Developing a Score to Grade Primary Care Providers' Potentially Inappropriate Thyroid-Stimulating Hormone Testing Behaviour in Nova Scotia

by

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Introduction: Primary care providers are gatekeepers, and they only open the 'gate' for sick patients to further care and testing. Blood work is potentially overused, and overtesting can worsen health outcomes. We will use the common Thyroid-Stimulating Hormone (TSH) test as an example for the study.

Objectives: Describe primary care providers' TSH testing behaviour in Nova Scotia from 2014 to 2018 and develop a method to identify potentially inappropriate testing (PIT).

Methods: Retrospective primary care electronic medical records from MaRNet-FP will be used to identify PITs and calculate PIT scores for participating physicians and nurse practitioners.

Findings: Almost 9 % of TSH tests were potentially inappropriate in 2018 on average per provider. Most providers had a low PIT score, but 7 % are potentially overtesting their patients with TSH at a high rate. We did not find any changes in the frequency of laboratory orders or visits after a PIT.

LIST OF ABBREVIATIONS USED

ALB	Albumin
ALP	Alkaline Phosphatase
ALT	Alanine Aminotransferase
ATTG	Antitissue Transglutaminase
BASO	Basophils
BIC	Bayesian Information Criterion
BILI	Bilirubin
BLAST	Blast Cells
CALC	Calcium
CARBA	Carbamazepine
CHLOR	Chloride
CHOL	Cholesterol
COPD	Chronic Obstructive Pulmonary Disease
CPCSSN	Canadian Primary Care Sentinel Surveillance Network
CREA	Creatinine
DIGO	Digoxin
EHR	Electronic Health Record
EMR	Electronic Medical Record
ED	Emergency Department
EOSIN	Eosinophils
FER	Ferritin
GMM	Gaussian Mixture Model

GLUCO	Glucose
GRAN	Granulocytes
HbA1C	Hemoglobin A1c
HBV	Hepatitis B Virus
HCG	Human Chorionic Gonadotropin
HCV	Hepatitis C Virus
HDL	High-Density Lipoprotein
HEMO	Hemotocrit
HGB	Hemoglobulin
HIV	Human Immunodeficiency Virus
INR	International Normalized Ratio
IQR	Interquartile Range
LDL	Low-Density Lipoprotein
LITH	Lithium
LYMPH	Lymphocytes
MAG	Magnesium
MaRNet-FP	Maritime Family Practice Research Network
Max	Maximum
MCH	Mean Corpuscular Hemoglobin
MCHC	Mean Corpuscular Hemoglobin Concentration
MCV	Mean Corpuscular Volume
MEAS	Measles
Min	Minimum
MIXED	Mixed cells

MONO	Monocytes
MPV	Mean Platelet Volume
MYELO	Myelocytes
NA	Not Applicable
NEUT	Neutrophils
NSHA	Nova Scotia Health Authority
PCA	Principal Component Analysis
PHENYT	Phenytoin
PHOS	Phosphate
PIR	Potentially Inappropriate Retesting
PIT	Potentially Inappropriate Testing
PLAT	Platelets
POT	Potassium
PROT	Protein
PTT	Partial Thromboplastin Time
QI	Quality Improvement
RBC	Red Blood Cells
RDW	Red Cell Distribution Width
REB	Research Ethics Board
RETIC	Reticulocytes
RUB	Rubella
SD	Standard Deviation
SOAP	Subjective, Objective, Assessment, and Plan
SOD	Sodium

TRIG	Triglycerides
TruncatedSVD	Singular Value Decomposition
TSH	Thyroid Stimulating Hormone
T3	Triiodothyronine
T4	Thyroxine
UREA	Urea
USPSTF	United States Preventive Services Task Force
VALPRO	Valproate
VANCO	Vancomycin
WBC	White Blood Cells

GLOSSARY

We are in this study using words that are not common and well-defined elsewhere in the literature. Below are our working definitions:

Overcare (verb) **Overcaring** (noun)	*Someone is providing excessive healthcare for a patient leading to potentially more harm than benefits.*
Overdiagnose (verb) **Overdiagnosis** (noun)	*Someone is giving an excessive diagnosis to a patient leading to potentially more harm than benefits.*
Overscreen (verb) **Overscreening** (noun)	*Someone is screening a patient with examinations, interviews, procedures, and tests leading to potentially more harm than benefits.*
Overtest (verb) **Overtesting** (noun)	*Someone is testing a patient leading to potentially more harm than benefits.*
Overtreat (verb) **Overtreating** (noun)	*Someone is treating a patient leading to potentially more harm than benefits.*

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CHAPTER 1: INTRODUCTION

Choosing Wisely Canada is concerned that healthcare services, including the laboratory blood test, thyroid-stimulating hormone (TSH), are being overused in primary care in Canada [1]. Choosing Wisely Canada is a leading quality of care organization that supports Canadian healthcare professionals to make smarter choices that benefit patients and reduce the use of unnecessary healthcare services [1].

The TSH test is frequently used among healthcare providers, and a Canadian study estimated that every third of primary care providers' patients had been TSH tested at some point [2]. We selected TSH for this study to examine the general testing behaviour among primary care providers due to the high testing rate with low abnormal test results (less than 5 per cent), and the test is often combined with other screening tests such as hemoglobin A1c or lipid tests [2]. To date, we have found no generalizable scoring system to describe the testing behaviour. To do this, we created a score called 'potentially inappropriate testing' (PIT). The score would allow the primary care providers to follow their testing behaviour over time and compare themselves with their peers to reflect on their use of healthcare services.

To do this, we used the MaRNet-FP (Maritime Family Practice Research Network) primary care electronic medical record (EMR) dataset containing data from a subset of primary care providers in Nova Scotia, Canada. The dataset has de-identified patient data, including patient visits, diagnoses, prescriptions, chronic conditions, and laboratory data. The data allowed us to investigate primary care providers' testing behaviour. One

significant limitation makes this a challenge: the laboratory data are not labelled with 'a requester of the laboratory tests.' So, we do not know who ordered which tests. We propose a solution as one step to construct the PIT score.

1.1 Problem Statement

Overtesting can be potentially harmful to patients, and Choosing Wisely Canada and the Canadian Task Force on Preventive Health Care have raised questions about overtesting behaviour in primary care, including TSH testing [1], [3]. However, there is no specific data on TSH overtesting in Nova Scotia, and no standards for measuring or grading overtesting behaviour were found published [2]. Furthermore, the MaRNet-FP dataset does not identify laboratory orders ordered by the primary care provider. This study aims to answer those gaps in knowledge with the following objectives.

1.2 Research Objectives

We examined the problems by the following outlined objectives.

1) Develop a method to identify primary care ordered laboratory test results in a dataset with both primary and secondary care laboratory test results;
2) Describe providers' patient demographics in the MaRNet-FP dataset in the years of 2014-2018;
3) Describe providers' practice behaviour (patient visit rates) in the MaRNet-FP dataset in the years of 2014-2018;

4) Describe TSH testing behaviour in Nova Scotia with the MaRNet-FP dataset in the years of 2014-2018;
5) Create a score to grade potentially inappropriate TSH testing behaviour; and
6) Describe some of the consequences for patients who are potentially being TSH overtested.

1.3 Research Approach

The literature around TSH overtesting in primary care is vague. To the author's knowledge, there have not been published methods to grade potentially overtesting behaviour and identify primary care ordered laboratory orders. Also, the rationale behind clinical testing and providers' testing behaviour is also vaguely described in the literature. This study is exploratory in its approach and explores methods that may not have been used before in this context. The study is based on clinical assumptions derived from clinical experience and not found in the literature. Therefore, this study should not be seen as a definitive work but as a beginning to start the debate on overtesting patients and providers who are potentially harming patients. Because of the nature of an exploratory study, the thesis is divided into two main sections: 1) identification of primary care ordered laboratory tests and 2) creation of a potentially inappropriate testing (PIT) score. There are some discussions and conclusions in the first section's results to allow the reader to better understand the second section. The study is a clinical study with the use of health informatics methods.

A recent study from 2021 looked at TSH overtesting in Canada and the United Kingdom [2]. They sought a method to identify primary care ordered laboratory work in EMR laboratory datasets [2]. Those EMR laboratory datasets contain test results from the EMR system user and other users. Unfortunately, the Canadian research networks that pull data from the primary care EMRs do not pull data on the laboratory order's creator.

A method to solve this issue has not yet been published to the author's knowledge. Therefore, we have decided to test two methods. The first one is looking at the proximity of laboratory tests and primary care encounters/visits. The assumption is that most orders are near in time to a visit; either before or after. The second method uses unsupervised machine learning to cluster laboratory orders. The assumption for the second method is that there are unknown patterns of mix-and-match of tests that tell us if a primary care provider ordered the test or not. The performance of the two methods will be compared against each other with a standard primary care laboratory requisition form as the reference.

The second part of the thesis focuses on measuring potential overtesting behaviour, using the TSH test for this study. We created a method that flags primary care providers' repetitive testing behaviour on patients with no relevant diagnoses, prescriptions, or previous history of abnormal test results.

1.4 Contributions

This study aims to support primary care providers testing more appropriately and avoid overtesting. In addition, the work from this study will support local primary care providers' daily clinical decision-making and could be implemented for quality improvement sessions.

This study developed a novel score to quantify and measure potentially inappropriate testing (PIT) behaviour. To the author's knowledge, no other score has been developed and published in the literature. The PIT is based on the assumption that patients with no relevant medical conditions, prescriptions, and no previous abnormal test results are potentially being overtested for a single type of test. In addition, forgiveness is, therefore, built into the PIT score, so only repeated tests are being reported and not the first test. The relevant medical conditions and prescriptions are derived from American and Canadian clinical guidelines. The PIT score is generalizable and can potentially be applied to other frequently used tests with a low number of true positive treatment-dependent cases. The rationale behind the PIT is that repeated behaviour with no beneficial outcomes might pose more harm and benefits and increase healthcare costs. The PIT score is tested and evaluated with MaRNet-FP primary care data. A validation against primary care charts is cumbersome and time-consuming, and it is out of scope for this thesis. Also, the MaRNet-FP dataset does not include free-text chartable comments.

Also, we developed a method to identify primary care laboratory orders within a mixed laboratory dataset. Two proposed methods were evaluated against each other, and a

standard primary care laboratory requisition form, and one method was selected for this study. Both proposed methods can be applied to other laboratory datasets in research studies.

1.5 Thesis Outline

Chapter 2 outlines the current landscape of overtesting behaviour in primary care and reviews the literature on the current ways to measure overtesting behaviour. Chapter 3 includes methods for creating a measure of TSH testing attributable to primary care (see section 3.9) and the analysis of practice testing behaviour (see section 3.10). Chapter 4 presents the results of the measure and the testing behaviour. We will discuss the findings in relation to the literature in Chapter 5 and touch on the limitations of this study in Chapter 6. Finally, the conclusion will be presented in Chapter 7.

CHAPTER 2: BACKGROUND

2.1 Primary Care

The healthcare system in Canada is mainly built on primary and secondary healthcare sectors, and in some cases, a tertiary sector [4], [5]. All sectors have integrated gatekeepers within the sectors and between them, and only relevant patients are moving forward to more specialized care [6]. Canada is known for a robust gatekeeping system between primary and secondary care with a high rate of referral letters [6]. The public has direct access to the healthcare system via primary care providers, and they are, in most places, family physicians, nurse practitioners, pharmacists, physiotherapists, private psychologists, dietitians, etc. [4]. Furthermore, most care is delivered within primary care [7]. On the other hand, secondary healthcare consists of local and regional emergency departments, specialists, etc. Finally, the tertiary sector has higher specialized units within the local authorities, regions, or national levels [5]. For the rest of this study, the health systems will be divided into primary care and secondary care, where secondary care includes tertiary care.

The role of primary care is to promote a healthy lifestyle, prevent poor health outcomes, screen for early-stage conditions, diagnose and treat diseases within the primary care scope, provide continued care, and follow up on care plans arranged in the secondary sector [4]. In addition, primary care providers are responsible for correct referrals when patients' medical conditions need specialist care.

Primary care providers (family physicians and nurse practitioners) are the first line of gatekeepers for the healthcare system. They make sure only a fraction of their patients is referred to the secondary health sector. Their goal is only to send the patients that cannot be diagnosed and treated within primary care to the specialists. The gatekeeping system is in place to control unnecessary healthcare spending and provide an appropriate level of care for each patient [8].

There is a limited number of primary care providers in Nova Scotia, and not all residents have a designated provider [9]. As a result, unlisted patients are dependent on care from walk-in clinics and emergency departments (EDs). Since no universal electronic health record (EHR) exists yet in Nova Scotia, walk-in clinics work in silos with little previous medical history in their EMRs, and repeated work is inevitable [10].

2.2 Defensive Medicine

Defensive medicine began in the 1970s as a response and protection in fear of being sued for malpractice [11]. It is defined as "…medical care provided by physicians mainly for preventing the risk of litigation." [12]. In self-reported surveys from several studies, 75 to 98 per cent of physicians have taken part in defensive medicine [13].

Healthcare professionals' two main tasks are diagnosing and treating, and they are both potential targets for defensive medicine—leading to potential overdiagnosing and overtreatment. Early on, errors by wrong treatments were dominant in US malpractice lawsuits, but since the mid-twentieth century, it changed to errors by wrong diagnosis

[11]. Overdiagnosing and overtreatment are in the ‘positive’ category, where the provider does more than expected. The ‘negative’ category is the opposite; refusal of care in high-risk patients, which is happening to a lesser extent [12]. This study will focus on the ‘positive’ category.

With the current legal system in healthcare, it is always better to overdo/overcare than do less care, which likely will lead to overutilization [12]. The field of medicine can be considered both an art and science. Art captures and allows intuitions, probability, rationality, and unpredictability in the decision-making process that can overrule the ‘right’ stringent scientific decision [12], [14]. The art of medicine and its human intuitions ‘not to overdo it’ can be challenging to defend in a courtroom, and we will often see that one clinician’s judgment differs from other clinicians' judgments.

Failure of diagnosis is one the most significant causes of medical errors [14], and pressure to not fail can enhance overdiagnostic behaviour. Providers’ behaviour can be divided into two groups 1) ‘intuitive decision making’ and 2) ‘analytic decision making’ and suggests using the intuitive decisions in low-risk areas and analytic decisions in high-risk areas to make rational decisions [14]. Providers might ‘let their guards down’ and have a less restricted gatekeeping role when making irrational, intuitive decisions without analytic thoughts.

2.3 Overtesting and Overscreening

When a healthcare provider is overtesting, the harmful consequences of the test are greater than the potential benefits of the test [7], [15]. Overscreening has the exact definition, except it is a generalized behaviour across a population or part of an official screening protocol.

Over 60 per cent of healthcare providers from high-malpractice-risk specialties in the US, for example, emergency medicine, reported ‘sometimes’ or ‘often’ overtesting as part of defensive medicine, and 57 per cent in low-malpractice-risk physicians, including primary care providers [13].

Diagnosing is complex, and diagnosing in primary care is challenging because of the high prevalence of healthy patients and low prevalence of severe conditions and diseases [7]. It is estimated that 40 per cent of encounters in primary care needs testing to support patients’ symptoms and signs and physical examination before a diagnosis can be made [7]. The high volume of patient encounters in primary care combined with the essential gatekeeping role and testing behaviour makes a system prone to overtesting.

Both over- and undertesting are inappropriate, and they can potentially delay diagnoses and treatments—or even delay the confirmation that a patient is healthy [7].

Undertesting can lead to undetected or inappropriately treated medical conditions [7]. On the other hand, overtesting has been shown to overdiagnose patients with conditions [7],

and those conditions might never progress or are not treatable. Other consequences are labelling patients with conditions that make patients anxious and adding a financial burden on patients and the healthcare system [16], [17]. Also, the wait time from a test is taken to its results can be an emotional stress factor for some patients [18]. Overtreating patients might increase the risk of prescribed treatments' adverse effects and side effects. Overtesting can start a vicious cycle leading to overdiagnosing and overtreatment and generate the desire to test even further.

The drivers for overtesting can come from the healthcare providers, patients and their loved ones, and the healthcare system [17], [19]. Simply not following recommendations or poor training of the providers make them vulnerable to overtesting behaviour in their clinics. Patients and relatives can be desperate to get answers/certainty, and providers might be ‘persuaded’ to order potentially unnecessary tests. The healthcare system may also have a low tolerance for mis- and underdiagnoses, driving providers to overtest their patients.

Choosing Wisely Canada is an organization that promotes and writes guidelines for appropriate and reasonable use of testing, diagnosing, treatment, and care among Canadian healthcare providers [20]. They have published a list of 13 potential items that need to be discussed in primary care, and thyroid function tests are listed [1].

2.4 Thyroid Function Test

The thyroid gland is one of the metabolism regulators in the human body, and the gland is regulated by the thyroid-stimulating hormone (TSH) [21]. Most endocrine conditions are in relation to the thyroid gland [16]. TSH is produced and regulated by the anterior pituitary gland [21]. The thyroid gland produces T3 (triiodothyronine) and T4 (thyroxine) hormones, whereas the T4 hormone is less effective on the metabolism, and it is converted to T3 as an active hormone [21]. T3 stimulates growth and development in the human body cells by increasing the basal metabolic rate [21]. Furthermore, T3 increases cardiac output and heart rate [21]. There is a negative feedback loop system between TSH and T3/T4, where an increase in T3/T4 decreases the TSH secretion, and then the T3/T4 secretion is decreased [21]. TSH, T4, and T3 are together forming a thyroid function test [21]. If TSH is within a normal range, T4 and T3 are typically not analyzed, and the thyroid function test is simply a TSH test [21]. A negative TSH test is good at confirming no primary thyroid conditions because of a high negative predictive value [22].

There are three states of the thyroid gland [16] and its function on the human cells:

- Euthyroidism (normal function)
- Hypothyroidism (abnormal decreased function)
- Thyrotoxicosis/hyperthyroidism (abnormal increased function)

Hypothyroidism is over three times more common than hyperthyroidism [23].

There is also an asymptomatic version (no symptoms) of the hypothyroidism called 'subclinical hypothyroidism,' and the same with the opposite condition 'subclinical hyperthyroidism' characterized as elevated thyroid function and also no symptoms [16].

There is an overview of the main thyroid conditions in Table 2-1 [16].

Table 2-1. Main thyroid conditions.

Condition [16]	**Symptoms**	**TSH testing**	**T3 and T4 testing**
Euthyroidism	asymptomatic	normal TSH	no T3 OR T4 tests
Hypothyroidism	symptomatic OR asymptomatic	elevated TSH	low T4
Subclinical hypothyroidism	asymptomatic	elevated TSH	normal T4
Hyperthyroidism	symptomatic OR asymptomatic	low TSH	low T3 OR T4
Subclinical hyperthyroidism	asymptomatic	low TSH	normal T3 OR T4

The symptoms of hypothyroidism and hyperthyroidism are often vague and widespread, such as fatigue, constipation, weight gain/loss, weakness, sweating, nervousness, depression, impaired memory, and anxiety [24], [25].

A patient can transit between each stage throughout life without medical treatments [16]. For example, a US study estimates 4.3 per cent of subclinical hypothyroidism in the population [23], and over a third of subclinical hypothyroidism patients in a Spanish study had a normal thyroid function years later [26].

There is insufficient hard evidence, such as mortality rates, suggesting improvements when diagnosing and treating an asymptomatic non-pregnant patient with a thyroid condition [16]. Therefore, early screening is not recommended by the American USPSTF (United States Preventive Services Task Force) [16]. In addition, Choosing Wisely Canada does not recommend TSH screening in asymptomatic patients [1]. On the other hand, there is no evidence suggesting harm from early screening [16].

Hypothyroidism is treated with synthetic T4 hormone substitution, called levothyroxine, as a tablet, and the dose is adjusted over time to patients' TSH and T4 levels [16]. Hyperthyroidism is treated with either anti-thyroid drugs, called methimazole, or radioactive iodine, and in some cases, surgery to remove excessive thyroid-producing gland [16].

2.5 TSH Overtesting—The Perfect Storm

TSH overtesting is 'the perfect storm' since each clinical action by the healthcare provider creates more 'wind' of potential inappropriateness and increases the risk of potentially overtesting behaviour with potentially harmful effects for the patient. First of all, many providers are generally practising defensive medicine and are generally overtesting [13]. Overtesting is generally a 'safer' legal choice than undertesting [12], and it motivates providers to overtest their patients. The 'storm' gets additional 'wind' by combining widespread defensive medicine with little medico-legal actions and frequently used TSH testing [16], [27]. Furthermore, the risk of having an abnormal test result is

low, and even if a TSH test result is abnormal, it is still likely part of the normal physiological fluctuation of TSH levels in the bloodstream [16]. Therefore, the few abnormal test results are likely not a sign of an illness. Finally, the 'storm' gets its last additional 'wind' from unnecessary treatments. Treatments in most cases are not supported with evidence for the subclinical hypothyroidism, and may pose a higher risk of side effects [16].

A US study found an annual primary care TSH-screening-rate of 18 % in 2002 [28], and a recent Canadian-UK study showed that a third of primary care patients had a potentially inappropriate TSH test every two years [2]. Another Canadian study found an uptake in TSH testing behaviour after implementing EMR systems with better laboratory modules in primary care [27]. This contradicts the idea of an increased level of care when using EMRs. A cascade of inappropriate events could happen if patients are casually TSH screened without reasonable considerations. TSH screening could lead to overdiagnosis, overtreatment, and side effects from treatments (see Figure 2-1).

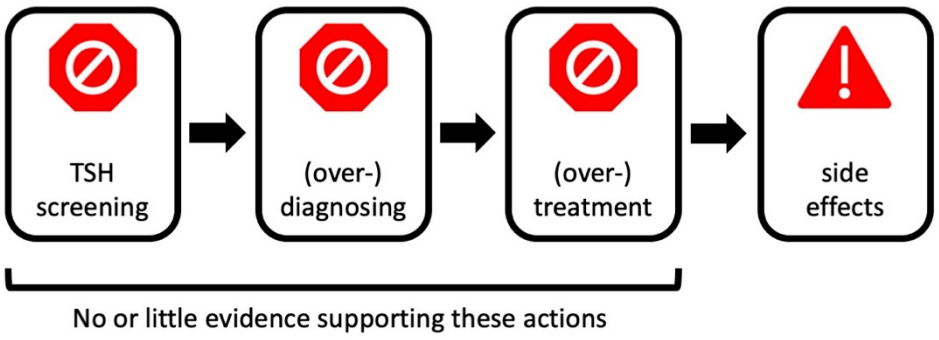

Figure 2-1. The perfect storm.

There is little evidence supporting TSH screening in asymptomatic patients (patients with no symptoms), except pregnant patients [16]. Patients who end up with a hypothyroidism diagnosis are being labelled as 'sick', even though some patients are normalizing or stabilizing their TSH levels on their own without any medical interventions [16]. It is not possible to predict whether patients with high TSH levels end up with treatment-required hypothyroidism or the hypothyroidism is self-limiting, which highlights the importance of re-testing abnormal TSH test results before diagnosing a patient [16]. The follow-up procedures for patients depend heavily on TSH levels and less on clinical signs and symptoms [16]. Furthermore, treatments can cover up patients' laboratory work. Therefore, it is difficult to know and track whether the patient needs the treatment or it is a self-limiting condition [16]. As mentioned earlier, the treatments can have side effects and pose more harm than benefits for non-pregnant asymptomatic patients [16].

The bottom line is that it is not recommended to screen asymptomatic and non-pregnant patients for thyroid conditions with TSH tests, and TSH-overtesting can pose more harm than benefits to the patients.

2.6 Potentially Inappropriate Testing (PIT) Score

Several literature searches were performed to find other published scores on overtesting behaviour for TSH testing. For the first search, we used PubMed on April 7, 2022, and the search terms "score" AND "thyroid" AND "overtesting", as well as "score" AND "TSH" AND "overtesting", and no studies were found in the human literature. A second

literature search, exploring a more generalized inquiry about inappropriate testing, and performed on PubMed on April 7, 2022, using the search terms “inappropriate” AND “score” AND “laboratory testing” yielded 123 studies in English. Finally, we searched adding the additional terms “overtesting” AND “score” with 11 found studies. One duplicate was removed. All 133 studies’ titles and abstracts were read using Rayyan online platform [29]. Six abstracts were found relevant, and the full papers were read, but none of them were about the scoring of TSH overtesting [30]–[35]. One of the studies created a health-economic score for primary care providers in Canada to estimate the financial savings of less overtesting if providers had a capitation model and rostered their patients [30]. They used another test, HbA1C (hemoglobin A1c), as an example and flagged repeated tests within three months [30]. None of the studies created a score where patients’ history of relevant conditions and prescriptions were included. The inappropriate nature of repetitiveness within a decided period by Chami et Sweetman, 2019, [30] was used in the proposed PIT score in this study.

CHAPTER 3: METHODS

We will first describe the data source and inclusion criteria, and then the data cleaning process. It will be followed by the methods for primary care ordered laboratory test identification, and then the testing/overtesting behaviour in the investigated population will be described. Figure 3-1 shows an overview of the used methods and the steps. In this study, the MaRNet-FP dataset will be used, and inclusion criteria will be applied to make sure we have a representative adult patient population; and a primary care provider population that has regular clinical activities. The dataset will be cleaned to remove duplicates and reorganize data in the correct columns in each table. Minor patient records will be removed. All laboratory test names will be grouped into a smaller set of names, and non-blood tests will be removed. Two methods to identify primary care ordered laboratory tests are proposed and evaluated. The best method (A or B) will be applied in the rest of the study. A PIT score is proposed and applied to the cleaned dataset after using one of the two methods (A or B). Finally, the consequences after a PIT event will be detected in two analyses: the number of laboratory orders after a PIT event and the number of encounters with the primary care provider after a PIT event.

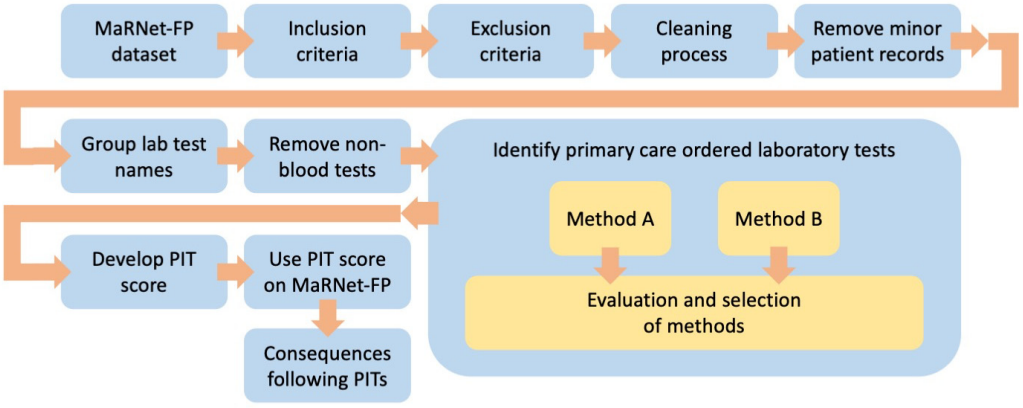

Figure 3-1. Overview of the methods.

