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MASTER PROGRAMME IN INTERNATIONAL BUSINESS AND ENTREPRENEURSHIP

DIGITAL MATURITY, GOVERNANCE/SUSTAINABILITY SIGNALS, AND BUSINESS MODELS IN U.S. PHARMACIES

Supervisor: Prof. Maria Chiara Demartini

Tesi di Laurea di

Stefan Matias Leon

Matr. n. 499940

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Abstract

This thesis reviews and examines digital transformation and sustainability related governance and how they are publicly communicated across different areas in the U.S. pharmacy sector. Particularly there will be a focus into the compounding pharmacy segment and its contrasts with the large pharmaceutical companies. The study is motivated by a difference in disclosure practices between the two pharmacy sectors. While large public pharmaceutical firms frequently publish yearly reports containing public signals, most compounding pharmacies do not produce comparable publicly accessible reports. This creates an important gap in comparing digital maturity and governance visibility across sectors.

To manage the disclosure gap, the study uses a two-layer design approach. First a benchmark of selected pharmaceutical companies is used to conduct an analysis in reporting disclosures from 2017 and 2024. The analysis uses selected digital and sustainability/governance variables. The inclusion of each variable is backed with specific sources found throughout the initial chapters. The thesis then complements this analysis with a descriptive examination of selected compounding pharmacies using publicly available evidence such as company websites. A separate set of variables is purposely used to find relevant data for the different pharmacy sector.

The findings indicate that the large public pharmaceutical companies show an increase in both digital and sustainability themed reporting between two years, suggesting more relevancy in recent years. Compounding pharmacies show a different type of public signaling, and sustainability themes are also much more muted than the first sample, opting for a more familiar approach transmitted through different language rather structured reporting language.

The study concludes that the themes reviewed are not publicly visible in the same way throughout different pharmacy sectors. This requires differentiated research into each area. In general, public signals have increased throughout the years, and certain digital and sustainable signals reviewed did have positive correlation, but of course this does not imply causation.

Abstract in Italian

Questa tesi analizza e approfondisce la trasformazione digitale e la governance legata alla sostenibilità, nonché le modalità di comunicazione pubblica di tali aspetti nei diversi settori farmaceutici statunitensi. In particolare, l'attenzione si concentrerà sul segmento delle farmacie galeniche e sulle sue differenze rispetto alle grandi aziende farmaceutiche. Lo studio è motivato da una discrepanza nelle pratiche di divulgazione tra i due settori farmaceutici. Mentre le grandi aziende farmaceutiche quotate in borsa pubblicano frequentemente report annuali contenenti informazioni rilevanti, la maggior parte delle farmacie galeniche non produce report comparabili e accessibili al pubblico. Ciò crea un'importante lacuna nel confronto tra maturità digitale e visibilità della governance nei diversi settori.

Per colmare questa lacuna informativa, lo studio adotta un approccio progettuale a due livelli. In primo luogo, viene utilizzato un benchmark di aziende farmaceutiche selezionate per condurre un'analisi delle informazioni divulgate nei report del 2017 e del 2024. L'analisi si basa su variabili selezionate relative alla digitalizzazione e alla sostenibilità/governance. L'inclusione di ciascuna variabile è supportata da fonti specifiche reperite nei capitoli iniziali. La tesi integra quindi questa analisi con un esame descrittivo di alcune farmacie galeniche selezionate, utilizzando dati pubblicamente disponibili, come i siti web aziendali. Un insieme separato di variabili viene utilizzato appositamente per individuare dati rilevanti per i diversi settori farmaceutici.

I risultati indicano che le grandi aziende farmaceutiche quotate in borsa mostrano un aumento nella rendicontazione sia digitale che di sostenibilità tra i due anni considerati, suggerendo una maggiore rilevanza negli ultimi anni. Le farmacie galeniche mostrano un diverso tipo di comunicazione pubblica e anche i temi della sostenibilità sono molto più attenuati rispetto al

primo campione, optando per un approccio più informale, veicolato attraverso un linguaggio diverso piuttosto che attraverso una rendicontazione strutturata.

Lo studio conclude che i temi analizzati non sono visibili al pubblico allo stesso modo nei diversi settori farmaceutici. Ciò richiede una ricerca differenziata per ciascun ambito. In generale, la comunicazione pubblica è aumentata nel corso degli anni e alcuni segnali digitali e di sostenibilità analizzati hanno mostrato una correlazione positiva, ma ovviamente questo non implica un rapporto di causalità.

Introduction

Pharmacy services in the United States are constantly transforming and evolving into new areas both in internal pharmacy procedures and patient offerings and experience. In addition to this sector's rapid growth, digital tools have also recently seen a rapid acceleration in all areas of the world. And albeit small (relative to the entire pharmacy market), the compounding industry has a very unique positioning in both the patient and provider market as well as industry regulations. Compounding pharmacies must deal with complex workflows, documentation requirements, and quality assurance activities. The additional regulatory scrutiny often keeps these processes under a microscope, resulting in significant operational risk exposure. Because of these reasons, the compounding pharmacy industry seems to have a strong setting to explore how digital tools have been used to shape the industry. Of course, the traditional commercial pharmaceutical company has been a benchmark for pharmacy operations because of the huge public size and influence. These pharmaceutical companies are known worldwide and in recent years have even been in the source of controversy for compounding pharmacies. Their business models differ greatly, often times managing a large number of healthcare companies under their corporate umbrella.

