast-cancer/
36. American Cancer Society. Key statistics for breast cancer in men. Updated January 16, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/breast-cancer-in-men/about/key-statistics.html>
 37. Ruckart PZ, Bove FJ, Shanley E 3rd, et al. Evaluation of contaminated drinking water and male breast cancer at Marine Corps Base Camp Lejeune, North Carolina: a case-control study. *Environ Health*. 2015;14:74. doi:10.1186/s12940-015-0061-4
 38. Culell P, Solernou L, Tarazona J, et al. Male breast cancer: a multicentric study. *Breast J*. 2007;13:213-215. doi:10.1111/j.1524-4741.2007.00412.x
 39. Giordano SH, Cohen DS, Buzdar AU, et al. Breast carcinoma in men: a population-based study. *Cancer*. 2004;101:51-57. doi:10.1002/cncr.20312
 40. American Cancer Society. Signs and symptoms of breast cancer in men. Updated April 27, 2018. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/breast-cancer-in-men/detection-diagnosis-staging/signs-symptoms.html>
 41. American Cancer Society. Tests to help diagnose breast cancer in men. Updated December 20, 2021. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/breast-cancer-in-men/detection-diagnosis-staging/how-diagnosed.html>
 42. Evans GF, Anthony T, Turnage RH, et al. The diagnostic accuracy of mammography in the evaluation of male breast disease. *Am J Surg*. 2001;181:96-100. doi:10.1016/S0002-9610(00)00571-7
 43. SEER. Cancer stat facts: leukemia. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/leuks.html>
 44. American Cancer Society. Signs and symptoms of acute myeloid leukemia (AML). Updated March 20, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/acute-myeloid-leukemia/detection-diagnosis-staging/signs-symptoms.html>
 45. American Cancer Society. Signs and symptoms of chronic lymphocytic leukemia (CLL). Updated March 4, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/chronic-lymphocytic-leukemia/detection-diagnosis-staging/signs-symptoms.html>
 46. American Cancer Society. Tests for acute myeloid leukemia (AML). Updated March 4, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/acute-myeloid-leukemia/detection-diagnosis-staging/how-diagnosed.html>
 47. American Cancer Society. Tests for chronic lymphocytic leukemia (CLL). Updated March 4, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/chronic-lymphocytic-leukemia/detection-diagnosis-staging/how-diagnosed.html>
 48. Giudice V, Selli C. Aplastic anemia: pathophysiology. *Semin Hematol*. 2022;59:13-20. doi:10.1053/j.seminhematol.2021.12.002
 49. National Cancer Institute. Myelodysplastic syndromes treatment (PDQ®)—patient version. Updated October 4, 2024. Accessed March 3, 2026. <https://www.cancer.gov/types/myeloproliferative/patient/myelodysplastic-treatment-pdq>
 50. SEER. Cancer statistics review (CSR) 1975-2013: myelodysplastic syndromes. Accessed March 3, 2026. https://seer.cancer.gov/archive/csr/1975_2013/browse_csr.php?sectionSEL=30&pageSEL=sect_30_table.01
 51. American Cancer Society. Signs and symptoms of myelodysplastic syndrome (MDS). Updated November 21, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/myelodysplastic-syndrome/detection-diagnosis-staging/signs-symptoms.html>
 52. American Cancer Society. Tests for myelodysplastic syndromes (MDS). Updated November 21, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/myelodysplastic-syndrome/detection-diagnosis-staging/how-diagnosed.html>
 53. SEER. Cancer stat facts: myeloma. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/mulmy.html>
 54. American Cancer Society. Signs and symptoms of multiple myeloma. Updated February 28, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/multiple-myeloma/detection-diagnosis-staging/signs-symptoms.html>
 55. American Cancer Society. Tests for multiple myeloma. Updated February 28, 2025. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/multiple-myeloma/detection-diagnosis-staging/testing.html>
 56. Laubach JP. Multiple myeloma: clinical features, laboratory manifestations, and diagnosis. UpToDate. Updated April 28, 2025. Accessed March 3, 2026. <https://www.uptodate.com/contents/multiple-myeloma-clinical-features-laboratory-manifestations-and-diagnosis>
 57. Hillengass J, Usmani S, Rajkumar SV, et al. International Myeloma Working Group consensus recommendations on imaging in monoclonal plasma cell disorders. *Lancet Oncol*. 2019;20:e302-e312. doi:10.1016/S1470-2045(19)30309-2
 58. SEER. Cancer stat facts: non-Hodgkin lymphoma. Accessed March 3, 2026. <https://seer.cancer.gov/statfacts/html/nhl.html>
 59. American Cancer Society. Signs and symptoms of non-Hodgkin lymphoma. Updated February 15, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/non-hodgkin-lymphoma/detection-diagnosis-staging/signs-symptoms.html>
 60. National Cancer Institute. Non-Hodgkin lymphoma treatment (PDQ®)—patient version. Updated August 22, 2024. Accessed March 3, 2026. <https://www.cancer.gov/types/lymphoma/patient/adult-nhl-treatment-pdq>
 61. American Cancer Society. Tests for non-Hodgkin lymphoma. Updated February 15, 2024. Accessed March 3, 2026. <https://www.cancer.org/cancer/types/non-hodgkin-lymphoma/detection-diagnosis-staging/how-diagnosed.html>
 62. College of American Pathologists. Medicare clinical laboratory fee schedule. Published November 2017. Accessed March 3, 2026. <https://documents.cap.org/documents/2018-final-medicare-clfs-rates.pdf>
 63. Medicare.gov. Procedure price lookup for outpatient services. Accessed March 3, 2026. <https://www.medicare.gov/procedure-price-lookup/cost/71270/>
 64. Medicare.gov. Procedure price lookup for outpatient services. Accessed March 3, 2026. <https://www.medicare.gov/procedure-price-lookup/cost/74177/>
 65. National Cancer Institute. Cancer trends progress report: financial burden of cancer care. Updated April 2025. Accessed March 3, 2026. https://progressreport.cancer.gov/after/economic_burden