3.1 Data Source

The data for this study is provided by MaRNet-FP (Maritime Family Practice Research Network) [36], which is one of the subnetworks in the pan-Canadian primary care research collaboration CPCSSN (Canadian Primary Care Sentinel Surveillance Network) [37]. MaRNet-FP has been extracting electronic medical records (EMRs) data quarterly from participating primary care providers in Nova Scotia since 2009.

The dataset for this study was the 2018 Q4 (fourth quarter) dataset that contained de-identified patient data from January 1, 2009, to December 31, 2018. All primary care providers in Nova Scotia were moving to new EMR platforms during 2019 without full validation of the historical patient records. Therefore, the 2018 Q4 is likely the most accurate dataset for research purposes until further validation is completed.

3.2 Data Tables

The following data tables and variables from the MaRNet-FP dataset have been used for this study. They have all associated with a: “Patient ID,” “Provider ID,” and “Site ID” (clinic ID). The variables include:

- Patient demographics: gender/sex*, birthyear
- Primary Care Provider: gender/sex*, birthyear
- Laboratory test results: test name, test result, normal test result range, date
- Encounters: date
- Encounter diagnosis: diagnosis names, date
- Chronic conditions: type of chronic condition per CPCSSN definition [38], date
- Prescriptions: medication names, start date, stop date
- Billing: date

* It is not specified if the variable and data entry were labelled as gender or sex.

3.3 Research Ethics Board Approval

The study was approved by the Nova Scotia Health Authority (NSHA) Research Ethics Board (REB), file number 1025135.

3.4 Inclusion Criteria

The inclusion criteria for the patients were:

- Adults (age ≥ 18 years)
- Defined as 'active patient' at the time of December 31, 2018, by the CPCSSN's definition with at least one encounter during the last two years

The EMRs are not always updated when patients are deceased or have left the clinic. The 'active patient' definition helps identify the patients likely to be alive and still attached to the clinic for research purposes. MaRNet-FP has only provided data for 'active patients.'

To be included, primary care providers had to have more than 20 encounters per month on average over a year for all included years (2014, 2015, 2016, 2017, and 2018). The minimum-encounter inclusion criterion was based on clinical reasoning by the researcher and Dr. Fred Burge.

Any records of diagnosis and medication were included, also the ones before 2014. Diagnoses and medications from patients' pre-adulthood are relevant for testing behaviour during patients' adulthood, and these records were kept.

3.5 Cleaning Process

The dataset was given as CSV files, a table for each area of the EMR, such as the laboratory test results table. See the list of tables under 3.2 Data Tables. Unfortunately, the text strings in the CSV files were not surrounded by quotation marks, and therefore, some of the strings were split up in more than one column. These strings were merged

and repaired. In addition, non-completed rows, or rows with noise (not recognizable data), and duplicates were removed. TSH test results without a laboratory test reference range were imputed by the median of the lower and upper boundaries from the known reference ranges in the rest of the dataset.

3.6 Removal of Minor Age Patients

All patient events, such as laboratory test results and encounters dated before the patients were 18 years old, were not used for further analyses. However, previous prescriptions or diagnosis codes from an earlier age were kept as historical data since they were relevant for testing behaviour later in adulthood. Since the dataset only had the birth year of patients, all patients were set to have “December 31” as the birthdate to make sure we did not include minor age patient records.

3.7 Grouping Laboratory Test Names

The laboratory test names were not standardized in the dataset, and some of the test names were named differently over the years--different laboratories is another possible explanation. The laboratory test names were grouped within larger classes. Categorizing laboratory names simplified the identification of primary care laboratory orders for the research purpose. The researcher categorized the laboratory test names based on his clinical experience in primary and secondary care. 24 % of the names could not be classified, and they were named NA (not applicable). The grouped laboratory names were reviewed by Dr. Fred Burge. Please find the complete list of grouped names in Appendix A.

3.8 Removal of Non-Blood Work in the Laboratory Dataset

The laboratory dataset contained other laboratory samples than blood work (serum or plasma). Therefore, samples identified as ‘bacteria,’ ‘cerebrospinal fluid,’ ‘fecal,’ ‘semen,’ or ‘urine’ were removed from the dataset.

3.9 Identify Primary Care Laboratory Orders

The laboratory dataset contained orders from providers other than the primary care providers. The other providers could be specialists from the secondary care sector and emergency departments. None of the variables in the dataset informed us who ordered the laboratory order or whether a laboratory order was ordered by a primary care provider or another provider. Since the study aims to look at overtesting behaviour of primary care providers, it was essential to differentiate the primary care laboratory orders from the non-primary care laboratory orders. To our knowledge, no strategy to support this process is presented in related literature.

3.9.1 Selected Methods to Identify Primary Care Laboratory Orders

The study proposed two methods to identify primary care laboratory orders. It is critical for the next steps in this study to know ‘who ordered what’ in the laboratory dataset. The laboratory dataset has mixed primary and secondary laboratory orders, and the study is only interested in primary care ordered laboratory orders. The proposed methods were developed by the clinical research team as possible solutions with the data that was available. The first method (Method A) assumed that a laboratory order made by a

primary care provider was within a close time window from the nearest encounter. The second method (Method B) used unsupervised machine learning to cluster laboratory orders in primary care and non-primary care orders. And a reference model was created based on a simple match-up with a primary care laboratory requisition form (please see Figure 3-2). These methods would not have been necessary if there was a variable indicating the ordered provider in the MaRNet-FP dataset.

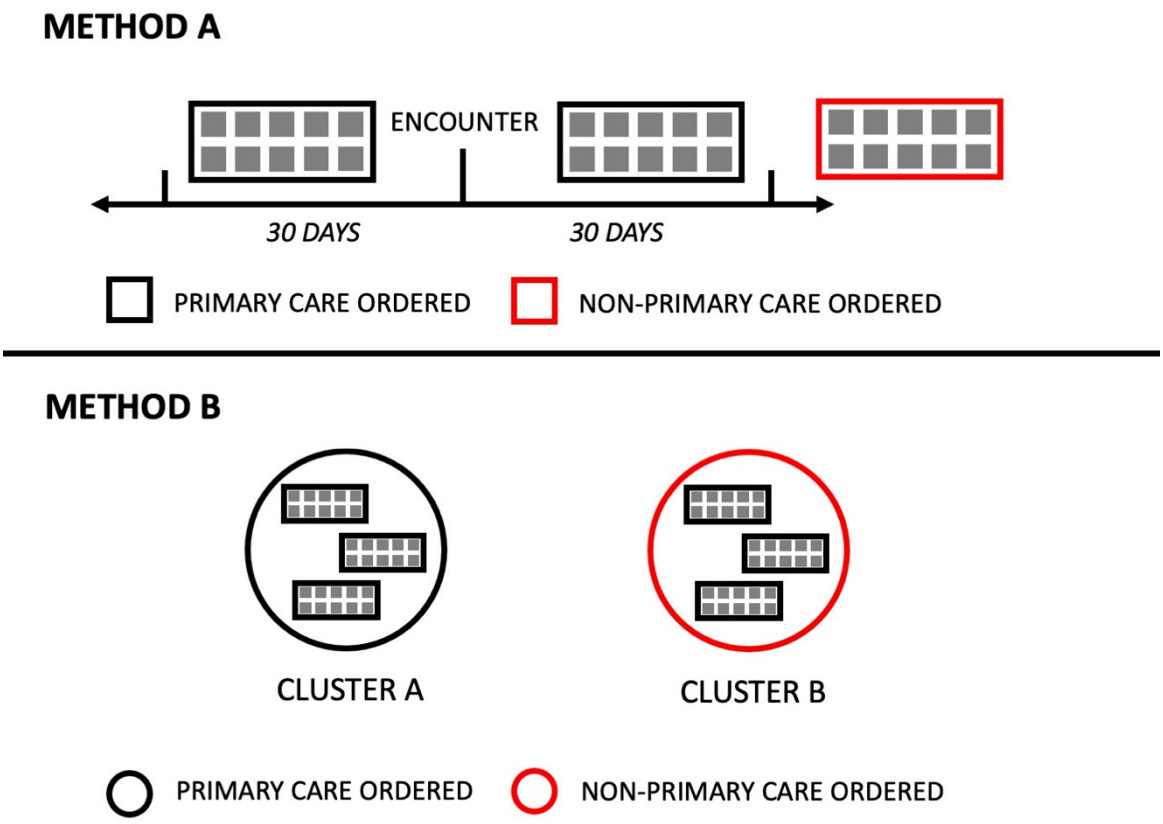

Figure 3-2. Method A and B.

Laboratory orders (the box frames) with laboratory tests (the squared boxes) performed outside a 30-day window in Method A were excluded as non-primary care tests.

Unsupervised machine learning was used to cluster laboratory work in Method B. The primary care tests can be found in the Appendix C.

3.9.2 Definition of a Laboratory Test and Order

A laboratory order in this study was defined as one or more laboratory test results for a single patient in a single day (see Table 3-1).

Table 3-1. Definition of a laboratory test and order.

Laboratory test	*A single laboratory test result for a given patient.*
Laboratory order	*A list of one or more laboratory test results for a given patient on a given day.*

3.9.3 Common Primary Care Laboratory Tests

There were no obvious standard and unique primary care ordered tests within the dataset. Instead, the primary care laboratory requisition forms had been collected from each Nova Scotia health zone except the Eastern zone. Unfortunately, it was impossible to locate the form from the Eastern zone. The requisition forms are tick-off forms with the most common laboratory tests and a free-text field for additional and more specialized test orders. The Northern and Western zone forms were not specialized for primary care providers and captured a more general approach, including secondary care. The form from the Central zone is specialized for primary care providers. Please find the requisitions forms in Appendix B. The requisition form from the Central zone had been chosen to reflect a typical primary care laboratory order pattern. The blood work

laboratory names on the form are named by the same 'group names' described earlier. Dr. Fred Burge reviewed the list (please find the list in Appendix C).

We made a few modifications to the primary care laboratory test list in Appendix C. The blood test 'Total CO_2' from the requisition form are not represented in Appendix C since it creates confusion with the acute blood gas test 'CO_2'. Furthermore, we did not find the blood tests for 'Epstein-Barr virus/mononucleosis,' 'syphilis,' or 'lyme disease' in the laboratory dataset. Those three tests were on the Central Zone primary care requisition form in Appendix B. On the other hand, we added 'T3 (triiodothyronine)' and 'T4 (thyroxine)' blood tests to the list the Appendix C. T3 and T4 are usually automatically added to the laboratory order by the laboratory if the TSH blood test is abnormal.

3.9.4 Removal of Common Secondary Care Laboratory Tests

Some laboratory tests are clinically highly likely used in an acute and emergency department setting. The researcher identified the acute laboratory tests based on his clinical experience in primary and secondary care. Therefore, laboratory orders containing any acute blood work were removed, as they were likely ordered outside a typical primary care setting (please see Figure 3-3). Please find the list of acute blood work in Appendix D. The list was reviewed by Dr. Fred Burge.

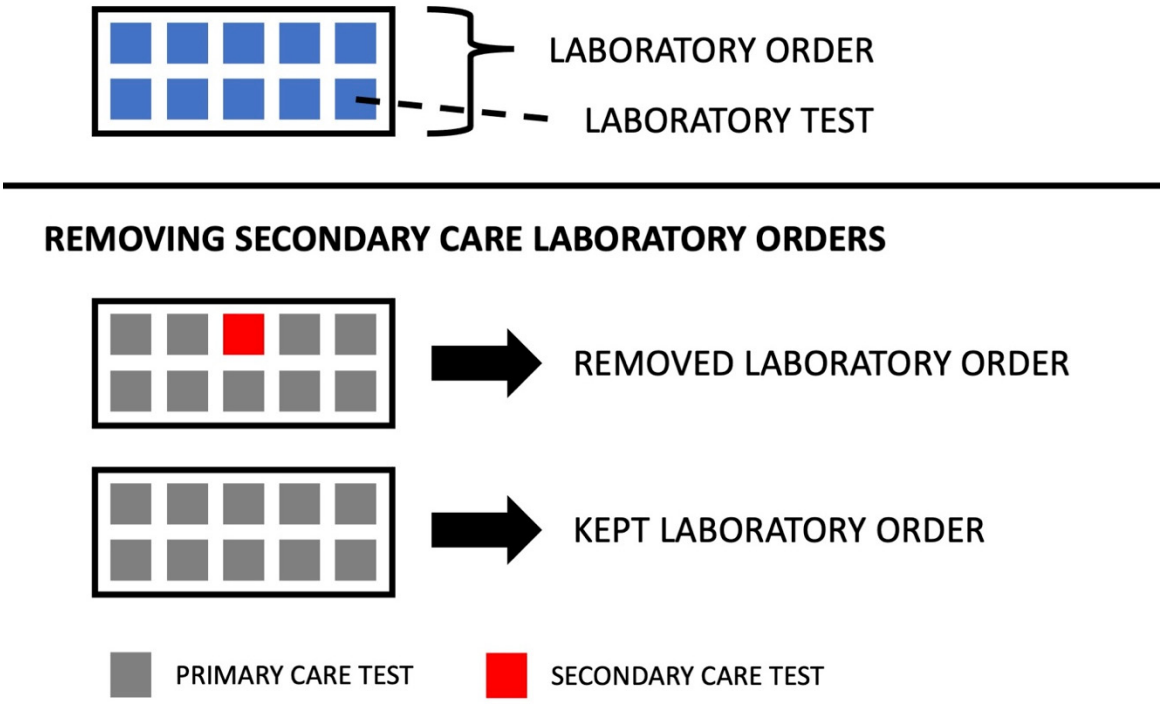

Figure 3-3. Removal of secondary care tests.

3.9.5 Method A: Near-Encounter Assumption

Primary care laboratory orders could be identified based on the assumption that a primary care laboratory order is placed near an encounter with the same provider or clinic. The number of days of nearest encounter for each laboratory order was found. The closest encounter could happen both before and after the laboratory order. For example, some providers might want a laboratory test before seeing the patient, and in other circumstances, the laboratory order is placed after the consultation. Models were constructed with a symmetric range of days before and after each encounter: ± 7 days, ± 14 days, ± 21 days, and ± 28 days. They all included the days of the encounter. The pragmatic reason for these four ranges was based on clinical experience by the researcher and clinical the co-supervisor, Dr. Fred Burge. Laboratory orders outside this window

were removed. The four ranges were evaluated by comparing them to the reference model (see 3.9.7).

3.9.6 Method B: Unsupervised Machine Learning

The second method was to apply unsupervised data mining to identify primary care ordered laboratory orders. The intention of this analysis was to use unsupervised machine learning to find clusters that could represent clusters for primary care ordered laboratory orders. Kmeans (baseline) [39], [40] and GMM (Gaussian Mixture Model) [41], [42] are applied to cluster the laboratory orders for comparison. Other recent studies have used GMM to cluster health-related data [43]–[47].

We used a workstation to apply the algorithms with the following specifications: Intel Core i9-9900 vPro, 3.10GHz, up to 5.0GHz with Turbo Boost, 8 Cores, 16MB Cache, 32 GB ram, NVIDIA Quadro P1000 4GB, Windows 10 Pro 64, Python 3.7, RStudio 1.4.1106, R 4.0.4.

The laboratory dataset was prepared for analyses by being rearranged to have each laboratory order per row and a binary test value. ‘Ones’ were for the tests that were taken and had a test result. ‘Zeros’ were for the tests with no test results in that particular laboratory order. See an example in Figure 3-4.

Laboratory order	Test
0001	WBC
0001	RBC
0001	TSH
0002	HGB
0003	TSH

Laboratory order	HBG	RBC	TSH	WBC
0001	0	1	1	1
0002	1	0	0	0
0003	0	0	1	0

Figure 3-4. An example of preparation of the laboratory dataset.

HBG: Hemoglobin. RBC: Red Blood Cells. TSH: Thyroid-Stimulating Hormone. WBC: White Blood Cells.

To increase the speed of the models, decomposition (reducing the dimension of the dataset) was used. The 139 features were reduced to a lower-dimensional space with TruncatedSVD and PCA. SVD sees the data points from the best possible angle where the data is spread most out to form clusters of associated data points. The following Figure 3-5 shows an illustrative example of a feature reduction from 4 to 2 with SVD [48]. PCA is centring the data to the origin of the axes before the reduction of the dimension (see Figure 3-6) [49].

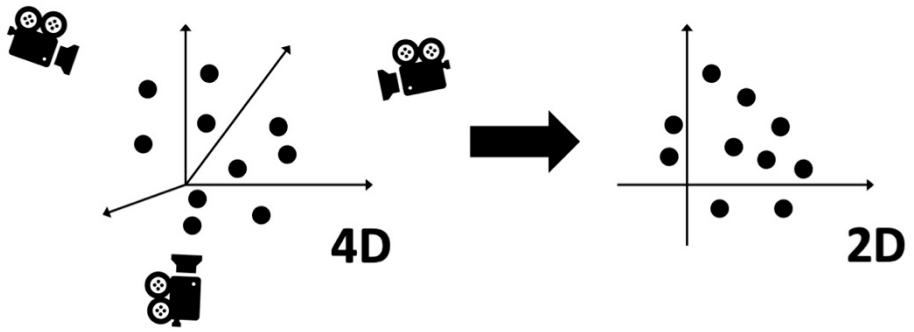

Figure 3-5. An illustration of SVD.

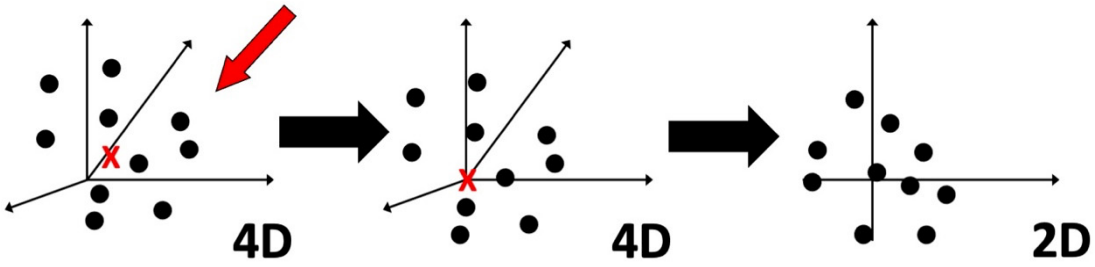

Figure 3-6. An illustration of PCA.

The explained variance ratio of SVD and PCA was calculated for the first 20 reduced dimensionalities (ranks), and there was an elbow sign at the three dimensions (ranks) for both models (see Figure 3-7 and Figure 3-8). Therefore, the 139 features were reduced to a three-dimensional space with SVD and PCA (see Figure 3-9 and Figure 3-10).

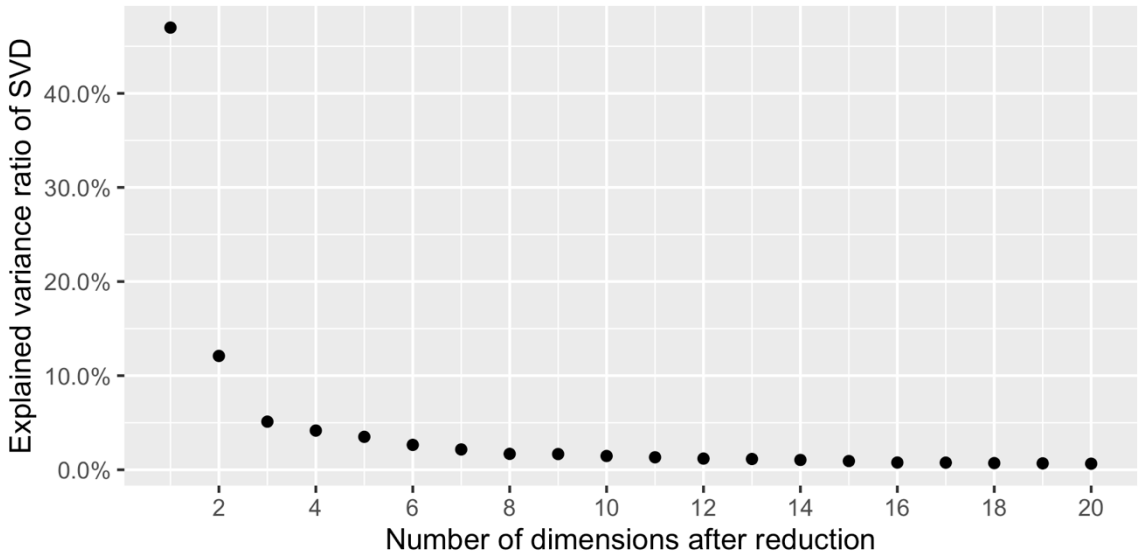

Figure 3-7. Explained variance ratio of SVD.

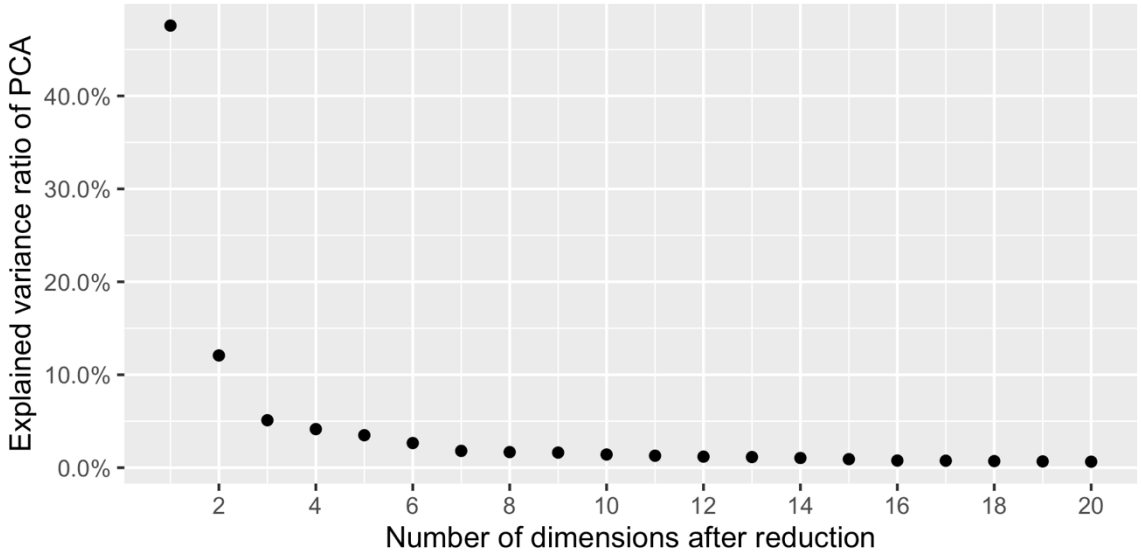

Figure 3-8. Explained variance ratio of PCA.

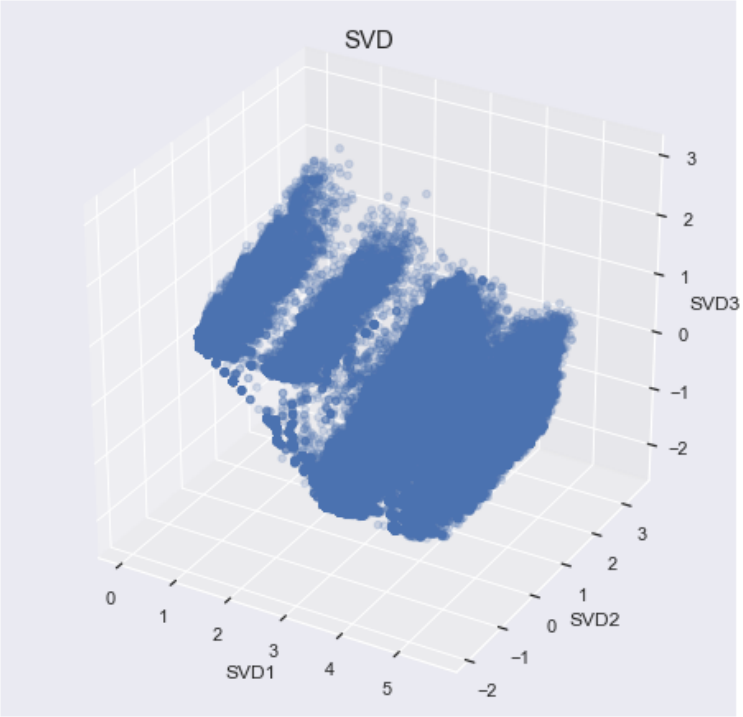

Figure 3-9. Three-dimensional space with TruncatedSVD.

A three-dimensional scatter plot of the reduced laboratory orders. SVD1 had an explained variance ratio of 0.47, SVD2 of 0.12, and SVD3 of 0.05, which together (0.64) is acceptable.

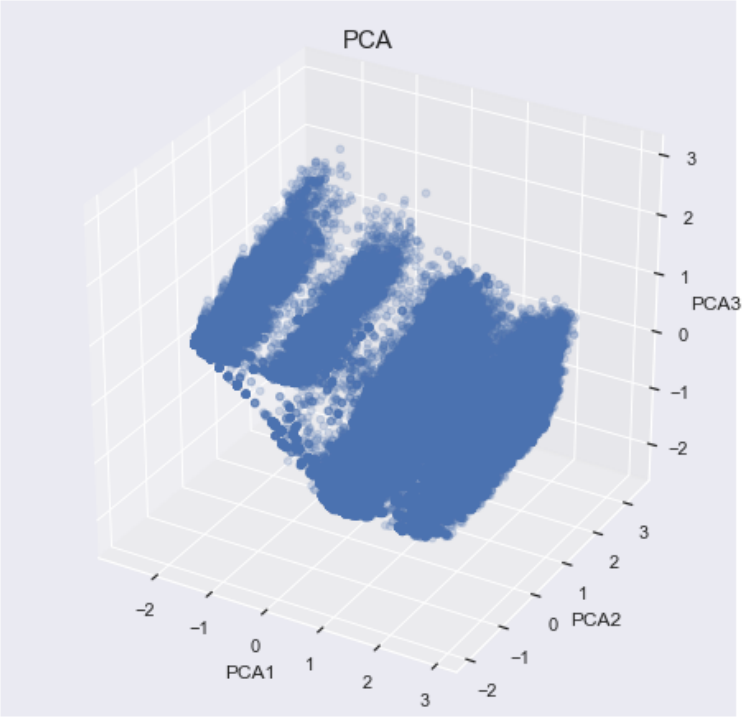

Figure 3-10. Three-dimensional space with PCA.

A three-dimensional scatter plot of the reduced laboratory orders. PCA1 had an explained variance ratio of 0.48, PCA2 of 0.12, and PCA3 of 0.05, which together (0.65) is acceptable.

TruncatedSVD (singular value decomposition) is normally chosen over PCA (Principal Component Analysis) since it is known for being better at reducing features of sparse datasets [49], [50]. Most patients in primary care are presumably healthy and did not have all tests done in each laboratory order. The prepared binary laboratory dataset (292,616 rows x 139 columns) was sparse since not all laboratory orders have included all 139 laboratory tests. Only 11.4 % of the binary dataset contained ‘ones,’ and the rest had ‘zeros.’ Although, the PCA model had a slightly better explained variance ratio, and it was chosen for this study.

The aim of the Kmeans and GMM was to cluster the laboratory orders into two categories: primary care ordered and non-primary care ordered, and therefore, the number of clusters was preferable two. Silhouette scores for 2 to 10 number of clusters for the baseline clustering model, Kmeans, were calculated and the highest value was at 2 clusters (see Table 3-2). A high silhouette score is preferable for a good fit of the clusters, and the two clusters are shown with red and blue colours in Figure 3-11.

Table 3-2. Silhouette scores for Kmeans.

	Number of clusters								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Silhouette scores	*0.655*	*0.646*	*0.652*	*0.641*	*0.614*	*0.611*	*0.598*	*0.584*	*0.582*

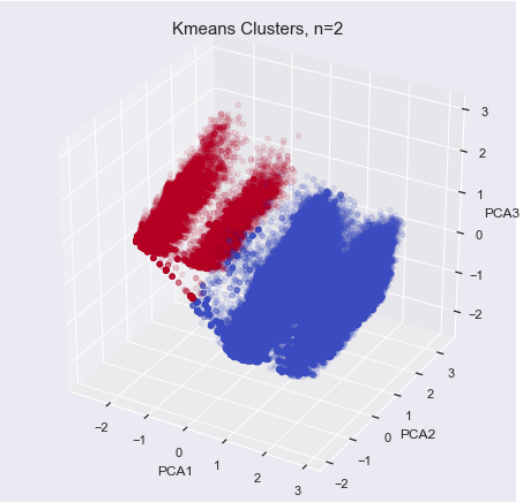

Figure 3-11. Kmeans cluster evaluation with two coloured clusters.

Compared to Kmeans, GMM can create more complex clusters, including elliptical patterns [51], [52]. The GMM clustering algorithm is known to be computationally fast and has the advantage that it can cluster datasets with more shapes (epileptical and spherical shapes) seen in Figure 3-9 [53]. GMM is based on a probabilistic model and uses probability and randomness opposite of a deterministic model that has no randomness [53], [54]. The model calculates the probability of each data point is in each of the clusters. The normal distribution in statistics, also called 'the bell curve,' is based on Gaussian distribution, and the name, Gaussian Mixture Model, comes from the use of the normal distribution and is a mixture model [55]. A mixture model means a model that can find sub-groups in a group without knowing the identity of the sub-groups [56].

We tested all four available covariance types: 'full,' 'diag,' 'spherical,' and 'tied' with BIC (Bayesian Information Criterion) applied to find the optimal number of clusters among the laboratory orders in the range of 1 to 10 clusters. 'Full' covariance type can group each cluster in any shape and position [41]. 'Diag'/diagonal covariance type can group each cluster horizontally or vertically along the axis [41]. 'Spherical' covariance type can group each cluster in spherical patterns like Kmeans [41]. 'Tied' covariance type can group each cluster in any epileptical/spherical shape but each cluster must be in the same shape [41].

The lower the BIC-value is in the following BIC curve plots, the better the fit of the clusters (see Figure 3-12). We looked for a large drop or sharp horizontal bend in BIC-value and further investigated the clusters using the number of clusters at the drop/bend.

We wanted to find a binary clustering and looked at the first large drop with number of 2 clusters.

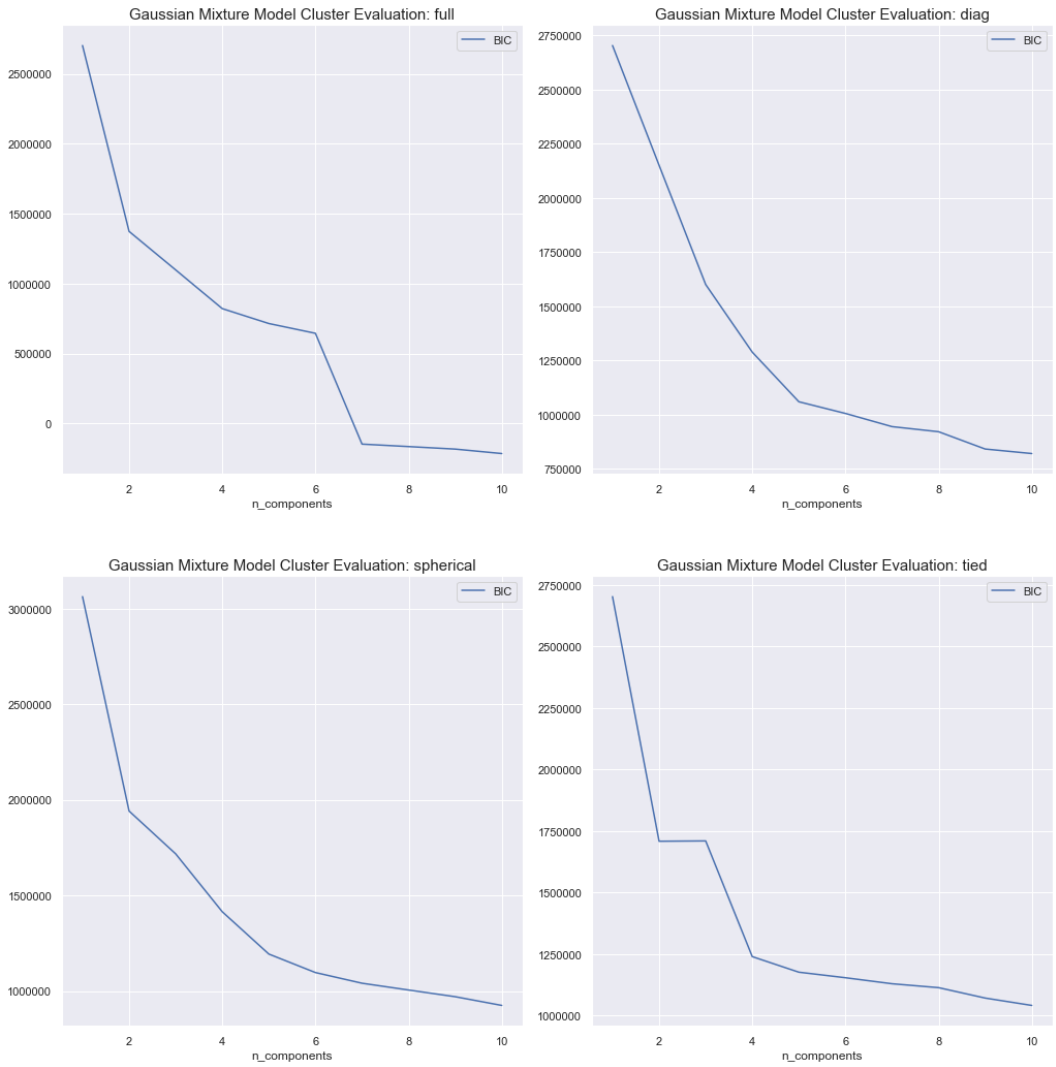

Figure 3-12. GMM cluster evaluation with BIC and covariances.

Three of the BIC plots ('full', 'spherical', and 'tied') in Figure 3-12 have a drop at 2 clusters and then flattening (the 'elbow sign'). The 'diag' covariance plot has an elbow sign at 5 clusters. The 'full', 'spherical', and 'tied' models were selected with our chosen cluster number of two.

Four GMM plots with 2 clusters is seen below for comparison (see Figure 3-13).

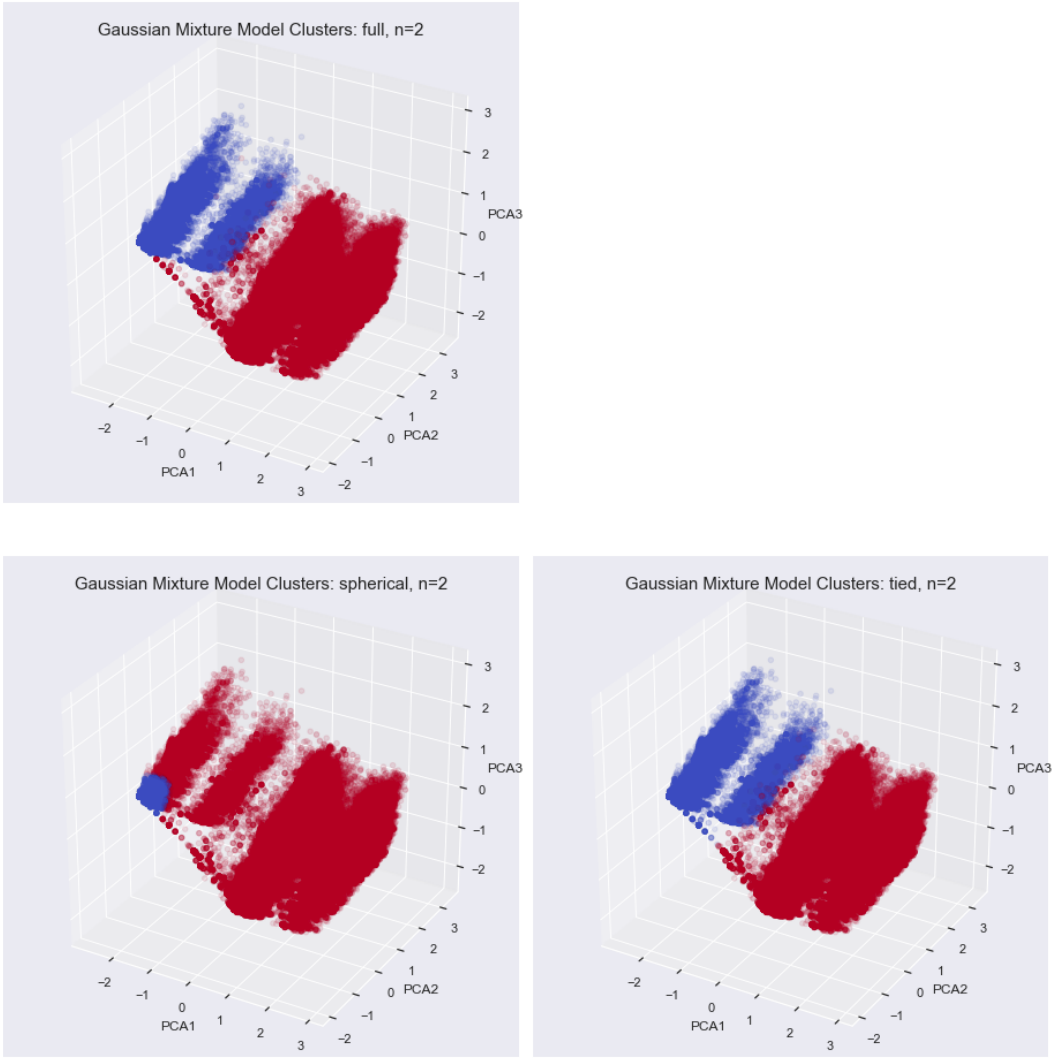

Figure 3-13. GMM cluster evaluation with covariances and 2 coloured clusters.

The plots visualize two clusters, each with blue and red colours. The spherical plot had not a very intuitively placed cluster at the tip on the left-handed side. The ‘full’ and ‘tied’ plots were almost identical, but the ‘full’ model had a smaller BIC-value at 2 clusters and was selected for further investigation.

The final Kmeans and GMM models are shown below (Figure 3-14).

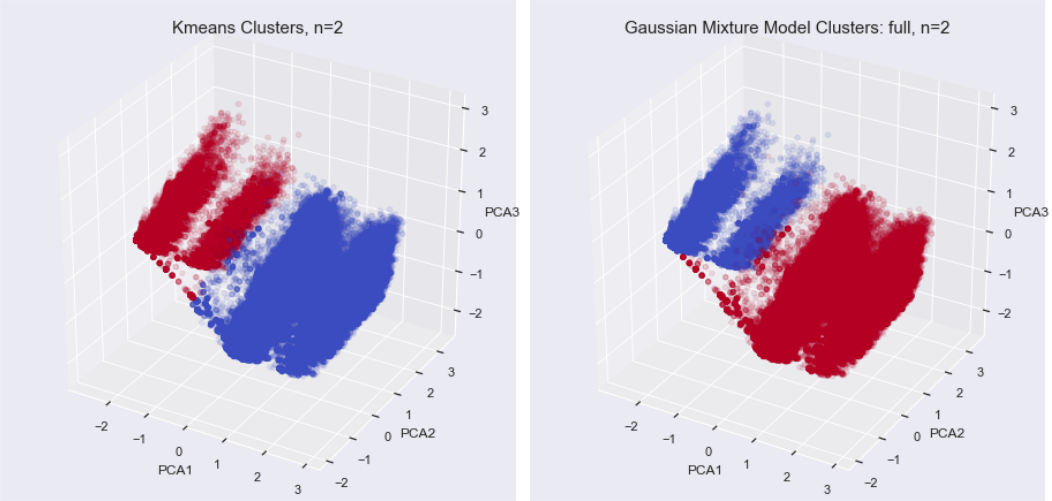

Figure 3-14. Chosen Kmeans and GMM models.

Kmeans plot: red dots: cluster 1; blue dots: cluster 0. GMM plot: red dots: cluster 0; blue dots: cluster 1.

Each pair of clusters from the chosen Kmeans and GMM model (Figure 3-14) was evaluated by comparing them to the reference model (see 3.9.7).

3.9.7 Reference Model

The reference model identified laboratory orders solely based on a match rate between the laboratory order and a standard laboratory requisition form for primary care providers in Nova Scotia (see Figure 3-15 and Appendix B and C). The threshold had been set to 90 % and higher for primary care orders. In other words, if nine out of ten laboratory tests in one order were listed on the standard laboratory requisition form and one test was not, the

order will be classified as a primary care ordered laboratory order. The match rate of ≥ 90 % was set based on clinical reasoning by the domain experts in the research team, and it allowed up to 10 % free-text field orders on the requisition form.

In Figure 3-15, each laboratory order (the black frames) and their tests (the blue squares) were matched against the laboratory requisition form. Every order ended up having a match-rate from 0 to 100 %. 0 % meant no match, and the laboratory order had no tests that had been found on the primary care requisition form. On the other hand, a 100 % match meant that all tests in the laboratory order were found on the requisition form.

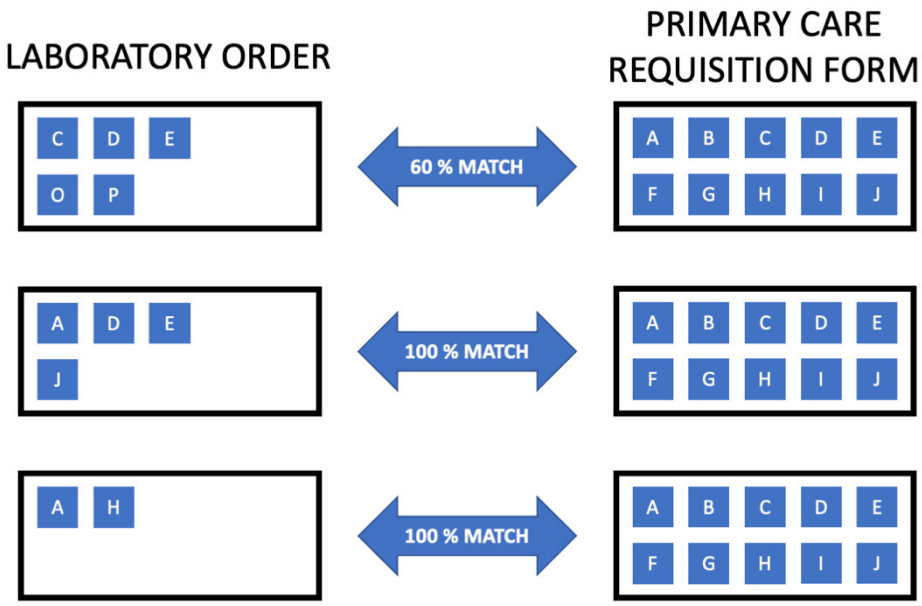

Figure 3-15. Examples of laboratory orders' match-rates.

There are three examples of laboratory orders on the left-hand side (the black frames), and they have some tests included (the blue squares). For simplicity, the test names are single alphabetic letters. On the right-hand side is the primary care requisition form with a

set of tests. The requisition form and the actual test names can be found in Appendix B and C. For each of the three examples in the above figure, the laboratory order is matched against the primary care requisition form with a match-rate from 0 to 100 %. The second and third rows of laboratory orders passed the 90 % threshold and were classified as primary care orders. The first row was classified as non-primary care ordered.

3.9.8 Evaluation of Identification Methods

There was no gold standard for the performance evaluation of the models in Method A and B. Therefore, the two methods (nearest encounter and unsupervised machine learning) were evaluated against a reference model as a binary classification (primary care ordered vs non-primary care ordered laboratory orders). Sensitivity, specificity, accuracy, and balanced accuracy were calculated for each method and its models. The method and model with the highest accuracy and balanced accuracy were selected for the following analyses.

3.10 Overtesting Behaviour Analysis

Screening patients with TSH tests is not recommended for those with no relevant signs, symptoms, diagnoses, medication, or other treatments, such as radiation therapy near the neck and head area. The group of patients with no relevant factors was defined as ‘overtested patients’ in the study. The following steps identified those patients.

3.10.1 Selection of Primary Care Laboratory Data

The laboratory orders classified as secondary care orders had been removed from the dataset, but the TSH test results from secondary care had been kept in a separate reference dataset. Secondary TSH test results were still important since the primary care providers had the test results in their EMR to guide them during consultations. For example, suppose a patient got several normal TSH test results and the primary care provider ordered another one. In that case, it is still potentially inappropriate if there were no other reasons for testing.

3.10.2 Practice Setting

Patient demographics were analyzed with descriptive statistics, such as age, the proportion of patients aged 60 years and older, gender/sex, and proportion of patients with chronic conditions. We used CPCSSN's definition of disease cases for eleven conditions: chronic kidney disease, chronic obstructive pulmonary disease, dementia, depression, diabetes mellitus, epilepsy, herpes zoster, hypertension, osteoarthritis, Parkinson's disease, and pediatric asthma [38]. All the above conditions were kept since the cohort of patients began in 2009, and an adult patient in 2018 could, for example, have a history of 'pediatric asthma' from the previous years as a minor. Provider practice behaviour was also descriptively analyzed with encounters per month, unique patients visited per month, and visited patients with laboratory orders.

3.10.3 TSH Testing

Descriptive analysis of TSH was created with the following variables: seen patients with TSH test results, seen patients with normal TSH test results, seen patients with elevated TSH test results, and finally, seen patients with lowered TSH test results. The normal, elevated, and lowered TSH test results were from primary care patients previously identified.

3.10.4 Relevant Thyroid Conditions and Diagnoses

The clinically relevant thyroid diagnoses had been identified among all recorded diagnoses in the selected patient population in the dataset. Based on the researcher's clinical experience in primary and secondary care and literature [16], these diagnoses were selected. Please find the list of relevant thyroid diagnoses in Appendix E. The list was reviewed by Dr. Fred Burge. In addition, any patients with related diagnoses in the whole dataset, and even diagnoses from before 2014, had been identified.

3.10.5 Relevant Thyroid Medication

We identified two drugs as relevant treatment drugs for thyroid conditions, Sodium Levothyroxine and Methiamazol/Thiamazole [16]. Furthermore, two other drugs were identified as relevant drugs where TSH is frequently monitored, Lithium and Amidiorone [2]. Any patient with prescriptions for these four drugs, and even from before 2014, have been identified.

3.10.6 Other Relevant Factors

It was impossible to identify patients with other relevant factors for TSH screening. Those factors were, for example, head and neck radiation therapy, thyroid surgeries, brain surgeries near the hypothalamus and pituitary gland, and family history of thyroid conditions [16]. Since the dataset did not include free-text chart notes, where patients' signs and symptoms and history are typically recorded, the above factors were not included.

3.10.7 Working Definition of TSH Overtesting

For this study, TSH overtesting was defined as:

"TSH tests that are repeated within a short period

with normal test results,

and no relevant and related diagnosis or medication."

We had no records of signs and symptoms in the MaRNet-FP dataset, such as 'persistent fatigue' or 'new weight gain'. Therefore, the repeated component was added to adjust for the lack of these signs and symptoms and other relevant factors. The repeated component was also found in the literature review in another score [30].

The Department of Pathology and Laboratory Medicine within Nova Scotia Health Authority (NSHA) created 'Laboratory Utilization Guidelines - Specimen cancellation rules' [57]. The NSHA laboratories automatically cancel a new TSH test if it is taken within six weeks of a previous TSH test. However, physicians can overrule the cancellation by adding "do not cancel" to the laboratory requisition form.

The ‘short period’ for repeated TSH tests had been set to 100 days in this study, around double the 6-week cancellation period. The 100-day period is based on clinical reasoning by the researcher and Dr. Fred Burge. All patients with abnormal TSH test results in their records had been excluded.

3.10.8 Potential Inappropriate Testing Score (PIT Score)

Based on the working definition of TSH overtesting, a Potential Inappropriate Testing score (PIT score) was being proposed in this study. A literature search has found no other publication of a similar score.

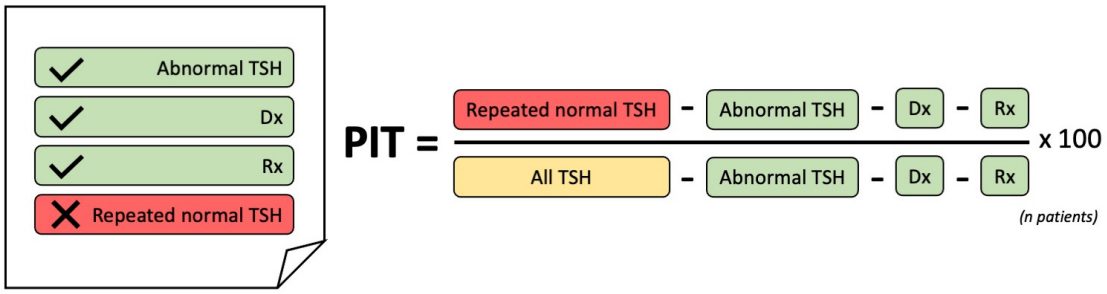

Figure 3-16. PIT score.

In the literature, TSH testing is appropriate in patients with previously abnormal TSH test results and patients with relevant conditions and prescriptions, but repeated normal TSH testing in non-pregnant patients is not recommended [2], [16], [22], [57]. The PIT score algorithm and explanation can be seen below.

$$\text{PIT score} = \frac{\text{TSH}_{\text{NORMAL}} - \text{TSH}_{\text{ABNORMAL}} - \text{Dx} - \text{Rx}}{\text{TSH}_{\text{ALL}} - \text{TSH}_{\text{ABNORMAL}} - \text{Dx} - \text{Rx}} \times 100$$

TSH_{NORMAL}:	Number of patients who had ≥ 2 normal TSH test results within a time period by the investigated provider *
TSH_{ALL}:	Number of patients who had a TSH test result by the investigated provider *
$TSH_{ABNORMAL}$:	Number of patients who had an abnormal TSH test result *
Dx:	Number of patients who had a relevant diagnosis and a TSH test result **
Rx:	Number of patients who had a relevant medication and a TSH test result **

* Any records in their electronic medical records from 18 years and older.

** Any records in their electronic medical records at any age.

The range of the PIT score is from 0 to 100, and providers with scores above 2 standard deviations from the mean are defined as outliers.

There were no variables in our dataset to tell us if the patient was pregnant, and therefore, telling us that the TSH test was relevant. Instead, we provided additional PIT scores and grades without women aged 18 to 45 years. The fertility age is registered from the age 15-year old's by Statistics Canada, and only 0.7 per thousand women gave birth at the age of over 45 years in 2016 [58]. We did not look at minor patients, and the lower cut-off is 18 years. A US study included women aged 21-45 years for a conception study [59].

The PIT scores from 2014 to 2018 were compared to show trends and changes over time. Furthermore, we looked at the relation between PITs and days between TSH tests.

3.10.9 Clinical Behaviour Leading up to TSH Overtesting

Each time a participating primary care provider ordered a TSH test classified as a PIT, 200 days of normal TSH results leading up to the PIT are identified. Those laboratory tests leading up to the PIT include laboratory test results from emergency departments and other secondary care providers. The rationale was that the primary care provider had those normal TSH test results from emergency departments and secondary care providers in their EMR when ordering the PIT. MaRNet-FP extracted only data that was available in primary care providers' EMR.

3.10.10 Clinical Behaviour After TSH Overtesting

The number of days between TSH-PIT and laboratory orders/encounters was compared to a control group of patients by the same provider and period but no PITs. Only a patient's first TSH-PIT or TSH-non-PIT (control group) from 2018 was included in the analysis. Any significant differences were reported with a paired t-test on a provider level. The control group had the same provider during the same period, including patients who never had an abnormal TSH test result but did not have repeated TSH results (PITs) (see Figure 3-17).

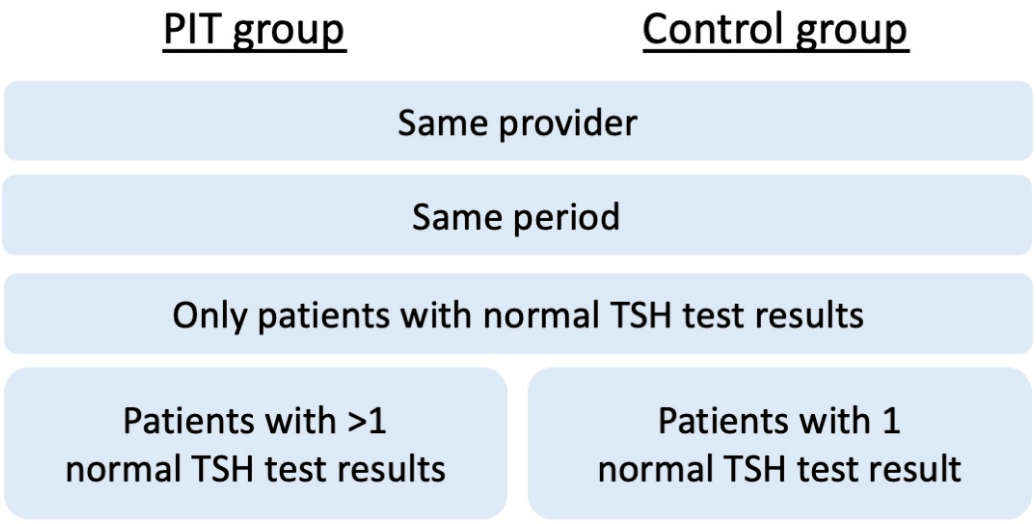

Figure 3-17. PIT and control group.

CHAPTER 4: RESULTS

4.1 Preparing Laboratory Dataset

After cleaning and preparing the laboratory dataset for further analyses, we ended up with about 6.1 million laboratory test results from almost 46,000 patients (see Table 4-1). The test results were categorized into 164 groups. Duplicates, excluded providers, minor patients, patients with missing birth years, records outside 2014-2018, acute and secondary orders, and finally, non-blood work were all removed.

Table 4-1. Cleaning the laboratory dataset.

[absolute numbers]		**Laboratory tests [count]**	**Patients [count]**	**Laboratory orders [count]**
Raw laboratory dataset		*23,373,500*	*80,903*	*918,221*
After removal of	*Duplicates*	*22,396,168*	*80,903*	*918,221*
	*Providers with a low encounter volume **	*21,485,916*	*78,318*	*880,805*
	Minor patients and missing birthyear	*20,465,655*	*64,794*	*831,441*
	Records outside 2014-2018 period	*10,657,727*	*52,350*	*422,080*
	Acute and obvious secondary test orders	*6,405,385*	*46,918*	*309,369*
	Non-blood work	*6,073,117*	*45,988*	*292,616*
Cleaned laboratory dataset		*6,073,117*	*45,988*	*292,616*

* Six of 77 providers in 2014-2018 were excluded from the encounter dataset since they had years with less than 20 encounters per month over the year. There are a different

number of providers in each calculation depending on the providers' activity in encounters, billing codes, and laboratory datasets.

TSH test results account for 1.6 % of the cleaned laboratory dataset. TSH test results without a defined range in their records with replaced with the median lower and upper boundaries of the reported ranges (0.35 and 4.68). 26 of 99,411 TSH tests were missing a lower reference level, and 2 were missing an upper reference level. The medians are close to other published TSH reference imputations (0.4 and 5.0) [2].

The next step was to identify primary care ordered laboratory orders in the cleaned laboratory dataset. The two proposed methods: A and B, were evaluated to find the most accurate method to identify the orders.

4.2 Method A Results

In Method A, 83 % of all laboratory tests were within the 28-day window of an encounter or billing date (see Table 4-2).

Table 4-2. Identification of primary care laboratory orders, Method A.

[absolute numbers]		**Laboratory tests [count]**	**Patients [count]**	**Laboratory orders [count]**
Cleaned laboratory dataset		*6,073,117*	*45,988*	*292,616*
Method A laboratory dataset	**± 7 days**	*3,231,137*	*37,133*	*154,383*
	± 14 days	*4,255,398*	*40,698*	*205,445*
	± 21 days	*4,750,451*	*42,039*	*229,086*
	± 28 days	*5,058,145*	*42,780*	*243,684*

4.3 Method B Results

The dataset has over six million data entries of laboratory tests and over 139 grouped laboratory test names (please see Appendix A). The cleaning process resulted in fewer grouped names and a discrepancy in the number of names between the raw (164 test names) and cleaned (139 test names) datasets. The number of laboratory tests and orders and patients for the Kmeans and GMM models and their clusters are listed below in Table 4-3.

Table 4-3. Identification of primary care laboratory orders, Method B.

[absolute numbers]		**Laboratory tests [count]**	**Patients [count]**	**Laboratory orders [count]**
Cleaned laboratory dataset		*6,073,117*	*45,988*	*292,616*
Method B laboratory dataset	**GMM cluster 0**	*362,005*	*25,698*	*118,708*
	GMM cluster 1	*5,711,112*	*41,957*	*173,908*
	Kmeans cluster 0	*5,707,184*	*41,921*	*173,460*
	Kmeans cluster 1	*365,933*	*25,829*	*119,156*

4.4 Reference Model Results

Method A and Method B's two clusters are compared to the method reference. The reference is a match between the cleaned laboratory dataset and the requisition form. It allowed laboratory orders with a match rate of 90 % and higher to pass through as primary care ordered (see Table 4-4). On average, each laboratory order contained 21 tests (6,073,117/292,616) with an SD of 16 tests. Therefore, on average, the laboratory orders would allow two tests not to be one of the default tests from the requisition form (see Appendix C).

Table 4-4. Identification of primary care laboratory orders, Reference model.

[absolute numbers]	**Laboratory tests [count]**	**Patients [count]**	**Laboratory orders [count]**
Cleaned laboratory dataset	*6,073,117*	*45,988*	*292,616*
Reference model laboratory dataset *Laboratory orders with ≥ 90 % match of a standard laboratory requisition form*	*2,707,349*	*35,319*	*164,129*

4.5 Evaluation of Method A and B

The two methods are compared to the method reference with sensitivity, specificity, accuracy, and balanced accuracy (see Table 4-5).

Table 4-5. Performance metrics for Method A and B.

[%]		**Sensitivity**	**Specificity**	**Accuracy**	**Balanced accuracy**
Method A	**± 7 days**	*51.7*	*45.9*	*49.1*	*48.8*
	± 14 days	*69.7*	*29.1*	*51.9*	*49.4*
	± 21 days	*77.9*	*21.1*	*53.0*	*49.5*
	± 28 days	*82.9*	*16.2*	*53.6*	*49.5*
Method B	**GMM cluster 0**	*46.3*	*66.7*	*55.3*	*56.5*
	GMM cluster 1	*53.7*	*33.3*	*44.7*	*43.5*
	Kmeans cluster 0	*53.5*	*33.3*	*44.6*	*43.4*
	Kmeans cluster 1	*46.5*	*66.7*	**** 55.4***	**** 56.6***

***** The model with the highest accuracy and balanced accuracy (Kmeans cluster 1).

The Kmeans cluster 1 had the highest accuracy and balanced accuracy. The reference data was balanced, and the two accuracies were similar. The Kmeans cluster 1 had a higher specificity and was better at excluding non-primary care orders. The Kmeans cluster 1 had almost the same performance as the GMM cluster 0.

The sensitivity increased for each week included in Method A, with a peak at 82.9 %. Method A ± 28 days was good at identifying primary care orders, but it was poor at excluding non-primary care orders.

The best method for the identification of primary care laboratory orders was Method B's Kmeans cluster 1, and we continued the analyses based on these selected laboratory orders.

4.6 Patient Demographics

We included 71 primary care providers (family doctors and nurse practitioners) and their 118,390 patients from Nova Scotia participating in MaRNet-FP. The following statistics are based on the retrospective cohort's most recent year, 2018. We are looking at practice behaviour among health providers, and therefore, all statistics are calculated per provider. For example, the minimum age in the following table is the youngest mean age of the patients among providers. In addition, not all providers have all data represented in their EMR (laboratory records etc.), and therefore, the number of providers differs in some of the analyses.

Table 4-6. Patient demographics per provider in 2018.

	n *	mean	SD	min	median	max
Age [years]	*69*	*54.1*	*6.3*	*41.5*	*54.3*	*74.9*
Age ≥ 60 years [%]	*69*	*41.9*	*14.0*	*13.5*	*43.2*	*89.5*
Female [%]	*69*	*57.3*	*11.1*	*36.8*	*56.7*	*85.1*
Patients with chronic conditions [%]	*69*	*49.2*	*13.1*	*18.7*	*52.4*	*78.9*

The table shows descriptive statistics of average values by each provider. * n = number of providers included. Two of the 71 providers had no patient demographic data and are therefore not represented in this table. SD = standard deviation. Chronic conditions: chronic kidney disease, chronic obstructive pulmonary disease, dementia, depression,

diabetes mellitus, epilepsy, herpes zoster, hypertension, osteoarthritis, Parkinson's disease, and pediatric asthma.

4.7 Practice Behaviour

The number of encounters and patients are displayed in Table 4-7. Providers had around 14 patient consultations per day (based on a 20-workday month). The providers had consultations with the same patients repeatedly, and they saw, on average, each patient three times during 2018. About 7 % of the patients had laboratory work done.

Table 4-7. Practice behaviour per provider in 2018.

	n *	mean	SD	min	median	max
Encounters per month [count]	*70*	*278*	*271*	*46*	*219*	*2,086*
Unique patients per month [count]	*70*	*92*	*126*	*19*	*72*	*1,085*
Seen patients with laboratory orders [%]	*69*	*7.1*	*5.2*	*0*	*7.4*	*23.0*

The table shows descriptive statistics of average values by each provider. * n = number of providers included.

4.8 TSH Testing Behaviour

Around 2 % of the seen patients had a TSH test included in their laboratory work (Table 4-8). Some providers ordered no TSH tests, and others ordered up to about 7 %. Most of patients' TSH test results came back as normal (79 %).

Table 4-8. TSH testing behaviour per provider in 2018.

	n *	mean	SD	min	median	max
Seen patients with TSH test results [%]	*69*	*1.8*	*1.6*	*0.0*	*1.7*	*6.9*
Seen patients with normal TSH test results [%]	*69*	*1.5*	*1.4*	*0.0*	*1.4*	*6.5*
Seen patients with elevated TSH test results [%]	*69*	*0.2*	*0.2*	*0.0*	*0.2*	*1.1*
Seen patients with lowered TSH test results [%]	*69*	*0.2*	*0.4*	*0.0*	*0.1*	*2.1*
PIT score (100 days)	*69*	*8.9*	*15.0*	*0.0*	*0.0*	*66.7*
PIT score without women aged 18 to 45 years (100 days)	*69*	*7.6*	*15.3*	*0.0*	*0.0*	*66.7*

Descriptive statistics of average values by each provider. * n = number of providers included in the analysis. The sum of normal, elevated, and lowered tests does not add up to the number of total tests since some patients have several tests with different results during 2018.

Table 4-9. Providers with PIT score outliers.

[number of providers in each category]	**≤ +2 SD**	**> +2 SD**
PIT score (100 days)	64	5
PIT score without women aged 18 to 45 years (100 days)	65	4

Five providers out of 69 had an outlier PIT score above 2 standard deviations (SD) from the mean with and without women aged 18 to 45 years. The rest of the providers, n = 64, had a PIT within or below 2 SD. Therefore, around 7 % of the participating providers had an outlier score (Table 4-9), and the PIT scores ranged from 0 to about 67 (Table 4-8). A PIT score of 67 means that the provider repeated the same TSH tests on 67 % of the TSH-tested patients within 100 days, even when all results came back normal. There were no relevant prescriptions indicating a need for the test. In Table 4-8 and Table 4-9, we have added the PIT scores and grades if we exclude TSH tests done for women aged 18 to 45 years to show if we exclude possible pregnant patients [58], [59].

The PIT scores did not change significantly from 2014 to 2018, $p < 0.05$ (see Figure 4-1).

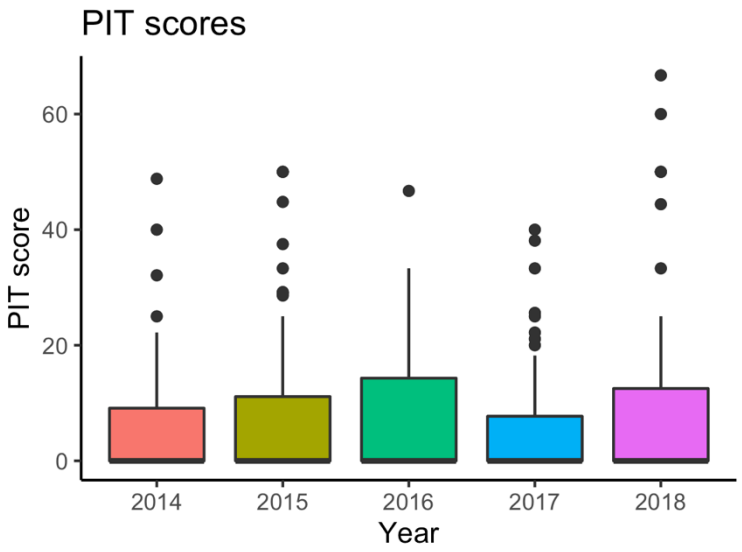

Figure 4-1. Trends of primary care providers' PIT scores from 2014 to 2018.

The boxplot diagram shows the median (the thick line), the 25% quantile (the lower hinge), the 75% quantile (the upper hinge), -1.5* interquartile range (IQR, the lower whisker), +1.5*IQR (the upper whisker), and outliers (the dots). There was no significant difference between the years of PIT scores, Kruskal-Wallis [$H(4) = 2.474$, $p > 0.05$].

The number of PITs increased when the windows of days in the PIT calculation widened (see Figure 4-2). For the sake of the study, a window of 100 days was decided. The number of PITs would be 2.4 times fewer if a 50-day window was chosen and an increase of 1.8 times if a 200-day window was chosen. The NSHA labs have a six-week automatic cancellation process (42 days), and the number of PITs would have been 35 % of the reported numbers in this study.

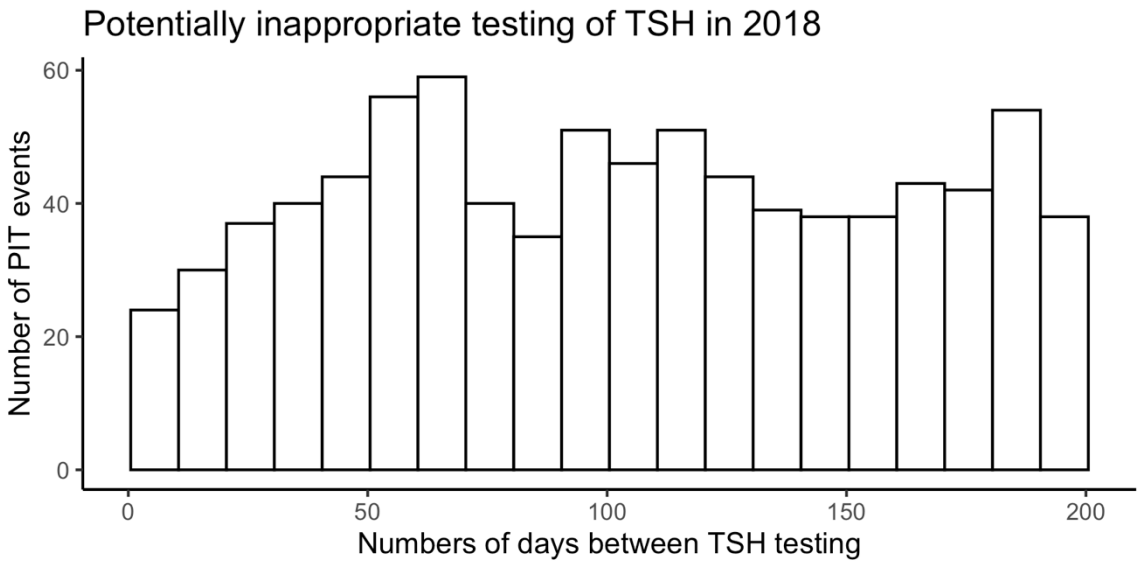

Figure 4-2. Days between PITs.

4.9 Consequences after Potentially Inappropriate TSH Testing

Each provider with and without PITs (control group) during 2018 was included in the following two analyses (44 and 47 providers in total). Please see Figure 3-17 on page 47 for more details about the PIT and control groups. First, the average number of days between two TSH tests in a patient for each provider in 2018 was calculated for the PIT and control groups to see if they ordered more frequent laboratory orders in the PIT patients than in the control group (see Figure 4-3). There was no significant difference between the PIT and control groups. However, a large spread in the range is seen in the PIT group.

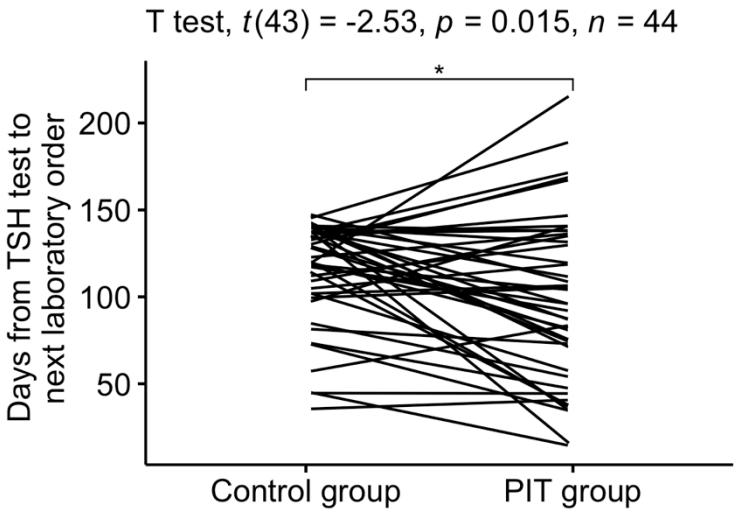

Figure 4-3. Change in laboratory orders following a PIT.

Paired t-test of patients with laboratory orders for the same provider in the control group compared with the PIT group after, respectively, a non-PIT and PIT of TSH, with a significant difference ($p < 0.05$). The PIT group had 98 days on average (SD 48 days) between their TSH PIT event and the next laboratory order compared to the control group with 115 days on average (SD 30 days).

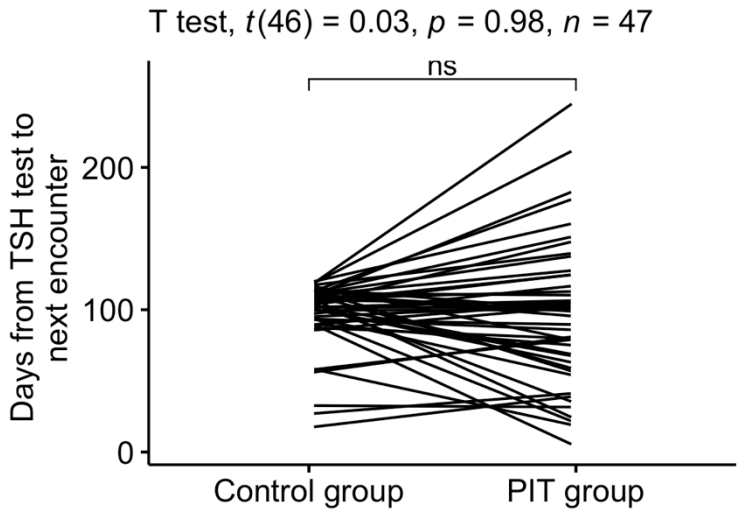

Figure 4-4. Change in encounters following a PIT.

Paired t-test of the number of encounters per patient for the same provider in the control group compared with the PIT group after, respectively, a non-PIT and PIT of TSH, with no significant difference ($p > 0.05$). The PIT group had 97 days on average (SD 51 days) between their TSH PIT event and the next encounter compared to the control group with 96 days on average (SD 24 days).

CHAPTER 5: DISCUSSION

The entrance to the healthcare system in Canada goes through the primary care providers. The gate-keeping function is critical to maintaining the proper care for the most critically ill patients and avoiding potentially inappropriate healthcare services. Overtesting, overscreening, overdiagnosis, and overtreatment are heavily linked to gatekeeping by avoiding potentially problematic services ranging from simple blood tests to invasive procedures. TSH testing is flagged by Choosing Wisely Canada as a test that could be potentially inappropriate in primary care [1]. In this study, we have chosen TSH as a proxy for potentially inappropriate testing (PIT).

We included 71 primary care providers and their 118,390 patients from Nova Scotia, Canada, and the patients were predominantly females and over the age of 60 years. Approximately half of the patients had one or more chronic conditions (chronic kidney disease, chronic obstructive pulmonary disease, dementia, depression, diabetes mellitus, epilepsy, herpes zoster, hypertension, osteoarthritis, Parkinson's disease, and pediatric asthma). In 2018, the providers saw under 300 encounters per month, and a varied group of patients visited their providers. Some providers had the same patients repeatedly coming, while others mainly had new patients coming by the clinic. On average, patients saw their provider three times during 2018.

The used laboratory dataset lacked a vital component—who ordered what? The dataset had both test results from primary care and secondary care, and there was no obvious way to distinguish between primary care ordered and secondary care ordered laboratory

orders. An issue previous Canadian and UK research centers have not found a solution for [2]. We came up with two methods to identify primary care ordered laboratory orders. The first method (A) assumed a close connection between an encounter date and a laboratory date. The second method (B) used unsupervised machine learning to cluster laboratory orders and select the clusters of a higher match with the requisition form. A reference model for the evaluation of the two methods assumed a close connection between a laboratory order and the laboratory requisition form for primary care. The models in Method A were in general good at identifying primary care orders but lacked the ability to exclude non-primary care orders. The Kmeans model outperformed the GMM model and Method A with the highest accuracy. Although, the accuracy was unfortunately not higher than 55-56 %. In method B for model GMM cluster 0 and Kmeans cluster 1, primary care orders might have been clustered based on more tests per order (about ten times more tests per order), and secondary care was based on fewer tests per order. Not intuitive and conflicting with traditional differences between primary and secondary care, where expanded testing panels are generally used in secondary care. We picked the Kmeans cluster 0 as the primary care ordered laboratory orders for the following analyses. About 6 % of laboratory tests from 2014 to 2018 were deemed secondary care ordered tests with the chosen solution, which is a low number and conflicts with the idea that patients typically have more intensive investigations in secondary care. On the other hand, it could also reflect that most of the patients with blood work stayed within primary care, and very few went to secondary care for blood work. About 4.3 million acute tests from, for example, emergency departments were already removed from the dataset.

After removing the secondary care ordered laboratory orders, seven per cent of the visited patients had laboratory work done with a wide variation between providers from 0 % to 23 % (Table 4-7)—reflecting a great variety in providers' clinical approaches. TSH testing was not common practice among the providers in 2018, and out of the seven per cent of patients who had laboratory work done, about 13 % of them had a TSH test (7.1 % * 1.8 %). The 1.8 % from our single year cohort is in sharp contrast to the 36 % found over a two-year period in a Canadian retrospective cohort study from 2016 to 2017—although, they had a larger spread among practices [2]. Importantly, the Canadian cohort study did not use any tools to identify primary care laboratory tests and could be inflated by secondary care test orders. Nova Scotian primary care providers may also behave differently compared to the rest of Canada. Another explanation could be the Nova Scotian automatic 6-week cancellation rule [57]. We found that 35 % of the PITs were happening within the 6-week cancellation rule—something that could be investigated in future studies to explain the reason for this high proportion.

For patients with no appropriate diagnosis or prescriptions, eight out of ten TSH-tested patients came back with normal results (euthyroidism), and elevated test results (hypothyroidism) were as common as lowered ones (thyrotoxicosis). The 2016-2017 Canadian cohort study found a higher proportion of normal test results, 96 % [2], and an older US study from a 2002 cohort found 95 % [28]. Our findings show that TSH is still used as a widespread test to screen patients, and most of the test results are normal. Although, we do not know if these patients had signs and symptoms leading to these tests.

Patients with repeatedly normal TSH test results within 100 days without any relevant diagnoses or prescriptions had a potentially inappropriate test (PIT). A PIT score (proportion of PITs among TSH tested patients) was calculated for each provider, and on average, the mean provider PIT score was 4.0 with a variation by providers from 0 to 27. The score of 4.0 means that the providers had potentially inappropriate TSH testing in 4.0 % of all patients with TSH testing. Only a few providers (7 %) had a high PIT score as outliers. The rest of the providers did only have a few PITs and were in the normal range (2 SD or below).

The PIT scores among providers did not significantly change from 2014 to 2018, suggesting that they had not changed their TSH testing behaviour over the investigated years. In addition, we found a positive linear trend on the graph between the number of days between TSH tests and the number of PITs within the first 70 days in patients with no relevant diagnoses or prescriptions (see Figure 4-2). The PITs hit a plateau from 80 to 200 days with little variation. If we had chosen the NSHA six-week period, our PIT calculations would still have been 35 % of the reported numbers. An explanation could be that clinicians feel it is necessary to repeat the test if signs and symptoms persist or evolve. Unfortunately, we could not read the signs and symptoms from the EMR since the dataset did not capture the free-text SOAP (subjective, objective, assessment, and plan) notes.

The average PIT score of 8.9 decreased to 7.6 when excluding TSH tests from female patients aged 18 to 45 years—a group of patients who potentially could be pregnant (see Table 4-8 and Table 4-9). The range of PIT scores stayed the same. The number of

outlying providers was one less (4 providers) when females aged 18 to 45 years were removed.

There might be no harm in repeating a TSH test several times, especially when the test results are in the normal range. The blood work is a simple and is generally seen as a low-risk procedure [60], and the TSH test is also common, and therefore, unlikely to be alarming for the patient. Although, many PITs could be a marker for an inefficacious behaviour trait of the provider. We might have a more significant issue if the TSH-PITs are generalizable for the provider's testing and practice behaviour. However, this is not part of the scope, and we did not test it in this study.

A simple blood test seems innocent, but it can start a cascade of unintentional healthcare service utilization. Both a negative and positive test result can lead to further investigations. If they pose more harm than benefits for the patient, a vicious circle of overtesting is generated. We did not find a significant difference in frequency of laboratory testing after a PIT compared to a non-PIT. Also, we did not find a significant difference in the frequency of encounters after a PIT compared to a non-PIT.

A summary of the overall study's findings could be distributed to each provider, including a comparison to their own findings. It has not been found strongly effective to distribute feedback reports to clinicians without other interventions [61], but a Canadian inpatient rehabilitation center found a relative reduction of 43 % in TSH testing at patients' admission by using Plan-Do-Study-Act methods and computerized clinical decision support [62]. If multiple intervention strategies are used, the summary or a

feedback report could give the provider an idea of how many PITs they have compared to themselves in the previous years and their peers. The report could also provide some context to the provider and possible reasons for their testing behaviour. Those reasons could be patients' age, gender/sex, and some chronic conditions [16]. Clinical production could also be a factor, such as how many encounters they had per month, visited patients, and how many laboratory tests the providers ordered. PIT score and the possible effects of PIT events in the number of additional encounters and other laboratory tests could help the provider to see the seriousness. Providers could follow their trends and compare themselves with peers across geographic areas. The purpose of the PIT score is not to punish primary care providers but to make them reflect on their testing behaviour. A Canadian study describing variations in care delivery across provinces used a similar approach where the presented range of performance parameters to make providers and policymakers reflect on their care delivery [63]. Providers could, in groups, share their clinical reasoning for testing behaviour to explain variation in performances and get feedback from other providers.

In addition, research networks, such as MaRNet-FP, could give feedback reports beyond the level that the silo-EMR vendors can provide with a full Quality Improvement cycle of developing, implementing, and evaluating behaviour changes.

CHAPTER 6: LIMITATIONS

The following limitations have been identified in the study design.

Limitations from: identification of primary care laboratory orders

- Our data source was the MaRNet-FP dataset, and there are some limitations when using a dataset based on volunteered participation. The participants (primary care providers) were all accepted to be part of a research network, and they might be incredibly motivated to do well in performance analyses. They might also be more academic in their clinical approach than their peers who are not part of MaRNet-FP. The participants received periodic feedback reports on their clinical performance but not on overtesting of TSH.
- Unfortunately, we could not use a newer dataset since most clinics got a new EMR vendor in 2019 without thoroughly researching the quality assurance of data transition between the two EMR platforms. Data before 2019 is generally more reliable.
- One of the most influential limitations is the mixed laboratory dataset with both primary and secondary data entries with no variables distinguishing those two data entries. For example, we will not know which laboratory test results are ordered by the primary care provider or ordered by the secondary care provider. We created two methods to address this limitation.
- CPCSSN's active patient classification does not guaranty a 100 % updated patient list. Although, it does not influence our findings since we only look at patients having encounters and laboratory work.

- Some providers had only a few encounters per month, and we excluded providers with limited clinical work to limit skewing included analyses by those low providers.
- Some of the CSV files were not correctly coded when provided, and laboratory orders with test names, including commas, were split up into several columns. A cleaning process merged the split names into one name to ensure all test names were correctly interpreted.
- Not all TSH test results included a range of accepted values, and the empty ranges were substituted with the median values from the other ranges.
- We did not have birth-months and -days in the dataset, and all patients were by default set to December 31 to limit the risk of including minor patients.
- The test names were spelled and entered in a non-standard way, and they were, therefore, merged into broader groups. As a result, misinterpretations and wrong grouping were possible. To address this limitation, Dr. Fred Burge reviewed the list of names. Tests that could not be grouped or interpreted by the author were categorized as NA. We made a few exemptions from the primary care laboratory requisition form, for example, removed ‘Total CO2’ and added ‘T3’ and ‘T4’. These exemptions should hopefully help increasing the chance of selecting the right primary care laboratory orders, but it is not possible to test whether it is successful or not.
- Some of the grouped test names are forming a single-test-order, for example, WBC, RBC, and HGB. In Method B, SVD and PCA are presumably taken into account in the reduction of the dimensions.

- There are pros, cons, and limitations to both two methods to identify primary care orders. Method A is prone to include emergencies and specialist care laboratory orders within the ±7 to ±28-day window of the primary care encounter. Especially when there is a strong collaboration between primary and secondary care with shared responsibility. For example, a patient with cardiovascular disease or diabetes gets specialist care at the hospital and follow-up monthly in primary care. On the other hand, some rural clinics also have a built-in emergency department, and therefore, the 'line' between primary and secondary care is less distinct. They might use the same EMR for their primary care tasks and the acute local emergency setting. If they order laboratory tests, including one from the acute blood work list, the whole laboratory order will be classified as non-primary care ordered. The proposed model can potentially remove primary care orders from the dataset in these cases.
- Method B had limitations with the computational power and dataset size when clustering laboratory work. Other approaches could have been tested and evaluated if hardware with more computational power was available for the author than the REB approved. Although, that is out of the scope of this master thesis.
- The reference model used the requisition form for classification, and it is the simplest method. The 90 % threshold is arbitrary and could be adjusted further for a better classification. However, this is out of the scope of this master thesis.

General limitations

- If a patient is seen by one provider and another provider from a different site, they will be two separate patients in the dataset.
- If a patient proceeded with two or more laboratory orders on the same day by different providers, it would show up as one order in this study.
- We did not have access to the SOAP notes from the EMRs with patients' signs and symptoms. Those records would have helped us identifying more precisely potentially inappropriate testing (PIT) behaviours. We added the repeated test factor to our PIT score model to account for not knowing signs and symptoms. If we had signs and symptoms and removed the repeating factor, then the mean PIT score could have changed. More PITs might be identified since all single TSH test without signs and symptoms would count. Fewer PITs would maybe be detected if providers were mentioning relevant signs and symptoms.
- The PIT score could be renamed to PIR (Potentially Inappropriate Retesting) score in future studies for clarification of the method behind the score.
- Since the author has not found any previously published score and grading scale for TSH overtesting, they are both arbitrary created for this study. Further research is needed to validate them with external datasets to ensure they are generalizable for other Canadian provinces and other parts of the world. Furthermore, additional investigation is needed to optimize the score, for example, adding weights.
- There is always a risk of 'cheating' in scores, like the proposed PIT score, where a denominator with the number of total tests can be inflated purposefully by the provider. Although, it would be contradicting the common guidelines and

potentially malpractice to inflate the number of single TSH tests for the solo purpose of lowering the PIT score.

- It was not possible to identify pregnant patients in the dataset. It is recommended to TSH-test patients during pregnancies [16]. Instead, we have provided the PIT scores and grades with and without women aged 18 to 45 years. Since we do not know if 'females' and 'males' are representing sex or gender or a mix in the MaRNet-FP dataset, then there could be patients who are pregnant and not listed as 'female'. Also, patients outside the decided age-period of 18 to 45 years could potentially be pregnant. We decided not to use HCG blood work test results since we do not know if all patients are tested during their pregnancy.

CHAPTER 7: CONCLUSION

About 2 % of the patients seen in primary care in Nova Scotia in 2018 had a TSH test, and eight of ten of those tests came back with a normal test result. This study looked for repeated normal test results with no found reasons, and most primary care providers had a low overtesting behaviour. Conversely, providers potentially inappropriate tested patients with TSH in 8.9 % of the tested patients on average, and there were no significant changes from 2014 to 2018. Furthermore, we found no significant difference in frequency of laboratory testing or encounters for patients after a PIT event.

To identify primary care ordered laboratory tests, two methods were proposed. First, we looked at laboratory tests that were in the days before and after an encounter. However, this method had a poor exclusion of non-primary care orders. Second, we selected Kmeans and Gaussian Mixture Model unsupervised machine learning and applied it to the laboratory dataset to cluster laboratory tests after a feature reduction. This method provided a high accuracy than Method A. The two proposed methods are both generalizable and can be applied in future research studies looking at laboratory datasets.

With increasing population size, ageing population, and increased healthcare expenses, healthcare services should be managed appropriately. Not only for the sake of our healthcare system but also to limit adverse events and not expose patients to unnecessary harm. Let healthy patients stay healthy.

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APPENDIXES

Appendix A – Grouping Laboratory Test Names

Group name => MaRNet-FP name

ACE ace::
ACE ang. conv. enz.::
ACE angiotensin converting enzyme::
ACET acetaminophen level::
ACET acetaminophen::
AFP afp: serum:
AFP afp::
AFP alpha fetoprotein::
ALAN alanine plasma::
ALAT ala /creat::
ALAT ala::
ALB 25% albumin 100 ml::
ALB 25% albumin 50 ml::
ALB 5% alb 50 ml::
ALB 5% albumin 250 ml::
ALB alb/creat ratio::
ALB alb/glob ratio (spe)::
ALB albumin (electrophoresis)::
ALB albumin (relative spe)::
ALB albumin (relative)::
ALB albumin electrophoresis::
ALB albumin excretion rate 24h::
ALB albumin excretion rate::
ALB albumin to globulin ratio::
ALB albumin::
ALB albumin:electrophoresis (spe):
ALB albumin:electrophoresis:
ALB albumin/creatinine ratio::
ALB albumin/globulin ratio::
ALB microalb/min::
ALB poc albumin::
ALB pre albumin::
ALB prealbumin::
ALC alcohol::
ALC alcohol:ethyl blood:
ALC ethanol: blood:
ALC ethyl alcohol::
ALLER almond f20::
ALLER apple f49::
ALLER beef f27::

ALLER birch t215::
ALLER blue mussel f37::
ALLER brazil nut f18::
ALLER cashew nut f202::
ALLER cat epith e1::
ALLER cat epithelium e1::
ALLER ched cheese f81::
ALLER chick pea f309::
ALLER clam f207::
ALLER crab f23::
ALLER d.farinae d2 (mites)::
ALLER d.farinae d2::
ALLER d.pteronis d1::
ALLER d.pteronissinus d1 (mites)::
ALLER d1 d.pteroniss::
ALLER d2 d.farinae::
ALLER dog epith e2::
ALLER dog epith e5::
ALLER dog epithelium e5::
ALLER e1 cat epith::
ALLER e3 horse dandr::
ALLER e82 rabbit epi::
ALLER egg white f1::
ALLER egg yolk f75::
ALLER environ mix dm1::
ALLER f1 egg white::
ALLER f10 sesame::
ALLER f13 peanut::
ALLER f14 soya bean::
ALLER f17 hazel nut::
ALLER f18 brazil nut::
ALLER f2 milk::
ALLER f20 almond::
ALLER f23 crab::
ALLER f24 shrimp::
ALLER f256 walnut::
ALLER f26 pork::
ALLER f27 beef::
ALLER f3 fish:cod:
ALLER f352 h8 peanut::
ALLER f36 coconut::
ALLER f4 wheat::
ALLER f40 tuna::
ALLER f41 salmon::
ALLER f423 h2 peanut::
ALLER f45 yeast::
ALLER f5 rye::

ALLER f6 barley::
ALLER f80 lobster::
ALLER f83 chicken::
ALLER fish: cod f3:
ALLER fish:cod f3:
ALLER garlic f47::
ALLER grass mix gm1::
ALLER halibut f303::
ALLER hamster e84::
ALLER hazel nut f17::
ALLER honey bee i1::
ALLER horse dandruff::
ALLER i1 honey bee::
ALLER i2 wf hornet::
ALLER i3 yel jacket::
ALLER i4 paper wasp::
ALLER i5 yel hornet::
ALLER kiwi f84::
ALLER latex k82::
ALLER lentils f235::
ALLER lobster f80::
ALLER macadamia nut f345::
ALLER milk f2::
ALLER mold mix mm1::
ALLER ngald1: ovomucoid: egg f233
ALLER ngald2: ovalbumin: egg f232
ALLER oat f7::
ALLER orange f33::
ALLER oyster f209::
ALLER oyster f290::
ALLER paper wasp i4::
ALLER pea f12::
ALLER peanut f13::
ALLER pecan f201::
ALLER pine nuts f253::
ALLER pistachio f203::
ALLER rahah2: peanut f423:
ALLER rahah8: pr-10: peanut f352
ALLER rye f5::
ALLER salmon f41::
ALLER scallop f338::
ALLER sesame seed f10::
ALLER shrimp f24::
ALLER sole f337::
ALLER soya bean f14::
ALLER strawberry f44::
ALLER tisseel 1 ml::

ALLER tomato f25::
ALLER tree mix tm2::
ALLER tree mix tm3::
ALLER w f hornet i2::
ALLER walnut f256::
ALLER wheat f4::
ALLER white faced hornet i2::
ALLER xxxxx labs h1::
ALLER xxxxx nut 345::
ALLER yeast f45::
ALLER yel hornet i5::
ALLER yel jacket i3::
ALLER yellow hornet i5::
ALLER yellow jacket i3::
ALP alk phosphatase::
ALP alkaline phosphatase:alkaline phosphatase in serum or plasma (alp):
ALP alp total:alkaline phosphatase in serum or plasma (alp):
ALP leukocyte alkaline phosphatase:alkaline phosphatase in serum or plasma (alp):
ALP poc alkaline phosphatase:alkaline phosphatase in serum or plasma (alp):
ALP poc alp:alkaline phosphatase in serum or plasma (alp):
ALPHA a1-antitrypsin:alpha-1 antitrypsin in serum or plasma (a1at):
ALPHA a1at clearance:alpha-1 antitrypsin in serum or plasma (a1at):
ALPHA a1at serum:alpha-1 antitrypsin in serum or plasma (a1at):
ALPHA a1at:alpha-1 antitrypsin in serum or plasma (a1at):
ALPHA alpha 1 (electrophoresis)::
ALPHA alpha 1::
ALPHA alpha 2 (electrophoresis)::
ALPHA alpha 2::
ALPHA alpha-1-antitrypsin: s:alpha-1 antitrypsin in serum or plasma (a1at)
ALPHA alpha-1-antitrypsin:alpha-1 antitrypsin in serum or plasma (a1at):
ALPHA alpha-1-globulin (relative)::
ALPHA alpha-1-globulin relative spe::
ALPHA alpha-1-globulins (spe)::
ALPHA alpha-1-globulins::
ALPHA alpha-2-antiplasmin::
ALPHA alpha-2-globulins (g/l) (spe)::
ALPHA alpha-2-globulins (g/l)::
ALPHA alpha-2-globulins relative spe::
ALPHA alpha-2-globulins relative::
ALPHA alpha2antiplasm::
ALT alanine amino transferase::
ALT alt:alanine aminotransferase in serum or plasma (alt):
ALT poc alt:alanine aminotransferase in serum or plasma (alt):
AMMON ammonia::
AMYLamylase::
AMYLamylase:pancreatic:
AMYLpoc amylase::

ANDRO androstenedione::
AST aspartate amino transferase::
AST ast:aspartate aminotransferase in serum or plasma (ast):
AST poc aspartate amino transferas::
AST poc ast:aspartate aminotransferase in serum or plasma (ast):
ATTG anti tissue transglutaminase::
ATTG anti-ttg-iga::
B12 vitamin b12::
B6 vitamin b6::
BACT bacteria::
BAND bands::
BASO abs baso ct::
BASO absolute basophil count::
BASO baso::
BASO basophils (auto)::
BASO basophils #::
BASO basophils::
BASO basos::
BETA beta (electrophoresis)::
BETA beta 1 (electrophoresis)::
BETA beta 1::
BETA beta 2 (electrophoresis)::
BETA beta 2 microglobulin::
BETA beta 2::
BETA beta globulins (relative spe)::
BETA beta globulins (relative)::
BETA beta globulins (spe)::
BETA beta globulins::
BETA beta-1-globulins (relative)::
BETA beta-1-globulins (spe)::
BETA beta-1-globulins relative(spe)::
BETA beta-1-globulins::
BETA beta-2-globulins (relative)::
BETA beta-2-globulins (spe)::
BETA beta-2-globulins relative(spe)::
BETA beta-2-globulins::
BETA microglobulin beta-2::
BILE total bile acids::
BILI age at collection of biliscrn:total bilirubin (tbil):
BILI bili conju cord:direct bilirubin (dbil):
BILI bili conjugated:direct bilirubin (dbil):
BILI bili screen:total bilirubin (tbil):
BILI bili total cord:total bilirubin (tbil):
BILI bili uncon cord:total bilirubin (tbil):
BILI bili unconj:indirect bilirubin (ibil):
BILI bilirubin conjugated:direct bilirubin (dbil):
BILI bilirubin direct:direct bilirubin (dbil):

BILI bilirubin indirect:indirect bilirubin (ibil):
BILI bilirubin total:total bilirubin (tbil):
BILI bilirubin unconjugated:indirect bilirubin (ibil):
BILI bilirubin:conjugated:direct bilirubin (dbil)
BILI bilirubin:direct:direct bilirubin (dbil)
BILI bilirubin:indirect:indirect bilirubin (ibil)
BILI bilirubin:total:total bilirubin (tbil)
BILI bilirubin:unconjugated:indirect bilirubin (ibil)
BILI direct bili:direct bilirubin (dbil):
BILI indirect bili:indirect bilirubin (ibil):
BILI neonatal bilirubin:total bilirubin (tbil):
BILI poc bilirubin:total:total bilirubin (tbil)
BILI poc t bili:total bilirubin (tbil):
BILI tot bili screen:total bilirubin (tbil):
BILI total bili:total bilirubin (tbil):
BLAST blastocytes::
BLAST blasts::
BLAST reg/norm blasts::
BLAST regenerating normal blasts::
BNP n-terminal pro brain natriuretic peptide::
BNP nt-probnp::
BNP pro-b-natriuretic peptide-nt::
BONE alkphos: bone:
BONE bm total cells counted::
BONE bm total cells::
BONE bone alkaline phosphatase:alkaline phosphatase in serum or plasma (alp):
BONE bone marrow band/neutrophils::
BONE bone marrow blastocytes::
BONE bone marrow eosin/precursors::
BONE bone marrow erythroblasts::
BONE bone marrow lymphocytes::
BONE bone marrow m:e ratio::
BONE bone marrow megakaryocytes::
BONE bone marrow metamyelocytes::
BONE bone marrow monocytes::
BONE bone marrow myelocytes::
BONE bone marrow plasma cells::
BONE bone marrow promyelocytes::
BONE bone marrow rbc precursors::
BPN nt pro brain natriuretic pept::
C3 complement c3::
C4 c4::
C4 complement c4::
CA ca 19-9::
CA125 ca 125::
CALC calcium ionized::
CALC calcium total::

CALC calcium: total:
CALC calcium::
CALC calcium/24h::
CALC cap. calculate calcium:ionized:
CALC corrected total calcium::
CALC ionized calcium (7.4) (serum)::
CALC ionized calcium (serum)::
CALC ionized calcium::
CALC measured calcium:ionized:
CALC poc ionized calcium::
CALC venous calculated ca ionized::
CALC venous measured ca ionized::
CALCIT calcitonin::
CALP calprotectin::
CARBA carbamazepine (tegretol) level::
CARBA carbamazepine::
CD cd3 x 10e9::
CD cd3::
CD cd34 cells::
CD cd34 cells/colln::
CD cd4 x 10e9::
CD cd4-abs ct::
CD cd4::
CD cd4/cd8 ratio::
CD cd8 x 10e9::
CD cd8-abs ct::
CD cd8::
CEA carcinoembryonic antigen:carcinoembryonic ag (cea):
CEA cea:carcinoembryonic ag (cea):
CELL hairy cells::
CELL immature cells::
CELL large unstained cells (auto)::
CELL large unstained cells #::
CELL mesothelial cel::
CELL mesothelial cells::
CELL other cell manual::
CELL other cell types::
CELL other cell::
CELL other cells::
CELL smudge cells::
CHLOR chloride no.::
CHLOR chloride::
CHLOR poc chloride::
CHOL chol/hdl ratio:cholesterol total/cholesterol in hdl ratio (tch/hdl):
CHOL chol/hdl:cholesterol total/cholesterol in hdl ratio (tch/hdl):
CHOL cholesterol non-fasting:total cholesterol (tch):
CHOL cholesterol:total cholesterol (tch):

CHOL cholesterol/hdl ratio:cholesterol total/cholesterol in hdl ratio (tch/hdl):
CHOL ldl cholesterol direct:cholesterol in ldl (ldlc):
CHOL non hdl cholesterol::
CIT citrate::
CK ck-mb relative index::
CK ck::
CK ckmb::
CK cpk::
CK creatine kinase::
CK creatine phosphokinase::
CLOZA clozapine::
CLOZA dm clozapine::
CLOZA total clozapine::
COLL collagen/adp::
COLL collagen/epi::
COLL collagen/epinep::
COLL collagen/epinephrine closure::
COPPER copper (24h)::
COPPER copper bld::
COPPER copper blood::
COPPER copper level::
COPPER copper whole bl::
COPPER copper whole blood::
COPPER copper: blood:
COPPER copper::
CORT cortisol: serum:
CORT cortisol::
CORT cortisol:30 minutes:
CORT cortisol:60 minutes:
CORT cortisol:am:
CORT cortisol:free:
CORT cortisol:pm:
CORT cortisol:random:
CPEP c peptide::
CPEP c-peptide::
CREA creat clearance:plasma creatinine clearance (egfr):
CREA creatine kinase (cpk)::
CREA creatinine clearance:plasma creatinine clearance (egfr):
CREA creatinine pre::
CREA creatinine ur::
CREA creatinine-xan:creatinine (serum-cr):
CREA creatinine:creatinine (serum-cr):
CREA creatinine/24h::
CREA estimated creat clearance test:plasma creatinine clearance (egfr):
CREA mg/mmol creat:creatinine (serum-cr):
CREA mps/creatinine::
CREA poc creatinine:creatinine (serum-cr):

CREA tp/creat::
CRP c reactive protein high sens::
CRP c reactive protein quantitativ::
CRP c-reactive protein::
CRP crp::
CSF alanine csf::
CSF chloride: csf:
CSF csf mononuclear cells::
CSF csf polymorphs::
CSF csf rbc count::
CSF csf wbc count::
CSF eosinophils: csf:
CSF galactocerebros::
CSF glucose csf::
CSF glucose: csf:
CSF glutamine csf::
CSF glycine csf::
CSF histidine csf::
CSF lactate csf::
CSF lactate dehydrogenase: csf:
CSF leucine csf::
CSF lymphocytes: csf:
CSF macrophages: csf:
CSF monocytes: csf:
CSF neutrophils: csf:
CSF protein csf::
CSF rbc: csf:
CSF tnc count - csf::
CSF total nuc cell count: csf:
CSF total protein: csf:
CSF tyrosine csf::
CSF valine csf::
CSF wbc count - csf::
CSF wbc: csf:
DIGO digoxin level::
DIGO digoxin::
DIMER d dimer semi-quantitative::
DIMER d-dimer quant::
DIMER d-dimer quantitative::
DIMER d-dimer screen::
DIMER d-dimer::
DOPA dopamine::
EOSINabs eosin ct::
EOSINabsolute eosinophil count::
EOSINeos::
EOSINeosin::
EOSINeosinophil cnt::

EOSINeosinophil count::
EOSINeosinophils (auto)::
EOSINeosinophils #::
EOSINeosinophils::
EOSINeosins::
EOSINimmature eosins::
EOSINmanual eosinophil count::
EOSINmature eosins::
ESR eryth sedimentation rate::
ESR erythrocyte sedimentation rate::
ESR esr::
ESR sed rate::
ESTRA estradiol::
FACTOR advate (factor viii)::
FACTOR f viii c::
FACTOR fact viii inhib::
FACTOR factor ii::
FACTOR factor ix assay::
FACTOR factor ix::
FACTOR factor v::
FACTOR factor vii assay::
FACTOR factor vii::
FACTOR factor viii assay::
FACTOR factor viii c::
FACTOR factor viii inhibitor::
FACTOR factor viii::
FACTOR factor viiic::
FACTOR factor x::
FACTOR factor xi assay::
FACTOR factor xi::
FACTOR factor xii assay::
FACTOR factor xii::
FACTOR mull inh factor::
FACTOR xiii activity::
FAT fatty acids: free:
FAT free fatty acid::
FECES a1at fecal::
FECES fat in stool::
FECES fecal calprotectin::
FECES occult blood #2::
FECES ph stool+h20::
FECES stool ph::
FECES stool weight::
FECES total stool fat::
FER fer::
FER ferritin::
FLUIDalbumin: body fluid:

FLUIDalbumin: peritoneal fluid:
FLUIDalbumin: pleural fluid:
FLUIDalt: pleural fluid:alanine aminotransferase in serum or plasma (alt)
FLUIDamylase: body fluid:
FLUIDamylase: peritoneal fluid:
FLUIDamylase: pleural fluid:
FLUIDast: pleural fluid:aspartate aminotransferase in serum or plasma (ast)
FLUIDbasophils: body fluid:
FLUIDbilirubin total: body fluid:total bilirubin (tbil)
FLUIDbilirubin total: pleural fluid:
FLUIDbody fluid albumin::
FLUIDbody fluid amylase::
FLUIDbody fluid cholesterol:total cholesterol (tch):
FLUIDbody fluid glucose::
FLUIDbody fluid ldh::
FLUIDbody fluid lipase::
FLUIDbody fluid specific gravity::
FLUIDbody fluid total protein::
FLUIDbody fluid triglyceride level:triglycerides (tg):
FLUIDbody fluid uric acid::
FLUIDcalcium: dialysate fluid:
FLUIDchloride: peritoneal fluid:
FLUIDcreatinine: body fluid:creatinine (serum-cr)
FLUIDcreatinine: dialysate fluid:creatinine (serum-cr)
FLUIDcreatinine: peritoneal fluid:creatinine (serum-cr)
FLUIDcreatinine: pleural fluid:
FLUIDdialysate creatinine per tv:creatinine (serum-cr):
FLUIDdialysate fluid creat test:creatinine (serum-cr):
FLUIDdialysate fluid glu test::
FLUIDdialysate fluid urea test::
FLUIDdialysate fluid volume::
FLUIDdialysate glu per tv::
FLUIDdialysate sg::
FLUIDdialysate total volume::
FLUIDdialysate urea per tv::
FLUIDeosinophils: body fluid:
FLUIDeosinophils: pleural fluid:
FLUIDfresh frozen plasma apheresis::
FLUIDfresh frozen plasma::
FLUIDglucose: body fluid:
FLUIDglucose: dialysate fluid:
FLUIDglucose: peritoneal fluid:
FLUIDglucose: pleural fluid:
FLUIDglucose: synovial fluid:
FLUIDhematocrit: pleural fluid:
FLUIDhistiocytes: pleural fluid:
FLUIDlactate dehydrogenase: peritoneal fluid:

FLUIDlactate dehydrogenase: pleural fluid:
FLUIDldh: peritoneal fluid:
FLUIDldh: pleural fluid:
FLUIDldh: synovial fluid:
FLUIDlymphocytes: body fluid:
FLUIDlymphocytes: pleural fluid:
FLUIDlymphocytes: synovial fluid:
FLUIDmacrophages: body fluid:
FLUIDmesothelials: body fluid:
FLUIDmonocytes: body fluid:
FLUIDmonocytes: pleural fluid:
FLUIDmonocytes: synovial fluid:
FLUIDmononuclear cells: body fluid:
FLUIDneutrophils: body fluid:
FLUIDneutrophils: pleural fluid:
FLUIDneutrophils: synovial fluid:
FLUIDother cells: body fluid:
FLUIDother cells: pleural fluid:
FLUIDother cells: synovial fluid:
FLUIDperitoneal fluid mononuclear::
FLUIDperitoneal fluid polymorphs::
FLUIDph: body fluid:
FLUIDph: pleural fluid:
FLUIDpleural fluid mononuclear cell::
FLUIDpleural fluid polymorphs::
FLUIDpolymorphs:body fluid:
FLUIDpotassium: body fluid:
FLUIDpotassium: peritoneal fluid:
FLUIDpotassium: pleural fluid:
FLUIDrbc: body fluid:
FLUIDrbc: peritoneal fluid:
FLUIDrbc: synovial fluid:
FLUIDred blood count: pleural fluid:
FLUIDsg: dial. fluid:
FLUIDsodium: body fluid:
FLUIDsodium: dialysate fluid:
FLUIDsodium: peritoneal fluid:
FLUIDsodium: pleural fluid:
FLUIDspec gravity: pleural fluid:
FLUIDspecific gravity: dialysate fluid:
FLUIDsweat chloride 1::
FLUIDsweat chloride 2::
FLUIDsweat chloride measurement::
FLUIDsweat chloride::
FLUIDsweat cl #1::
FLUIDsweat cl #2::
FLUIDsweat conductivity::

FLUIDsynovial fld mononuclear cell::
FLUIDsynovial fluid polymorphs::
FLUIDtotal nuc cell ct: body fluid:
FLUIDtotal nuc cell ct: pleural fld:
FLUIDtotal protein: body fluid:
FLUIDtotal protein: peritoneal fluid:
FLUIDtotal protein: pleural fluid:
FLUIDtotal protein: synovial fluid:
FLUIDtotal volume: dialysate fluid:
FLUIDtriglyceride: body fluid:triglycerides (tg)
FLUIDtriglyceride: peritoneal fluid:triglycerides (tg)
FLUIDtriglyceride: pleural fluid:triglycerides (tg)
FLUIDurea: body fluid:
FLUIDurea: dialysate fluid:
FLUIDurea: pleural fluid:
FLUIDuric acid: body fluid:
FLUIDuric acid: pleural fluid:
FLUIDuric acid: synovial fluid:
FLUIDwbc count: pleural fluid:
FLUIDwbc: body fluid:
FLUIDwbc: pericardial fluid:
FLUIDwbc: peritoneal fluid:
FLUIDwbc: synovial fluid:
FLUIDweight sweat 1::
FLUIDweight sweat 2::
FLUIDweight: dialysate fluid:
FOLAT serum folate::
FOLAT folate: rbc:
FOLAT folate::
FOLAT rbc folate::
FOLAT red cell folate::
FSH follicle stimulating hormone::
FSH fsh::
G6D g6pd::
G6D g6pdh::
G6D gluc 6 phosphate dehydrogenase::
GABA gabapentin::
GAMMA gamma (electrophoresis)::
GAMMA gamma electrophoresis::
GAMMA gamma globulin (relative spe)::
GAMMA gamma globulin (relative)::
GAMMA gamma globulins (spe)::
GAMMA gamma globulins::
GAS a-a oxygen gradient::
GAS anion gap::
GAS art bld partial pressure co2::
GAS art bld partial pressure o2::

GAS art cord blood gas temperature::
GAS art cord partial pco2::
GAS art cord partial pressure o2::
GAS arterial cord ph::
GAS arterial bld gas o2 saturation::
GAS arterial blood gas base excess::
GAS arterial blood gas fio2::
GAS arterial blood gas hco3::
GAS arterial blood gas ph::
GAS arterial blood gas temperature::
GAS arterial deoxyhemoglobin::
GAS arterial oxyhemoglobin::
GAS arterial pco2 (temp corr)::
GAS arterial ph (temp corr)::
GAS arterial po2 (temp corr)::
GAS arterial tco2::
GAS base excess venous::
GAS base excess::
GAS be art cord (a)::
GAS be ven cord (a)::
GAS be ven::
GAS be::
GAS bicarb ven::
GAS bicarbonate arterial cord (a)::
GAS bicarbonate venous cord (a)::
GAS bicarbonate venous::
GAS bicarbonate::
GAS cap base excess::
GAS cap bld gas o2 saturation::
GAS cap bld partial pressure co2::
GAS cap bld partial pressure o2::
GAS cap blood gas hco3::
GAS cap blood gas temperature::
GAS cap ct hb carboboxyhemoglobin::
GAS cap methemoglobin::
GAS cap pco2 (temp corr)::
GAS cap ph (temp corr)::
GAS cap po2 (temp corr)::
GAS cap tco2::
GAS capillary blood gas fio2::
GAS capillary blood gas ph::
GAS capillary deoxyhemoglobin::
GAS capillary o2 content::
GAS carbon monoxide screen::
GAS carboxyhemgbn::
GAS carboxyhemoglobin::
GAS carboxyhgb::

GAS carboxyhglobin::
GAS co2::
GAS cor pco2::
GAS cor ph::
GAS cor po2::
GAS ct carboxyhemoglobin::
GAS ct hb carboxyhemoglobin::
GAS fio2::
GAS fio2:::
GAS hco3 art cd (a)::
GAS hco3 ven cd (a)::
GAS hco3::
GAS hgb o2 sat:hemoglobin (hb):
GAS o2 content ven::
GAS o2 content venous::
GAS o2 content::
GAS o2 sat venous::
GAS o2 sat::
GAS o2 saturation venous::
GAS o2 saturation::
GAS o2hb::
GAS oxyhemoglobin::
GAS pco2 art cd (a)::
GAS pco2 arterial cord (a)::
GAS pco2 temp corrt::
GAS pco2 ven cd (a)::
GAS pco2 ven::
GAS pco2 venous cord (a)::
GAS pco2 venous::
GAS pco2::
GAS ph (serum)::
GAS ph art cord (a)::
GAS ph temp corrtd::
GAS ph ven cord (a)::
GAS ph ven::
GAS ph venous cord (a)::
GAS ph venous::
GAS ph water::
GAS ph::
GAS po2 art cd (a)::
GAS po2 arterial cord (a)::
GAS po2 temp corrtd::
GAS po2 ven cd (a)::
GAS po2 ven::
GAS po2 venous cord (a)::
GAS po2 venous::
GAS po2::

GAS poc anion gap::
GAS poc base excess::
GAS poc bld gas o2 saturation::
GAS poc carboxyhemoglobin::
GAS poc cor pco2::
GAS poc cor ph::
GAS poc cor po2::
GAS poc hco3::
GAS poc o2hb::
GAS poc pco2::
GAS poc ph::
GAS poc po2::
GAS poc so2::
GAS poc tco2::
GAS poc v pco2 istc::
GAS poc v po2 istc::
GAS poc ven be is::
GAS poc ven blood gas base excess::
GAS poc ven blood gas hco3::
GAS poc ven fio2 is::
GAS poc ven hco3 is::
GAS poc ven lact is::
GAS poc ven lactate::
GAS poc ven partial pressure co2::
GAS poc ven partial pressure o2::
GAS poc ven pco2 is::
GAS poc ven ph is::
GAS poc ven ph istc::
GAS poc ven po2 (temp corr)::
GAS poc ven po2 is::
GAS poc ven so2 is::
GAS poc ven tco2 is::
GAS poc venous blood gas ph::
GAS poc venous pco2 (temp corr)::
GAS poc venous ph (temp corr)::
GAS poc venous total co2::
GAS so2::
GAS tco2 serum::
GAS total carbon dioxide level::
GAS total co2::
GAS v bld gas o2 saturation::
GAS ven bld partial pressure co2::
GAS ven bld partial pressure o2::
GAS ven blood gas hco3::
GAS ven carboboxyhemoglobin::
GAS ven cord blood gas temperature::
GAS ven cord partial pressure o2::

GAS ven cord pco2::
GAS ven cord ph::
GAS venouos blood gas fio2::
GAS venous blood gas base excess::
GAS venous blood gas ph::
GAS venous blood gas temperature::
GAS venous deoxyhemoglobin::
GAS venous lactate::
GAS venous oxyhemoglobin::
GAS venous pco2 (temp corr)::
GAS venous ph (temp corr)::
GAS venous po2 (temp corr)::
GAS venous tco2::
GASTRIN gastrin::
GENTA gentamicin level extended::
GENTA gentamicin level::
GENTA gentamicin post dose::
GENTA gentamicin post::
GENTA gentamicin pre dose::
GENTA gentamicin pre::
GENTA gentamicin random::
GENTA gentamicin::
GFR egfr (non african american):plasma creatinine clearance (egfr):
GFR egfr:plasma creatinine clearance (egfr):
GFR est glomerular filtration rate::
GGT gamma glutamyl transferas::
GGT gamma glutamyl transferase::
GGT gamma gt:gamma glutamyl transferase in serum or plasma (ggt):
GGT gamma-glutamyl transferase (ggt):gamma glutamyl transferase in serum or plasma (ggt):
GGT gamma::
GGT ggt:gamma glutamyl transferase in serum or plasma (ggt):
GGT poc gamma glutamyl transferase::
GGT poc ggt:gamma glutamyl transferase in serum or plasma (ggt):
GH growth hormone::
GLOB globulin::
GLOB globulins::
GLUCA glucagon level::
GLUCO % diff glu::
GLUCO 0.5 hour glucose:glucose tolerance test (gtt):
GLUCO 1 hour 50g gct::
GLUCO 1 hr glucose:glucose tolerance test (gtt):
GLUCO 1-hour 50g glucose challenge::
GLUCO 2 hr glucose:glucose tolerance test (gtt):
GLUCO 3 hr glucose:glucose tolerance test (gtt):
GLUCO 50g 1hr trutol::
GLUCO ac gluc::

GLUCO glucose (ac):fasting blood glucose (fbg):
GLUCO glucose (pc)::
GLUCO glucose (random)::
GLUCO glucose 1 hour:glucose tolerance test (gtt):
GLUCO glucose 1 hr (gct):glucose tolerance test (gtt):
GLUCO glucose 1 hr (trutol):glucose tolerance test (gtt):
GLUCO glucose 1 hr:glucose tolerance test (gtt):
GLUCO glucose 1.5 hour:glucose tolerance test (gtt):
GLUCO glucose 2 hour pc:glucose tolerance test (gtt):
GLUCO glucose 2 hour:glucose tolerance test (gtt):
GLUCO glucose 2 hr:glucose tolerance test (gtt):
GLUCO glucose 3 hour:glucose tolerance test (gtt):
GLUCO glucose 30 minutes::
GLUCO glucose ac (pl):fasting blood glucose (fbg):
GLUCO glucose ac: plasma:fasting blood glucose (fbg)
GLUCO glucose ac:fasting blood glucose (fbg):
GLUCO glucose fasting:fasting blood glucose (fbg):
GLUCO glucose loading dose::
GLUCO glucose monitor poc testing::
GLUCO glucose monitor::
GLUCO glucose patient::
GLUCO glucose pc 1hr:glucose tolerance test (gtt):
GLUCO glucose pc 2 hr:glucose tolerance test (gtt):
GLUCO glucose pc: plasma:
GLUCO glucose pc::
GLUCO glucose random: plasma:
GLUCO glucose random::
GLUCO glucose::
GLUCO glucose(bf):fasting blood glucose (fbg):
GLUCO percent difference pt. glu::
GLUCO poc glucose::
NA glycine plasma::
GRAN abs imm gran::
GRAN abs immature granulocytes::
GRAN granular casts::
GRAN granulocytes (auto)::
GRAN granulocytes #::
GRAN immature grans::
GRAN immature granulocyte (auto)::
GRAN immature granulocyte #::
HBA1C a1c hgb la1c:hemoglobin a1c (hba1c):
HBA1C a1c p4:hemoglobin a1c (hba1c):
HBA1C hba1c referred:hemoglobin a1c (hba1c):
HBA1C hemoglobin a1c:hemoglobin a1c (hba1c):
HBA1C hgb a1c:hemoglobin a1c (hba1c):
HGB fetal hemoglobin::
HGB total hemoglobin:hemoglobin (hb):

HBV hbv surface ab::
HBV hepatitis b surface antibody::
HBV hepatitis b surface antigen::
HBV hepatitis b viral load::
HCG beta hcg quantitative::
HCG beta hcg::
HCG hcg beta::
HCG hcg: beta:
HCG hcgb::
HCG quantitative serum hcg::
HCT hct referred in::
HCT hct::
HCT hematocrit neo::
HCT hematocrit::
HCT poc hct::
HCT poc hematocrit::
HCV hcv ab screen:hepatitis c virus ab in serum or plasma (hcv-ab):
HCV hcv ab:hepatitis c virus ab in serum or plasma (hcv-ab):
HCV hcv genotype::
HCV hep c ab:hepatitis c virus ab in serum or plasma (hcv-ab):
HCV hep c pcr::
HCV hepatitis c antibody:hepatitis c virus ab in serum or plasma (hcv-ab):
HCV hepatitis c viral load::
HDL hdl cholesterol non-fasting:cholesterol in hdl (hdlc):
HDL hdl cholesterol:cholesterol in hdl (hdlc):
HDL hdl-cholesterol:cholesterol in hdl (hdlc):
HDL hdl:cholesterol in hdl (hdlc):
HDL hdlc:cholesterol in hdl (hdlc):
HGB cap total hemoglobin:hemoglobin (hb):
HGB concentration of hgb in retics:hemoglobin (hb):
HGB hemoglobin a::
HGB hemoglobin a2::
HGB hemoglobin f::
HGB hemoglobin neo:hemoglobin (hb):
HGB hemoglobin s::
HGB hemoglobin:hemoglobin (hb):
HGB hgb a2::
HGB hgb neonatal:hemoglobin (hb):
HGB hgb:hemoglobin (hb):
HGB poc hemoglobin:hemoglobin (hb):
HGB poc hgb:hemoglobin (hb):
HGB retic hemoglobin equivalent::
HGB unstable hgb::
HGB venous total hemoglobin:hemoglobin (hb):
HIST histidine plasm::
HIST histidine plasma::
HIV hiv 1/2 antibody::

HIV hiv viral load::
HIV hiv western blot confirmatory::
HOMO homocysteine::
HOMO homocysteine:plasma:
HOMO homocystine p::
HOMO homocystine plasma::
HOMO homocystine u::
HOMO homocystine::
IG anti s cer iga::
IG anti s cer igg::
IG anti-cardiolipin igg::
IG anti-saccromyces cervisae iga::
IG anti-saccromyces cervisae igg::
IG card igg::
IG dat:igg + c3d::
IG ig absolute::
IG ig percent auto::
IG iga iep::
IG iga::
IG igd::
IG ige::
IG igg::
IG igg1::
IG igg2::
IG igg3::
IG igg4::
IG igm iep::
IG igm::
IG immunoglobulin a::
IG immunoglobulin e::
IG immunoglobulin g::
IG immunoglobulin m::
IG rubeola (measles) igg::
IG varicella-zoster ig::
IGF igf-1::
IGF igf1::
IGF igfbp3::
IGF ins like growth factor -1::
IGF insulin like growth factor 1::
INR inr - qeii:international normalized ratio (inr):
INR inr 50/50 mix:international normalized ratio (inr):
INR inr capillary:international normalized ratio (inr):
INR inr man:international normalized ratio (inr):
INR inr:international normalized ratio (inr):
INR manual inr:international normalized ratio (inr):
INR poc inr istat:international normalized ratio (inr):
INR poc inr:international normalized ratio (inr):

INR prothrombin time-vgh (inr):international normalized ratio (inr):
INR pt inr:international normalized ratio (inr):
INSUL insulin ab::
INSUL insulin::
IRON iron content::
IRON iron total::
IRON iron: liver tissue:
IRON iron::
IRON unsaturated iron binding capacity::
KAPPA free kappa::
KAPPA kap lam ratio::
KAPPA kap/lam ratio::
KAPPA kappa iep::
KAPPA kappa level::
KAPPA kappa::
KAPPA kappa/lambda ratio::
KETO ketone (serum)::
KETO ketone::
KETO ketones::
KETO poc ketones::
LACT cap lactate::
LACT lac ratio::
LACT lac::
LACT lactate::
LACT lactic acid level::
LACT poc lactate::
LAMBDA free lambda::
LAMBDA lambda iep::
LAMBDA lambda level::
LAMBDA lambda::
LAMO lamotrigine::
LDH lactate dehydrogenase: body fluid:
LDH lactate dehydrogenase::
LDH ld::
LDH ldh::
LDL ldl calculated:cholesterol in ldl (ldlc):
LDL ldl cholesterol:cholesterol in ldl (ldlc):
LDL ldl direct:cholesterol in ldl (ldlc):
LDL ldl-c:cholesterol in ldl (ldlc):
LDL ldl-calculated:cholesterol in ldl (ldlc):
LEAD lead level::
LEAD lead: blood:
LEAD lead::
LEAD lead:blood:
LH lh::
LH luteinizing hormone::
LH lutenizing hormone::

LIPA lipase::
LITH lithium level::
LITH lithium::
LYMPH abs lymph count::
LYMPH abs lymph ct::
LYMPH absolute lymphocyte count::
LYMPH atypical lymphocytes::
LYMPH atypical lymphocytes::
LYMPH atypical lymphs::
LYMPH large granular lymphocytes::
LYMPH lymph::
LYMPH lymphocytes (auto)::
LYMPH lymphocytes #::
LYMPH lymphocytes::
LYMPH lymphs::
LYMPH poc lym abs::
LYMPH poc lymphocytes (auto)::
LYMPH poc lymphocytes #::
LYMPH poc lympocyte::
LYMPH prolymphocytes::
LYMPH reactive lymphocytes::
LYMPH villous lymphocytes::
MAG magnesium level::
MAG magnesium::
MAG magnesium/24h::
ALB microalbumin::
ALB microalbumin:ur:
MCH mch neo:erythrocyte mean corpuscular hemoglobin (mch):
MCH mch:erythrocyte mean corpuscular hemoglobin (mch):
MCH mean cell hemoglobin::
MCH mean corpuscular hemoglobin:erythrocyte mean corpuscular hemoglobin (mch):
MCHCmchc neo:erythrocyte mean corpuscular hemoglobin concentration (mchc):
MCHCmchc:erythrocyte mean corpuscular hemoglobin concentration (mchc):
MCHCmean cell hemoglobin conc::
MCHCmean corpuscular hgb conc::
MCHCpoc mch:erythrocyte mean corpuscular hemoglobin (mch):
MCHCpoc mchc:erythrocyte mean corpuscular hemoglobin concentration (mchc):
MCHCpoc mean corpuscular hemoglobi::
MCHCpoc mean corpuscular hgb conc::
MCV mcv neo:erythrocyte mean corpuscular volume (mcv):
MCV mcv:erythrocyte mean corpuscular volume (mcv):
MCV mean cell volume::
MCV mean corpuscular volume:erythrocyte mean corpuscular volume (mcv):
MCV poc mcv:erythrocyte mean corpuscular volume (mcv):
MCV poc mean corpuscular volume:erythrocyte mean corpuscular volume (mcv):
MEAS measles (rubeola) igm::
MEAS measles antibody igg::

MEAS measles antibody igm::
MERC mercury:bld:
MIXED mixed cells (auto)::
MIXED mixed cells #::
MIXED poc mixed (mono/eos/baso)::
MIXED poc mixed cells (auto)::
MIXED poc mixed cells #::
MIXED poc mixed::
MONO abs mono count::
MONO abs mono ct::
MONO absolute monocyte count::
MONO mono::
MONO mono/macrophage::
MONO mono/macrophages::
MONO monocytes (auto)::
MONO monocytes #::
MONO monocytes::
MONO monocytes/macrophages::
MONO monoocytes::
MONO monos::
MPV mpv::
MPV poc mpv::
MYELO metamyelocytes::
MYELO myelo::
MYELO myeloblasts::
MYELO myelocytes::
MYELO myeloid:erythroid ratio::
MYELO myeloperox.ab::
MYELO promyelocytes::
NA /codeine 1::
NA /morphine 1::
NA 11-deoxycortisol::
NA 11deoxycortisol::
NA 17 alpha-hydroxy progesterone::
NA 17-oh-corticost::
NA 3-methistidine::
NA a-1-antitrypsin:alpha-1 antitrypsin in serum or plasma (a1at):
NA a-oh progest::
NA a.g.::
NA a/g ratio electrophoresis::
NA a/g ratio::
NA a1at phenotype::
NA acb receptor ab::
NA acetone::
NA acth::
NA acylcarnitine fract blood spot::
NA acylcarnitines::

NA adh::
NA adrenocorticotropic horm::
NA afpmat serum scr 2nd trimester::
NA aim dq typ tplt::
NA aldolase::
NA aldosterone bld::
NA aldosterone:blood:
NA aluminum::
NA amitriptyline::
NA amylas-salivary::
NA ana titre hep2::
NA ana titre::
NA angiotensin conv enz::
NA anserine::
NA anti - gad::
NA anti ccp::
NA anti mpo::
NA anti mull horm::
NA anti pr3::
NA anti streptolysin o titer::
NA anti thyroid peroxidase antibo::
NA anti xa (heparin xa)::
NA anti xa::
NA anti-cardiolipa::
NA anti-ccp::
NA anti-cyclic citrulinated pepti::
NA anti-cyclic citrullinated peptide::
NA anti-dna titre::
NA anti-dna-ds::
NA anti-dna::
NA anti-double strand dna ab::
NA anti-gbm scr::
NA anti-gbm screen::
NA anti-gbm::
NA anti-glomerular base memb::
NA anti-la/ssb::
NA anti-mpo::
NA anti-myeloperoxidase::
NA anti-nuclear antibody screen::
NA anti-nuclear antibody titer::
NA anti-parietal cell titre::
NA anti-pemphigoid titre::
NA anti-pic titre::
NA anti-pr3::
NA anti-proteinase::
NA anti-rnp::
NA anti-ro/ssa::

NA anti-scl 70::
NA anti-sm::
NA anti-smooth muscle screen::
NA anti-smooth muscle titre::
NA anti-streptolysin o titre::
NA anti-streptolysin o::
NA anti-thyroglob::
NA anti-thyroglobulin antibody::
NA anti-tissue transglutaminase::
NA anti-tpo::
NA anti-xa::
NA antithrombin iii::
NA antithyroid peroxidase antibody::
NA apolipoprotein b::
NA apolipoproteinb::
NA apprx m:e ratio::
NA aptt (xxxxx)::
NA aptt-xxxxx reag::
NA aptt-xxxxx::
NA arginine plasma::
NA arginine::
NA arsenic::
NA arylsulphatasea::
NA as-3 red blood cells:lr:irrad
NA asa screen::
NA asa titre::
NA asma titre::
NA asot::
NA asparagine plasma::
NA asparagine::
NA aspartic acid::
NA atiii::
NA auto cont @ 4::
NA b-alanine::
NA b-hydroxy butyr::
NA b-type natriuretic peptide::
NA b2 microglobuln::
NA ba total volume::
NA ba white blood cell:leukocytes in blood (wbc):
NA band::
NA bethesda inhib::
NA biotinidase scr::
NA biotinidase::
NA bleeding time::
NA bm accession#'s::
NA c1 ester inact::
NA c1 inactivator::

NA c3::
NA c8 carnitine::
NA ca 15-3 antigen::
NA ca 15-3::
NA ca phosphate::
NA ca/phos product::
NA ca15-3::
NA ca19-9::
NA caffeine::
NA calculated calcium:ionized:
NA capillary oxyhemoglobin::
NA carbohydrate antigen 19-9::
NA cardiolipin ab::
NA carnitine:free blood spot:
NA carnitine:total blood spot:
NA carnosine::
NA cast type::
NA cbc (cell count)::
NA cbz epoxide::
NA cd3-abs ct::
NA centromere b::
NA ceruloplasmin::
NA ch50 alternate pathway::
NA ch50 alternate::
NA ch50 classical::
NA ch50 complement::
NA chloride-direct::
NA cholinesterase::
NA chromatin::
NA citrulline plas::
NA citrulline plasma::
NA clobazam::
NA clomipramine::
NA cold aggln @ 20::
NA cold aggln @ 37::
NA cold aggln @ 4::
NA cold agglutinin 4 degree::
NA cold agglutinins titer::
NA combined metabolite::
NA complement c1q component::
NA concentrated ppc:ir: lr
NA cont/pt immed::
NA control immed::
NA copro /creat::
NA copro::
NA coproporphyrin::
NA corticost 18 ho::

NA cp2d platelets: lr: irrad
NA cpd frozen plasma::
NA crp (qeii)::
NA crystals::
NA cy bands::
NA cy basophils::
NA cy eosinophils::
NA cy ependymal::
NA cy lymphocytes::
NA cy mesothelial::
NA cy metamyelo::
NA cy mono/macro::
NA cy neutrophils::
NA cy nucleatd rbc::
NA cy other cells::
NA cy total cells counted::
NA cy total cells::
NA cya 2::
NA cyclosporin a::
NA cyclosporine a::
NA cyclosporine::
NA cystathionine::
NA cystine plasma::
NA d-xylose::
NA dehydrochol::
NA deoxycorticosterone::
NA desipramine::
NA desmethyl doxepin::
NA desmethylclomip::
NA desmethylclozapine::
NA despipramine::
NA dhea::
NA dibucaine no.::
NA dm clomipramine::
NA dm trimipramine::
NA doxepin::
NA dsdna::
NA epinephrine sup::
NA epinephrine supine::
NA epinephrine::
NA epival::
NA erythroblasts::
NA erythropoietin::
NA ethanolamine::
NA f test-analogue::
NA f232 ovalbumin::
NA f233 ovomucoid::

NA fg::
NA fibrinogen assay::
NA fibrinogen::
NA fk506 (tacrolimus)::
NA fk506::
NA fluoride no.::
NA follicle stim. hormone::
NA free carnitine::
NA free k/l ratio::
NA fructosamine::
NA gad65::
NA galactosid:beta:
NA galactosidase:alpha:
NA gamimune 10.0 grams::
NA gamimune 20.0 grams::
NA gamimune 5.0 grams::
NA gamunex 10.0 grams::
NA gamunex 2.5 grams::
NA gamunex 20.0 grams::
NA gamunex 5.0 grams::
NA gerbil e209::
NA glutamic acid decarboxyl ab 65::
NA glutamine plasm::
NA glutamine plasma::
NA haptoglobin: serum:
NA haptoglobin::
NA hematopoietic::
NA heparin xa::
NA hexosamin b ser::
NA hexosaminid b %::
NA hexosaminidase b:serum %:
NA hexosaminidase b:serum:
NA hexosaminidase:total:
NA hexosaminidaset::
NA hit interp::
NA hizentra 10 ml::
NA hizentra 20 ml::
NA hla ab screen::
NA homovanillic acid random::
NA humate p::
NA hva random::
NA hva::
NA hvaran::
NA hyaline cast::
NA hyaline casts::
NA hydroxy butyrate:beta:
NA hydroxyproline plasma::

NA hydroxyproline::
NA hypoxanthine::
NA igivnex 10 grams::
NA igivnex 20 grams::
NA imipramine::
NA infliximab::
NA inflixmab::
NA inhib ptt c/p immed::
NA inhib ptt control immed::
NA inhib ptt patient immed::
NA ins growth fct binding prot 3::
NA isohem tit a/a::
NA isohem tit a/b::
NA isohem tit auto::
NA isoleucine plasma::
NA isoleucine::
NA isopropanol::
NA jo-1::
NA kleih post amni::
NA kleihauer betke::
NA kleihauer::
NA lamellar bodies::
NA leptin::
NA leucine plasma::
NA leukemia::
NA leukocyte esterase::
NA lipemia::
NA lysine plasma::
NA lysine::
NA m ab prelim::
NA m ab template::
NA m fxm template::
NA m lr typ tplt::
NA m:e ratio::
NA macrophages::
NA malaria count::
NA malignant cells::
NA mannose binding lectin::
NA manual ptt::
NA mbl activity::
NA mbl::
NA mcad::
NA metas::
NA methemoglobin::
NA methionine p::
NA methionine plasma::
NA methotrexate::

NA methyl alc:bld:
NA methyl alcohol: quant:
NA mevalonic acid::
NA mpv neo::
NA mthfr gene interpretation::
NA mucopolysac.scr::
NA mycophenolate::
NA mycophenylate::
NA myoglobin::
NA myoglobulin::
NA n-desmethylclobazam::
NA ndmc::
NA norepineph sup::
NA norepinephrine supine::
NA norepinephrine::
NA normal control pt (for 50mix)::
NA nortriptyline::
NA nrbc #::
NA nrbc::
NA ornithine plasma::
NA ornithine::
NA osteocalcin::
NA oxalate::
NA pancreatic elas::
NA patient's pt (for 50mix)::
NA patient's ptt (50mix test)::
NA pbg::
NA pbg/creatinine::
NA pc::
NA pcp 1::
NA pen g c1::
NA pen v c2::
NA pfa interp:::
NA pg::
NA pha blood spot::
NA pha corr. plsma::
NA phenobarbital level::
NA phenobarbital::
NA phenylalanine corr. to plasma::
NA phenylalanine plasma::
NA phosphoethanola::
NA phosphoethanolamine plasma::
NA phytanic acid::
NA pipecolic acid::
NA plasma extr rc: lr: irr
NA plasminogen act inhibitor::
NA plasminogen inh::

NA poc alanine amino transferase::
NA poc bun/urea::
NA poc ica::
NA poc leukocyte esterase::
NA poc methemoglobin::
NA poc rdw-cv:erythrocyte distribution width [ratio] (rdw_cv):
NA poc red blood count::
NA poc specific gravity::
NA poc urobilinogen::
NA poc v pt tempis::
NA porphobilinogen::
NA privigen 10g::
NA privigen 20g::
NA proline plasma::
NA proline::
NA promyelos::
NA proteinase 3 ab::
NA pt 50% correct::
NA pt capillary::
NA ptt (50/50 mix immediate)::
NA ptt (xxxxx)::
NA ptt 50/50 mix::
NA ptt 50% correct::
NA ptt-vgh::
NA pyruvate kinase::
NA pyruvate::
NA rdw neo:erythrocyte distribution width [ratio] (rdw_cv):
NA reaction prodct::
NA renin mass supine::
NA renin mass upright::
NA renin mass::
NA renin supine::
NA renin upright::
NA reverse t3::
NA ribosomal p::
NA rro test request::
NA schistocytes::
NA scl-70::
NA scoline no.::
NA seg neuts::
NA serine plasma::
NA serine::
NA serum haptoglob::
NA serum haptoglobulin::
NA sex hormone binding glob::
NA sex hormone binding globulin::
NA sexhormbindglob::

NA sg-g::
NA sg::
NA sirolimus::
NA sm::
NA sm/rnp::
NA squamous::
NA ss-a::
NA ss-a/ro::
NA ss-b::
NA ss-b/la::
NA supernatant reduc. rc: lr: irr
NA syn tcc::
NA t.metanephrine::
NA ta(thyroglobul)::
NA tab microsomal::
NA tacrolimus::
NA taurine plasma::
NA taurine::
NA tcc::
NA telopeptide-c::
NA tetanus imm globulin::
NA theophylline level::
NA theophylline::
NA thiopurine methyltransferase::
NA threonine plasma::
NA threonine::
NA thyroglob ab::
NA thyroglobulin::
NA thyroid ab::
NA thyroid antibody::
NA tisseel 2 ml::
NA tisseel 4 ml::
NA tobra daily pk::
NA tobramycin level post::
NA tobramycin level::
NA tobramycin post::
NA tobramycin pre dose::
NA tobramycin pre::
NA tobramycin::
NA tot amitriptyl::
NA tot clomipramin::
NA tot imipramine::
NA total bileacids::
NA total carnitine::
NA total clobazam::
NA total clomip::
NA total erythroid::

NA total imipramine::
NA total myeloid::
NA total nuc cell ct: pericardial:
NA total nuc cell ct: peritoneal:
NA total nuc cell ct: synovial fl:
NA total protein qeii::
NA tp (qeii)::
NA tpmt::
NA trephine biopsy::
NA trimipramine::
NA troponin-t hs by cardiac xxxxx::
NA tryptase::
NA tryptophan::
NA tv::
NA tyrosine blood spot::
NA tyrosine bs::
NA tyrosine plasma::
NA tyrosine::
NA ufc/creatinine::
NA upe::
NA uracil::
NA uro /creat::
NA uro::
NA urobilinogen::
NA uroporphyrin::
NA valine plasma::
NA valpoic acid::
NA valproic acid (depakene) level::
NA vancomycin post level::
NA venous methemoglobin::
NA vivaglobin 10ml::
NA vivaglobin 3ml::
NA vlcfa c:26:0::
NA vlcfa c24:0/c22::
NA vlcfa c24:0/c22:0::
NA vlcfa c24/c22::
NA vlcfa c26:0::
NA vlcfa c26:0/c22::
NA vlcfa c26:0/c22:0::
NA vlcfa c26/c22::
NA vma / creat:creatinine (serum-cr):
NA vma /creat::
NA vma random::
NA vma::
NA vmar::
NA vmaran::
NA weed mix wm1::

NA weed mix wm2::
NA winrho 120 ug::
NA winrho 300 ug::
NA xanthine::
NA xxxxx ptt::
NA xxxxx. esterase::
NA yeast::
NA zpp::
NEUT poc neu abs::
NEUT poc neut::
NEUT poc neutrophils (auto)::
NEUT poc neutrophils #::
NEUT abs neutro ct::
NEUT absolute neutrophil count::
NEUT neut::
NEUT neutro::
NEUT neutrophils (auto)::
NEUT neutrophils #::
NEUT neutrophils::
NEUT neutros::
NEUT seg neutrophils::
NEUT sf neut::
OSM osmolality::
OTHER % saturation::
OTHER 10:11 epoxide:
OTHER 1pt cya 2hr specimen::
OTHER 2pt area under the curve::
OTHER 2pt cya 1hr specimen::
OTHER 2pt cya 3hr specimen::
OTHER 50/50 mix pt (patient/control)::
OTHER accession #::
OTHER additional locus::
OTHER age at coll'n::
OTHER age at collection::
OTHER analysis::
OTHER arrival time::
OTHER body surface area::
OTHER cast type:::
OTHER col'n time::
OTHER diagnosis::
OTHER discussion::
OTHER donation number::
OTHER dosage::
OTHER dosage:::
OTHER dose given::
OTHER dose:::
OTHER drawn by::

OTHER	drawn by:::
OTHER	dur collection::
OTHER	early::
OTHER	enc:::
OTHER	end time:::
OTHER	epithelial::
OTHER	fluid volume::
OTHER	glucose device::
OTHER	gross descript::
OTHER	hold duration::
OTHER	hold sample::
OTHER	intermediate::
OTHER	late::
OTHER	microscopic::
OTHER	number of referred in slides::
OTHER	osmolality-calculated::
OTHER	others::
OTHER	p blood film::
OTHER	performed by:::
OTHER	poc blood::
OTHER	poc patient temperature::
OTHER	reaction donor #::
OTHER	rfq::
OTHER	size::
OTHER	spec gravity::
OTHER	spec received::
OTHER	specific gravity::
OTHER	specimen #::
OTHER	start time:::
OTHER	stimulated::
OTHER	temperature::
OTHER	time:::
OTHER	total volume::
OTHER	total volume:::
OTHER	tube #::
OTHER	unstimulated::
OTHER	verified by::
OTHER	visc serum::
OTHER	viscosity:serum:
OTHER	volume::
OTHER	volume:::
OTHER	weight: liver tissue:
OTHER	weight:::
PHENYL	phenylalanine::
PHENYT	phenytoin (dilantin)::
PHENYT	phenytoin by hplc::
PHENYT	phenytoin::

PHOS phosphate::
PHOS phosphate/24h::
PHOS phosphorous level::
PHOS phosphorus::
PKU pku known::
PKU pku nn recheck::
PLASM plasma cells::
PLAT 2platelets apheresis lr: irrad:platelets in blood (plt)
PLAT citrate plt:platelets in blood (plt):
PLAT cpd platelets:pooled:lr
PLAT imm plt fract:platelets in blood (plt):
PLAT immature platelet fraction:platelets in blood (plt):
PLAT manual platelet count:platelets in blood (plt):
PLAT manual plt:platelets in blood (plt):
PLAT mean platelet volume:platelets in blood (plt):
PLAT plat: apheresis:lr
PLAT platelet count:platelets in blood (plt):
PLAT platelet estimate:platelets in blood (plt):
PLAT platelets apheresis lr: irrad:platelets in blood (plt)
PLAT platelets:platelets in blood (plt):
PLAT plt count neo:platelets in blood (plt):
PLAT plt count:platelets in blood (plt):
PLAT plt:platelets in blood (plt):
PLAT poc mean platelet volume:platelets in blood (plt):
PLAT poc platelets:platelets in blood (plt):
PLAT poc plt:platelets in blood (plt):
POT k::
POT poc potassium::
POT potassium level-direct::
POT potassium level::
POT potassium::
PROG 17 a-oh progest::
PROG progesterone::
PROLAC prolactin::
PROT poc protein::
PROT poc t protein::
PROT poc total protein::
PROT prot c resist::
PROT prot c resist.::
PROT prot/creat ratio::
PROT protein c activ::
PROT protein c activity::
PROT protein c resis::
PROT protein c resistance::
PROT protein c::
PROT protein s free::
PROT protein s::

PROT protein total::
PROT protein::
PROT protein/24h::
PROT tot. protein bf::
PROT total protein (spe)::
PROT total protein: peritoneal fld:
PROT total protein::
PROT ur tot protein random::
PSA fpsa/psa ratio:free prostate specific ag ratio in serum or plasma (psa: f/t ratio)
PSA free prostatic antigen::
PSA prostate specific antigen free:free prostate specific ag in serum or plasma (psa: free)
PSA prostate specific antigen:total prostate specific ag in serum or plasma (psa: total)
PSA prostatic specific antige::
PSA psa free to psa ratio:free prostate specific ag ratio in serum or plasma (psa: f/t ratio)
PSA psa free/total:free prostate specific ag ratio in serum or plasma (psa: f/t ratio)
PSA psa: free:free prostate specific ag in serum or plasma (psa
PSA psa:total prostate specific ag in serum or plasma (psa: total)
PT prothrombin time::
PT pt::
PTH parathyroid hormone intac::
PTH parathyroid hormone intact::
PTH pth intact::
PTH pth: intact:
PTT partial thromboplast time::
PTT partial thromboplastin time::
PTT ptt::
RBC nrbc/100 wbc::
RBC nrbc/100 wbc's::
RBC nrbc/100 wbcs::
RBC nuc rbc's/100 wbc's::
RBC nucleated rbc (automated)::
RBC nucleated rbc::
RBC nucleated rbcs::
RBC nucleated red blood cells::
RBC poc rbc:erythrocytes in blood (rbc):
RBC rbc casts::
RBC rbc count:erythrocytes in blood (rbc):
RBC rbc distribution width:erythrocyte distribution width [ratio] (rdw_cv):
RBC rbc neo:erythrocytes in blood (rbc):
RBC rbc x 10e12/l:erythrocytes in blood (rbc):
RBC rbc:erythrocytes in blood (rbc):
RBC red blood cell count:erythrocytes in blood (rbc):
RBC red blood count::
RBC red cells::
RDW poc rdw -cv:erythrocyte distribution width [ratio] (rdw_cv):

RDW rdw:erythrocyte distribution width [ratio] (rdw_cv):
RDW red cell distribution width sd:erythrocyte distribution width [entitic volume] (rdw_sd):
RDW red cell distribution width:erythrocyte distribution width [ratio] (rdw_cv):
RETIC abs retic::
RETIC abs retics::
RETIC imm retic fract::
RETIC immature reticulocyte fraction::
RETIC manual retic count::
RETIC manual retic ct::
RETIC ret-hgb:hemoglobin (hb):
RETIC retic (abs)::
RETIC retic # auto::
RETIC retic percent::
RETIC retic ref in::
RETIC retic::
RETIC reticulocyte count absolute::
RETIC reticulocytes (automated)::
RETIC reticulocytes absolute::
RETIC reticulocytes::
RF rheumatoid factor quantitative::
RF rheumatoid factor titre::
RF rheumatoid factor::
NA rnp::
RUB rubella igg antibody::
RUB rubella igg::
SAGM sagm red blood cells:lr:irrad
SALI salicylate level::
SALI salicylate::
GAS %sat::
GAS %saturation::
SEMEN semen ph::
SEMEN semen volume::
SEMEN sperm count (sa)::
SEMEN sperm count (sapv)::
SEMEN sperm morphology::
SEMEN sperm motility (sa)::
SMEAR smear cells::
SOD na::
SOD poc sodium::
SOD sodium level::
SOD sodium-direct::
SOD sodium::
T3 free t3:free triiodothyronine (t3):
T3 t3 free:free triiodothyronine (t3):
T3 t3 total::
T3 t3: free:free triiodothyronine (t3)

T3 t3: total:
T3 t3:free triiodothyronine (t3):
T3 total t3::
T4 free t4:free thyroxine (t4):
T4 t4 free:free thyroxine (t4):
T4 t4: free:free thyroxine (t4)
T4 thyroid stim hormone:free thyroxine (t4):
T4 thyroid stim im:free thyroxine (t4):
T4 thyroxine b.glb:free thyroxine (t4):
TESTO bioavailable testosterone::
TESTO dheas::
TESTO t testosterone::
TESTO testost:bioava:
TESTO testosterone - bioavailable::
TESTO testosterone: total:
TESTO testosterone::
TESTO testosterone:ba:
TESTO testosterone:bioavailable:
TESTO testosterone:bl:
TESTO testosterone:blood:
TIBC tibc::
TIBC total iron binding capacity::
TRANS transferrin::
TRIG 6-tg:triglycerides (tg):
TRIG tg ab:triglycerides (tg):
TRIG triglyceride bf:triglycerides (tg):
TRIG triglycerides level:triglycerides (tg):
TRIG triglycerides non-fasting:triglycerides (tg):
TRIG triglycerides:triglycerides (tg):
TROM anti-thrombin::
TROM thrombin time::
TROP poc trop-t::
TROP poc troponin i::
TROP troponin i::
TROP troponin t semi-quant::
TROP troponin t::
TROP troponin-t high sensitivity::
TROP troponin-t::
TSH thyroid stimulating hormone:thyroid-stimulating hormone (tsh):
TSH tsh blood spot:thyroid-stimulating hormone (tsh):
TSH tsh neonatal:thyroid-stimulating hormone (tsh):
TSH tsh nn recheck:thyroid-stimulating hormone (tsh):
TSH tsh:thyroid-stimulating hormone (tsh):
URAT sodium urate::
URAT urate::
UREA poc urea::
UREA urea::

URIC uric acid::
URIC uric acid/24h::
URINE 2 hour urine amylase test::
URINE 24 hour urine amylase test::
URINE 24 hour urine cortisol::
URINE 24 hour urine glucose:glucose tolerance test (gtt):
URINE 24 hour urine ph::
URINE 24 hour urine potassium::
URINE 24 hr urine creatinine:creatinine in 24 hour urine (u-cr24):
URINE 24 hr urine osmolality::
URINE 24 urine chloride test::
URINE 24 urine creatinine test:creatinine in 24 hour urine (u-cr24):
URINE 24 urine sodium test::
URINE 24 urine uric acid test::
URINE 24hr urine total volume::
URINE 3-methylhistidine urine::
URINE 5hiaa quantitative: urine:
URINE ala: urine:
URINE alanine urine::
URINE albumin urine:albumin in urine (u-alb):
URINE albumin: urine:albumin in urine (u-alb)
URINE amylase: urine:
URINE anserine urine::
URINE arginine urine::
URINE arsenic: urine:
URINE asparagine urin::
URINE asparagine urine::
URINE bacteria: urine:
URINE beta 2 microglobulin: urine:
URINE bilirubin: urine:
URINE blood: urine:
URINE ca/creat ratio random urine::
URINE ca/creat urine ratio::
URINE ca/creat urine::
URINE calcium oxalate crystals:urine:
URINE calcium to creatinine: urine:creatinine in urine (u-cr)
URINE calcium ur::
URINE calcium urine::
URINE calcium: urine:
URINE carnosine urine::
URINE chloride ur::
URINE chloride: urine:
URINE citrate: urine:
URINE citrate:ur/tv:
URINE citrate:urine:
URINE citrulline urin::
URINE citrulline urine::

URINE coarse granular cast: urine:
URINE copper: urine:
URINE copper:urine:
URINE coproporphyrin: urine:
URINE cortisol to creatinine: urine:creatinine in urine (u-cr)
URINE cortisol: urine:
URINE cortisol:free u:
URINE creat urine/tv::
URINE creatinine clearance: urine:
URINE creatinine urin::
URINE creatinine urine acr/pcr:urine albumin/creatinine ratio (acr):
URINE creatinine urine:creatinine in urine (u-cr):
URINE creatinine: urine random:creatinine in urine (u-cr)
URINE creatinine: urine:creatinine in urine (u-cr)
URINE creatinine: urine(vgh):creatinine in urine (u-cr)
URINE creatinine:ur:
URINE cystathionine urine::
URINE cystine urine::
URINE d xylose: urine:
URINE dopamine: urine:
URINE dopamine: urine:
URINE dur collection 24 h urine::
URINE epinephrine: urine:
URINE epinephrine: urine:
URINE epithelial cell urine::
URINE ethanolamine urine::
URINE ethyl alcohol: urine:
URINE fine granular cast: urine:
URINE glucose u::
URINE glucose-ru::
URINE glucose: urine:
URINE glutamine urine::
URINE glycine urine::
URINE histidine urine::
URINE hyaline cast: urine:
URINE hydroxyproline urine::
URINE igg iep::
URINE isoleucine urine::
URINE ketones: urine:
URINE leucine urine::
URINE leukocyte esterase: urine:
URINE lysine urine::
URINE magnesium ur::
URINE magnesium urine::
URINE magnesium: urine:
URINE methionine u::
URINE methionine urine::

URINE	microalb/creat:urine albumin/creatinine ratio (acr):
URINE	microalbumin to creatinine: urine:
URINE	microalbumin urine:albumin in urine (u-alb):
URINE	microalbumin: urine:albumin in urine (u-alb)
URINE	microalbumin:urine (random):albumin in urine (u-alb)
URINE	microalbumin:urine:albumin in urine (u-alb)
URINE	mucus: urine:
URINE	myoglobin: urine:
URINE	norepinephrine: urine:
URINE	norepinephrine: urine:
URINE	ornithine urine::
URINE	osmolality ur::
URINE	osmolality urine::
URINE	osmolality: urine:
URINE	osmolality:urine:
URINE	other casts: urine:
URINE	oxalate random urine::
URINE	oxalate ur rand::
URINE	oxalate: urine:
URINE	ph urine::
URINE	ph: urine:
URINE	ph:urine:
URINE	phenylalanine urine::
URINE	phosphate urine::
URINE	phosphoethanolamine urine::
URINE	phosphorus: urine:
URINE	poc u glucose::
URINE	poc u ketone::
URINE	poc u ph::
URINE	poc u protein::
URINE	poc u specific gravity::
URINE	poc urobilinogen: urine:
URINE	porphobilinogen: urine:
URINE	potassium ur::
URINE	potassium: urine:
URINE	proline urine::
URINE	prot/creat ratio random urine::
URINE	protein urine::
URINE	protein: urine:
URINE	protein:total urine (upe):
URINE	random urine urea::
URINE	rbc: urine:
URINE	red blood cell cast: urine:
URINE	renal epithelial cells: urine:
URINE	serine urine::
URINE	sodium urine::
URINE	sodium: urine:

URINE	specific gravity: urine:
URINE	sperm: urine:
URINE	squamous epithelial cell urine::
URINE	taurine urine::
URINE	threonine urine::
URINE	total protein to creatinine: urine:creatinine in urine (u-cr)
URINE	total protein: urine:
URINE	total volume: urine:
URINE	transitional epi cells: urine:
URINE	tyrosine urine::
URINE	u 24 magnesium test::
URINE	u acr:urine albumin/creatinine ratio (acr):
URINE	u amylase u per hour::
URINE	u pcr::
URINE	u24 alb/creat ratio::
URINE	uca/crea ratio random urine::
URINE	ufc/ creatinine::
URINE	uprot/crea ratio random urine::
URINE	ur 24 calcium test::
URINE	ur 24 microalbumin::
URINE	ur 24 phosphorus test::
URINE	ur 24 tot protein test::
URINE	ur amylase random::
URINE	ur calcium random::
URINE	ur chloride random::
URINE	ur magnesium random::
URINE	ur microalbumin:split-time/day:
URINE	ur microalbumin:split/night:
URINE	ur phos random::
URINE	ur potassium random::
URINE	ur sodium random::
URINE	ur urea mmol/l::
URINE	ur:sulfatides:
URINE	urate: urine:
URINE	urea: urine:
URINE	uric acid urine::
URINE	urine 24hr urea::
URINE	urine amylase 2 hour::
URINE	urine bacteria auto::
URINE	urine citrate initial value::
URINE	urine citrate::
URINE	urine creatinine:creatinine in urine (u-cr):
URINE	urine creatinine/24hr::
URINE	urine crystals auto::
URINE	urine epithelial cells auto::
URINE	urine hyaline cast auto::
URINE	urine magnesium/24h::

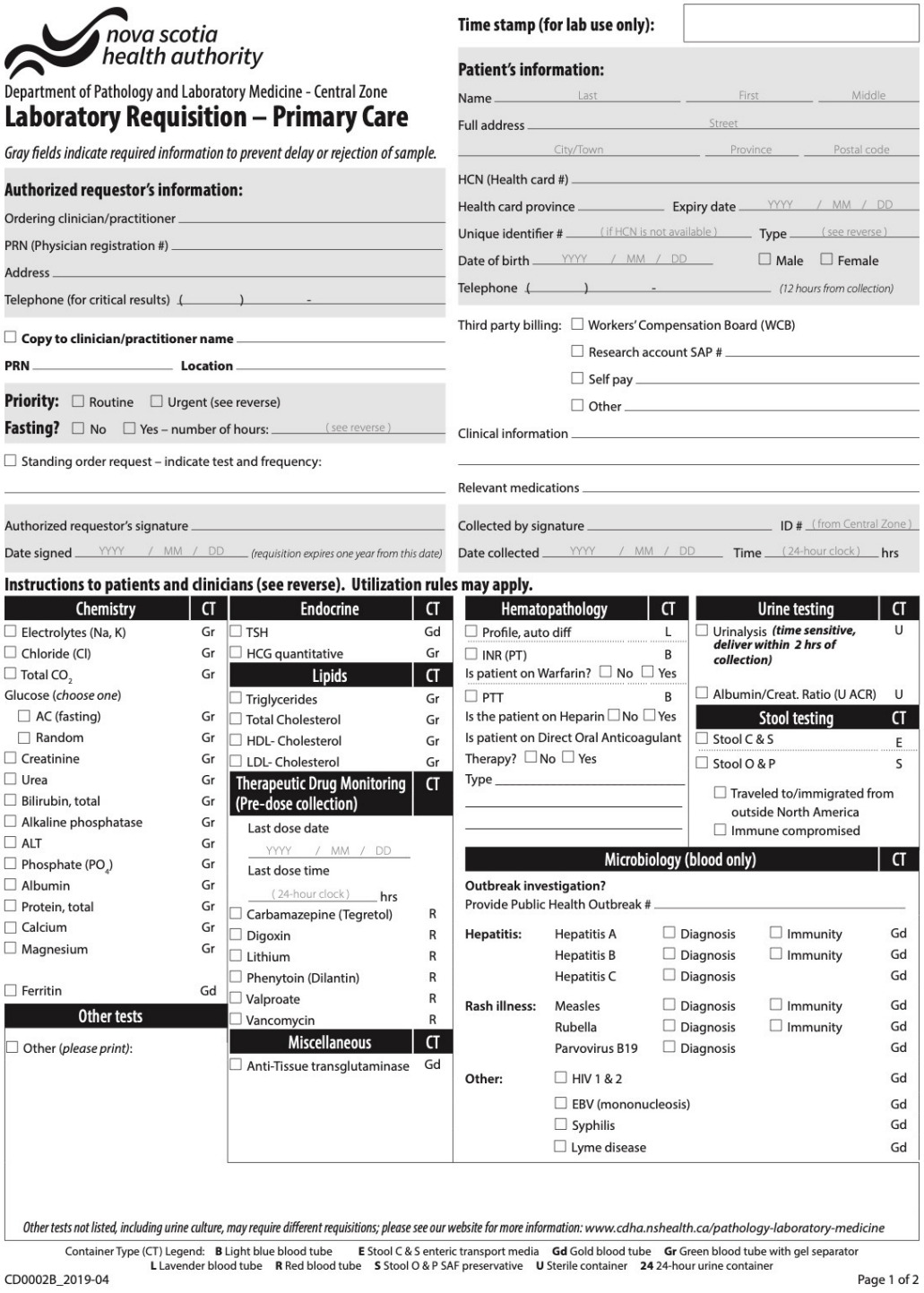
URINE urine phosphate/24h::
URINE urine protein/24h::
URINE urine random albumin:albumin in urine (u-alb):
URINE urine random protein::
URINE urine rbc auto::
URINE urine rbc::
URINE urine reducing substances::
URINE urine small round cells auto::
URINE urine spermatozoa auto::
URINE urine urea::
URINE urine uric acid/24h::
URINE urine wbc auto::
URINE urine wbc::
URINE urine yeast like cells auto::
URINE urine: 24-hr ph:
URINE urobilinogen: urine:
URINE uroporphyrin: urine:
URINE valine urine::
URINE waxy cast: urine:
URINE wbc: urine:
URINE white blood cell cast: urine:
VALPRO valproic acid::
VANCO vancomycin level trough::
VANCO vancomycin level::
VANCO vancomycin pre::
VANCO vancomycin random::
VANCO vancomycin::
VITA vitamin a::
VITC ascorbic acid/vitamin c::
VITC vit c:bld:25-hydroxycalciferol in serum or plasma (vitd2)
VITC vitamin c:bld:
VITD 1:25-dihydroxy-vitamin d:cholecalciferol in serum or plasma (vitd3)
VITD 25-hydroxy vitamin d:25-hydroxycalciferol in serum or plasma (vitd2):
VITD vit d 25 oh:25-hydroxycalciferol in serum or plasma (vitd2):
VITD vit d 25oh:25-hydroxycalciferol in serum or plasma (vitd2):
VITD vitamin d 1:25 dihydroxy:cholecalciferol in serum or plasma (vitd3)
VITD vitamin d 1:25:cholecalciferol in serum or plasma (vitd3)
VITD vitamin d 25 hydroxy:25-hydroxycalciferol in serum or plasma (vitd2):
VITD vitamin d 25hyd:25-hydroxycalciferol in serum or plasma (vitd2):
VITD vitamin d:25-hydroxy:25-hydroxycalciferol in serum or plasma (vitd2)
VITE vitamin e::
VWF vwf act (xxxxx)::
VWF vwf act rco::
VWF vwf act::
VWF vwf activity (xxxxx)::
VWF vwf activity::
VWF vwf activty-rco::

VWF vwf actvty(rco)::
VWF vwf antigen::
WBC absolute wbc/colln:leukocytes in blood (wbc):
WBC corrected white blood count:leukocytes in blood (wbc):
WBC manual wbc::
WBC poc wbc:leukocytes in blood (wbc):
WBC poc white blood count:leukocytes in blood (wbc):
WBC wbc casts::
WBC wbc count:leukocytes in blood (wbc):
WBC wbc neo:leukocytes in blood (wbc):
WBC wbc:leukocytes in blood (wbc):
WBC white blood cell count:leukocytes in blood (wbc):
WBC white blood count:leukocytes in blood (wbc):
ZINC zinc level::
ZINC zinc: blood:
ZINC zinc::
ZINC zinc:bld:
ZINC zinc:blood:
ZINC zinc:plasma:

Appendix B – Laboratory Requisition Forms

The following laboratory requisition forms are kindly provided through the courtesy of the Department of Pathology and Laboratory Medicine at Nova Scotia Health Authority.

Laboratory requisition form for the central health zone in Nova Scotia:



nova scotia health authority

Department of Pathology and Laboratory Medicine - Central Zone

Laboratory Requisition – Primary Care

Gray fields indicate required information to prevent delay or rejection of sample.

Time stamp (for lab use only):

Authorized requestor's information:

Ordering clinician/practitioner

PRN (Physician registration #)

Address

Telephone (for critical results) ( ) -

☐ **Copy to clinician/practitioner name**

PRN **Location**

Priority: ☐ Routine ☐ Urgent (see reverse)

Fasting? ☐ No ☐ Yes – number of hours: (see reverse)

☐ Standing order request – indicate test and frequency:

Authorized requestor's signature

Date signed YYYY / MM / DD *(requisition expires one year from this date)*

Patient's information:

Name Last First Middle

Full address Street

City/Town Province Postal code

HCN (Health card #)

Health card province Expiry date YYYY / MM / DD

Unique identifier # (if HCN is not available) Type (see reverse)

Date of birth YYYY / MM / DD ☐ Male ☐ Female

Telephone ( ) - *(12 hours from collection)*

Third party billing: ☐ Workers' Compensation Board (WCB)

☐ Research account SAP #

☐ Self pay

☐ Other

Clinical information

Relevant medications

Collected by signature ID # (from Central Zone)

Date collected YYYY / MM / DD Time (24-hour clock) hrs

Instructions to patients and clinicians (see reverse). Utilization rules may apply.

Chemistry	CT
☐ Electrolytes (Na, K)	Gr
☐ Chloride (Cl)	Gr
☐ Total CO_2	Gr
Glucose (*choose one*)	
☐ AC (fasting)	Gr
☐ Random	Gr
☐ Creatinine	Gr
☐ Urea	Gr
☐ Bilirubin, total	Gr
☐ Alkaline phosphatase	Gr
☐ ALT	Gr
☐ Phosphate (PO_4)	Gr
☐ Albumin	Gr
☐ Protein, total	Gr
☐ Calcium	Gr
☐ Magnesium	Gr
☐ Ferritin	Gd

Other tests
☐ Other (*please print*):

Endocrine	CT
☐ TSH	Gd
☐ HCG quantitative	Gr

Lipids	CT
☐ Triglycerides	Gr
☐ Total Cholesterol	Gr
☐ HDL- Cholesterol	Gr
☐ LDL- Cholesterol	Gr

Therapeutic Drug Monitoring (Pre-dose collection)	CT
Last dose date YYYY / MM / DD	
Last dose time (24-hour clock) hrs	
☐ Carbamazepine (Tegretol)	R
☐ Digoxin	R
☐ Lithium	R
☐ Phenytoin (Dilantin)	R
☐ Valproate	R
☐ Vancomycin	R

Miscellaneous	CT
☐ Anti-Tissue transglutaminase	Gd

Hematopathology	CT
☐ Profile, auto diff	L
☐ INR (PT)	B
Is patient on Warfarin? ☐ No ☐ Yes	
☐ PTT	B
Is the patient on Heparin ☐ No ☐ Yes	
Is patient on Direct Oral Anticoagulant Therapy? ☐ No ☐ Yes	
Type	

Urine testing	CT
☐ Urinalysis ***(time sensitive, deliver within 2 hrs of collection)***	U
☐ Albumin/Creat. Ratio (U ACR)	U

Stool testing	CT
☐ Stool C & S	E
☐ Stool O & P	S
☐ Traveled to/immigrated from outside North America	
☐ Immune compromised	

Microbiology (blood only)				CT
Outbreak investigation? Provide Public Health Outbreak #				
Hepatitis:	Hepatitis A	☐ Diagnosis	☐ Immunity	Gd
	Hepatitis B	☐ Diagnosis	☐ Immunity	Gd
	Hepatitis C	☐ Diagnosis		Gd
Rash illness:	Measles	☐ Diagnosis	☐ Immunity	Gd
	Rubella	☐ Diagnosis	☐ Immunity	Gd
	Parvovirus B19	☐ Diagnosis		Gd
Other:	☐ HIV 1 & 2			Gd
	☐ EBV (mononucleosis)			Gd
	☐ Syphilis			Gd
	☐ Lyme disease			Gd

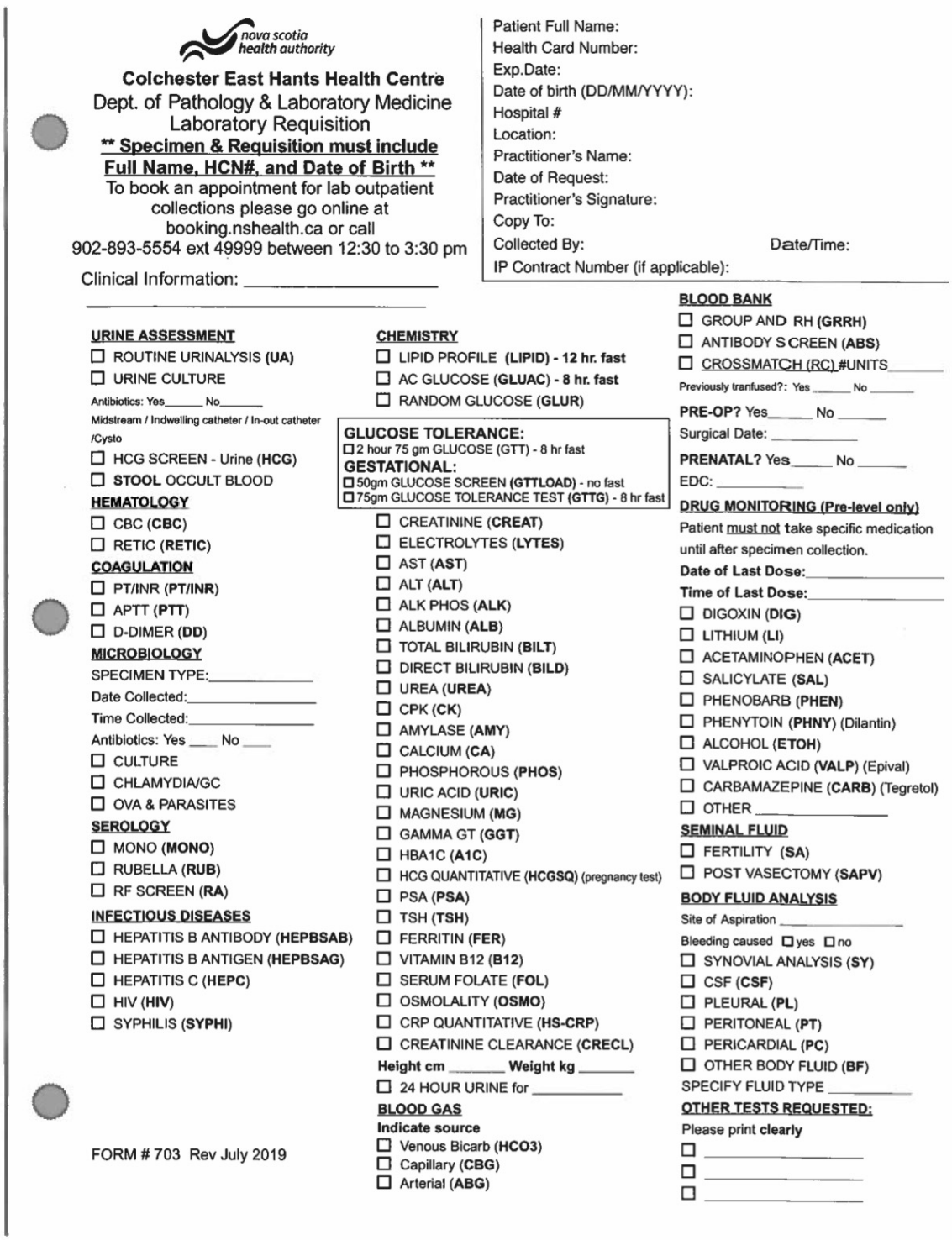
Other tests not listed, including urine culture, may require different requisitions; please see our website for more information: www.cdha.nshealth.ca/pathology-laboratory-medicine

Container Type (CT) Legend: **B** Light blue blood tube **E** Stool C & S enteric transport media **Gd** Gold blood tube **Gr** Green blood tube with gel separator **L** Lavender blood tube **R** Red blood tube **S** Stool O & P SAF preservative **U** Sterile container **24** 24-hour urine container

CD0002B_2019-04

Page 1 of 2

Laboratory requisition form for the northern health zone in Nova Scotia:



nova scotia health authority

Colchester East Hants Health Centre
Dept. of Pathology & Laboratory Medicine
Laboratory Requisition
**** Specimen & Requisition must include Full Name, HCN#, and Date of Birth ****
To book an appointment for lab outpatient collections please go online at booking.nshealth.ca or call
902-893-5554 ext 49999 between 12:30 to 3:30 pm

Clinical Information: _____

Patient Full Name:
Health Card Number:
Exp.Date:
Date of birth (DD/MM/YYYY):
Hospital #
Location:
Practitioner's Name:
Date of Request:
Practitioner's Signature:
Copy To:
Collected By: Date/Time:
IP Contract Number (if applicable):

URINE ASSESSMENT
- ☐ ROUTINE URINALYSIS (**UA**)
- ☐ URINE CULTURE

Antibiotics: Yes_____ No_____
Midstream / Indwelling catheter / In-out catheter /Cysto
- ☐ HCG SCREEN - Urine (**HCG**)
- ☐ **STOOL** OCCULT BLOOD

HEMATOLOGY
- ☐ CBC (**CBC**)
- ☐ RETIC (**RETIC**)

COAGULATION
- ☐ PT/INR (**PT/INR**)
- ☐ APTT (**PTT**)
- ☐ D-DIMER (**DD**)

MICROBIOLOGY
SPECIMEN TYPE:_____
Date Collected:_____
Time Collected:_____
Antibiotics: Yes ___ No ___
- ☐ CULTURE
- ☐ CHLAMYDIA/GC
- ☐ OVA & PARASITES

SEROLOGY
- ☐ MONO (**MONO**)
- ☐ RUBELLA (**RUB**)
- ☐ RF SCREEN (**RA**)

INFECTIOUS DISEASES
- ☐ HEPATITIS B ANTIBODY (**HEPBSAB**)
- ☐ HEPATITIS B ANTIGEN (**HEPBSAG**)
- ☐ HEPATITIS C (**HEPC**)
- ☐ HIV (**HIV**)
- ☐ SYPHILIS (**SYPHI**)

FORM # 703 Rev July 2019

CHEMISTRY
- ☐ LIPID PROFILE **(LIPID) - 12 hr. fast**
- ☐ AC GLUCOSE (**GLUAC**) **- 8 hr. fast**
- ☐ RANDOM GLUCOSE (**GLUR**)

GLUCOSE TOLERANCE:
☐ 2 hour 75 gm GLUCOSE (GTT) - 8 hr fast
GESTATIONAL:
☐ 50gm GLUCOSE SCREEN **(GTTLOAD)** - no fast
☐ 75gm GLUCOSE TOLERANCE TEST **(GTTG)** - 8 hr fast

- ☐ CREATININE (**CREAT**)
- ☐ ELECTROLYTES (**LYTES**)
- ☐ AST (**AST**)
- ☐ ALT (**ALT**)
- ☐ ALK PHOS (**ALK**)
- ☐ ALBUMIN (**ALB**)
- ☐ TOTAL BILIRUBIN (**BILT**)
- ☐ DIRECT BILIRUBIN (**BILD**)
- ☐ UREA (**UREA**)
- ☐ CPK (**CK**)
- ☐ AMYLASE (**AMY**)
- ☐ CALCIUM (**CA**)
- ☐ PHOSPHOROUS (**PHOS**)
- ☐ URIC ACID (**URIC**)
- ☐ MAGNESIUM (**MG**)
- ☐ GAMMA GT (**GGT**)
- ☐ HBA1C (**A1C**)
- ☐ HCG QUANTITATIVE (**HCGSQ**) (pregnancy test)
- ☐ PSA (**PSA**)
- ☐ TSH (**TSH**)
- ☐ FERRITIN (**FER**)
- ☐ VITAMIN B12 (**B12**)
- ☐ SERUM FOLATE (**FOL**)
- ☐ OSMOLALITY (**OSMO**)
- ☐ CRP QUANTITATIVE (**HS-CRP**)
- ☐ CREATININE CLEARANCE (**CRECL**)

Height cm _____ **Weight kg** _____
- ☐ 24 HOUR URINE for _____

BLOOD GAS
Indicate source
- ☐ Venous Bicarb (**HCO3**)
- ☐ Capillary (**CBG**)
- ☐ Arterial (**ABG**)

BLOOD BANK
- ☐ GROUP AND RH (**GRRH**)
- ☐ ANTIBODY SCREEN (**ABS**)
- ☐ CROSSMATCH (RC) #UNITS_____

Previously tranfused?: Yes _____ No _____

PRE-OP? Yes_____ No _____
Surgical Date: _____

PRENATAL? Yes_____ No _____
EDC: _____

DRUG MONITORING (Pre-level only)
Patient must not take specific medication until after specimen collection.
Date of Last Dose:_____
Time of Last Dose:_____
- ☐ DIGOXIN (**DIG**)
- ☐ LITHIUM (**LI**)
- ☐ ACETAMINOPHEN (**ACET**)
- ☐ SALICYLATE (**SAL**)
- ☐ PHENOBARB (**PHEN**)
- ☐ PHENYTOIN (**PHNY**) (Dilantin)
- ☐ ALCOHOL (**ETOH**)
- ☐ VALPROIC ACID (**VALP**) (Epival)
- ☐ CARBAMAZEPINE (**CARB**) (Tegretol)
- ☐ OTHER _____

SEMINAL FLUID
- ☐ FERTILITY (**SA**)
- ☐ POST VASECTOMY (**SAPV**)

BODY FLUID ANALYSIS
Site of Aspiration _____
Bleeding caused ☐ yes ☐ no
- ☐ SYNOVIAL ANALYSIS (**SY**)
- ☐ CSF (**CSF**)
- ☐ PLEURAL (**PL**)
- ☐ PERITONEAL (**PT**)
- ☐ PERICARDIAL (**PC**)
- ☐ OTHER BODY FLUID (**BF**)

SPECIFY FLUID TYPE _____

OTHER TESTS REQUESTED:
Please print **clearly**
- ☐ _____
- ☐ _____
- ☐ _____

Laboratory requisition form for the western health zone in Nova Scotia:

nova scotia health authority

Western Zone - Laboratory Requisition
Toll Free Booking Line 1-833-998-2722

NOTE: ***Specimens and Requisition must clearly include Patient Full Name, HCN and DOB, Physician Full Name***

Clinical Information: _____
_____
Special Collection Information: _____
_____

Patient Name: _____

Health Card #: _____

Date of Birth :(Day/Month/Year):_____

Requesting Provider: _____PMB#:_____

Copy to: _____PMB#: _____

Date Requested (Day/Month/Year): _____ (Valid for one year only)

Indicate if requests are for UNINSURED SERVICES:
☐ WCB ☐ Insurance ☐ Self Pay ☐ DND ☐ Corr. Can
☐ Corporate ☐ Other _____
See MSI MD Billing Guide, 2012 for details.

HEMATOLOGY
☐ CBC (**CBC**) includes automated differential
☐ PT/INR (**PTINR**)
Anticoagulant Therapy Yes___ No___
Specify _____
☐ PTT (**PTT**)
☐ ESR (**ESR**)

OTHER
☐ Routine Urinalysis (**UA**)
☐ Culture and Sensitivity (**URNC**)
Date Coll _____ Time Coll _____
Antibiotic Yes____ Specify_____
Midstr ____ Indwel. Cath ____ In/Out Cath ___
Other _____

☐ HCG Screen-Urine (**HCG**)
☐ Urine Albumin/Creatinine Ratio (**UACR**)
☐ Stool Occult Blood x _____ (**STOB1 STOB2 STOB3**)
☐ H. pylori (**STHPAG**) Stool Sample

☐ Semen Analysis
See instructions on reverse
___ Post Vasectomy (**SAPV**)
___ Complete Fertility (**SA**)
Time Coll _____ Time Rec'd _____

☐ CREATININE CLEARANCE (**CRECL**)
Height cm _____ Weight kg _____

SEROLOGY
☐ MONO (**MONO**)
☐ Hepatitis B Antibody (**HEPBSAB**)
☐ Hepatitis B Antigen (**HEPBSAG**)
☐ Hepatitis C Antibody(**HEPC**)
☐ RA (**RAQ**)
☐ CRP (**CRPQ**)

CHEMISTRY
☐ AC Glucose (**GLUAC**)
(No food or drink except water for 8 hours)
☐ Random Glucose (**GLUR**)

GLUCOSE TOLERANCE
☐ 75GM Glucose (**GTT**)
(No food or drink except water for 8 hours)
GESTATIONAL
☐ 50GM Glucose Screen (**GTTLOAD**)
☐ 75 GM Glucose Tolerance Test (**GTTG**)
(No food or drink except water for 8 hours)

☐ eGFR (**EGFR**)
☐ Electrolytes (**LYTES**)
(Sodium/Potassium/Chloride)
☐ Uric Acid (**URIC**)
☐ Calcium (**CA**)
☐ Phosphorus (**PHOS**)
☐ Magnesium (**MG**)
☐ Albumin (**ALB**)
☐ Total Bilirubin (**BILTOT**)
☐ AST (**AST**)
☐ ALT (**ALT**)
☐ ALK PHOS (**ALK**)
☐ Amylase (**AMY**)
☐ Lipase (**LIP**)
☐ LDH (**LDH**)
☐ CPK (**CK**)
☐ Iron (**IRON**)
☐ TSH (**TSH**)
Medication Yes____ No ____
☐ Ferritin (**FER**)
☐ CEA (**CEA**)
☐ PSA (**PSA**)
☐ HbA1c (**A1C**)
☐ Lipid Profile (**LIPID**)

TRANSFUSION SERVICES
☐ Group and Rh (**GRRH**)
☐ Antibody Screen (**ABS**)
☐ Crossmatch (**RC**) # UNITS_____
Previously Transfused? Yes____ No____
PRE-OP? Yes__ No__ Surgical Date: _____

PRENATAL
EDC: _____
Rh immune given? Yes__ No __ Date: _____
☐ Initial Prenatal Screen
(**CBC, RUB, SYPAB, GRRH, ABS, HEPSAG, UA**)
☐ Varicella – if indicated (**VZ**)
☐ HIV-if consented (**HIVAGAB**)
Due Date: _____

DRUG MONITORING
Date of last dose: _____ Time of last dose: _____

Patient **must not** take specific medication until after Specimen collection.

☐ Digoxin (**DIG**)
☐ Lithium (**LI**)
☐ Phenytoin (Dilantin) (**PHNY**)
☐ Carbamazepine (Tegretol) (**CARB**)
☐ Valproic Acid (**VALP**)

OTHER TESTS REQUESTED:
Print Clearly Below
(Please do not abbreviate tests)
☐ _____
☐ _____
☐ _____
☐ _____
☐ _____

Collected By: _____
Collection Date: _____
Collection Time: _____

Form # NWZ-F-PP-0001 Revised date: June 12, 2020
This is a CONTROLLED document. Any documents appearing in paper form are not controlled and should be checked against the electronic file version prior to use.

Appendix C – Primary Care Laboratory Pattern

Group name:

- ALB
- ALP
- ALT
- ATTG
- BASO
- BILI
- BLAST
- CALC
- CARBA
- CHLOR
- CHOL
- CREA
- DIGO
- EOSIN
- FER
- GLUCO
- GRAN
- HBV
- HCG
- HCV
- HDL
- HEMO
- HGB
- HIV
- INR
- LDL
- LITH
- LYMPH
- MAG
- MCH
- MCHC
- MCV
- MEAS
- MIXED
- MONO
- MPV
- MYELO
- NEUT
- PHENYT
- PHOS

- PLAT
- POT
- PROT
- PTT
- RBC
- RDW
- RETIC
- RUB
- SOD
- T3
- T4
- TRIG
- TSH
- UREA
- VALPRO
- VANCO
- WBC

Appendix D – Acute Laboratory Tests

MaRNet-FP name:

Anion Gap
ANION GAP
ARTERIAL CORD PH
ARTERIAL BLD GAS O2 SATURATION
ARTERIAL BLOOD GAS BASE EXCESS
ARTERIAL BLOOD GAS FIO2
ARTERIAL BLOOD GAS HCO3
ARTERIAL BLOOD GAS pH
ARTERIAL BLOOD GAS TEMPERATURE
ARTERIAL DEOXYHEMOGLOBIN
ARTERIAL OXYHEMOGLOBIN
ARTERIAL pCO2 (temp corr)
ARTERIAL pH (temp corr)
ARTERIAL pO2 (temp corr)
ARTERIAL TCO2
CAP BASE EXCESS
CAP BLD GAS O2 SATURATION
CAP BLD PARTIAL PRESSURE CO2
CAP BLD PARTIAL PRESSURE O2
CAP BLOOD GAS HCO3
CAP BLOOD GAS TEMPERATURE
CAP ct HB CARBOBOXYHEMOGLOBIN
CAP LACTATE
CAP METHEMOGLOBIN
CAP pCO2 (temp corr)
CAP pH (temp corr)
CAP pO2 (temp corr)
CAP TCO2
CAPILLARY BLOOD GAS FIO2
CAPILLARY BLOOD GAS pH
CAPILLARY DEOXYHEMOGLOBIN
CAPILLARY O2 CONTENT
CAPILLARY OXYHEMOGLOBIN
cor PCO2
cor pH
cor PO2
CSF MONONUCLEAR CELLS
CSF POLYMORPHS
CSF RBC COUNT
CSF WBC COUNT
ct CARBOXYHEMOGLOBIN
ct HB CARBOXYHEMOGLOBIN

pH
PH
pH (serum)
pH Art Cord (A)
PH ART CORD (A)
pH ven
PH VENOUS
PH VENOUS CORD (A)
POC Anion Gap
POC ANION GAP
POC Base Excess
POC BLD GAS O2 SATURATION
POC HCO3
POC pCO2
POC pH
POC Trop-T
POC TROPONIN I
POC Ven BE iS
POC VEN BLOOD GAS BASE EXCESS
POC VEN BLOOD GAS HCO3
POC Ven FiO2 iS
POC Ven HCO3 iS
POC Ven Lact iS
POC VEN LACTATE
POC VEN PARTIAL PRESSURE CO2
POC VEN PARTIAL PRESSURE O2
POC Ven PCO2 iS
POC Ven pH iS
POC Ven pH iSTC
POC VEN pO2 (temp corr)
POC Ven PO2 iS
POC Ven SO2 iS
POC Ven TCO2 iS
POC VENOUS BLOOD GAS pH
POC VENOUS pCO2 (temp corr)
POC VENOUS pH (temp corr)
POC VENOUS Total CO2
Total CO2
TROPONIN I
Troponin T
TROPONIN T
TROPONIN T SEMI-QUANT
Troponin-T
TROPONIN-T
Troponin-T High Sensitivity
Troponin-T HS by Cardiac XXXXX
VEN BLOOD GAS HCO3

VEN CARBOBOXYHEMOGLOBIN
VENOUS BLOOD GAS pH

Appendix E – Relevant Thyroid Diagnoses

Acute thyroiditis
Benign neoplasm of parathyroid gland
Benign neoplasm of thyroid glands
Chronic lymphocytic thyroiditis
Congenital hypothyroidism
Cyst of thyroid
Hemorrhage and infarction of thyroid
Hyperparathyroidism
Hypoparathyroidism
Malignant neoplasm of thyroid gland
Nonspecific abnormal results of function study of thyroid
Other and unspecified chronic thyroiditis
Other disorders of thyroid
Other iatrogenic hypothyroidism
Other postablative hypothyroidism
Other specified acquired hypothyroidism
Other specified disorders of thyroid
Postsurgical hypothyroidism
Subacute thyroiditis
Thyroid dysfunction of mother
Thyroiditis
Thyrotoxicosis from ectopic thyroid nodule without mention of thyrotoxic crisis or storm
Thyrotoxicosis without mention of goiter or other cause
Toxic diffuse goiter without mention of thyrotoxic crisis or storm
Toxic multinodular goiter without mention of thyrotoxic crisis or storm
Tuberculosis of thyroid gland
Unspecified disorder of parathyroid gland
Unspecified disorder of thyroid
Unspecified hypothyroidism