The scope of the study was intentionally limited to a single country for a few reasons. Keeping the same country throughout, it allows us to hold the legal and broad healthcare environment constant. Additionally, the feasibility of obtaining U.S. only data and using conventional metrics was a factor (both general and specific to pharmacy accreditations).

It is important to note that this study will not claim that digital tools cause specific outcomes, however we will identify patterns and associations between digital maturity, governance/disclosure signals, business model features, and sustainability metrics. With this we hope to generate explanations that can guide future research and managerial decision-making.

The main research objective will follow this question closely: How are digital maturity, governance/sustainability signals, and business model configurations related in U.S. pharmacy sectors, with a focus on compounding pharmacies? The differences in business model and reporting style throughout both the commercial and compounding sector will shape how the research is conducted and the data analysis that follows.

After the context and background for the pharmacy sector in the U.S. has been described, the study will conduct a literature review analyzing what current topics are prevalent in studies regarding the pharmaceutical sector and digital/sustainable environments. This information will highlight a real gap that the research will help in lessening. The difference in reporting habits between pharmacy sectors will be an important topic that results in a dual approach when analyzing the commercial and compounding sample. The commercial sample will have two years of data to analyze while the compounding sample will focus on current available public data. All of these factors will be taken into account during the discussion and importance of the data that has been analyzed. Important limitations will also be discussed and potential opportunities for future research.

1 Context and Background

1.1 What is pharmacy compounding?

Just like most healthcare areas, pharmacy compounding follows guidelines imposed by the *FDA*[1]. The government agency states: "A drug may be compounded for a patient who cannot be treated with an FDA-approved medication, such as a patient who has an allergy to a certain dye and needs a medication to be made without it, or an elderly patient or a child who cannot swallow a tablet or capsule and needs a medicine in a liquid dosage form" (FDA, 2017). There are additional restrictions that describe the limitations of those who can compound: "Federal law addresses compounding by a licensed pharmacist in a state-licensed pharmacy, or federal facility, or by a physician, as well as compounding by or under the direct supervision of a licensed pharmacist in an outsourcing facility" (FDA, 2017).

This differs from the standard retail medications that can be over the counter or even prescribed. When a patient is prescribed and able to take a traditional medication, they may go to a local retail pharmacy and pick it up immediately. These would be products that have already been manufactured by pharmaceutical companies such as PCCA or Medisca. However, if a patient is prescribed a compounded drug, they will need to wait for the pharmacy to create it, as referenced above. In addition, both sterile and non-sterile products can be created in compounding pharmacies. Sterile compounding must be done in a clean room and usually pertains to injectable preparations. Nonsterile compounding would be the more standard creams, capsules, etc.

[1] The Food and Drug Administration is a federal agency that regulates food, drugs, and other products in the United States (FDA, 2024).

However, compounded drugs must offer an alternative to FDA approved medications in order to be prescribed. In fact, these drugs must abide by certain guidelines as described previously by the FDA. These are not merely recommendations, compounding can provide customized formulations to create alternate dosage strengths or forms, and omit components of FDA-approved drugs to which a patient has an allergy. Compounding can also fill gaps in cases of shortages and discontinuations of FDA-approved drug products (Mattison et al., 2020) The FDA also explicitly mentions that compounded drugs are not FDA-approved and therefore cannot guarantee or verify safety or effectiveness (FDA, 2017).

In addition to the general compounding sector of pharmacy, there exists two sub-sectors, 503A and 503B compounding. 503A compounding is the traditional patient specific prescribing that usually would occur at the independent pharmacy level. However, many 503A pharmacies have grown to a level of volume that was once unheard of. (While still dispensing patient specific prescriptions) 503B pharmacies however exist as outsourcing facilities. These pharmacies allow for bulk compounding that is purchased by pharmacies and hospitals without patient prescriptions.

1.1.1 Retail Pharmacies

Before diving deeper into the compounding world, it is important to touch on the traditional retail or commercial pharmacy that is widely recognized as the standard. Differing from what was described earlier, these pharmacies use FDA-approved products instead of creating their own formulations. For example, the commonly used Ibuprofen is found in abundance in the FDA approved drug website. Large pharmaceutical companies such as Sandoz and Teva Pharmaceuticals are just a few of many companies that manufacture Ibuprofen in the FDA-approved database (FDA. 2025). These drugs would then be purchased at a retail pharmacy such

as CVS Pharmacy or Walgreens. These can be both over the counter (*OTC*)[2] drugs or prescribed by a provider. OTC drugs do not require a prescription. It is important to have a fundamental understanding of this standard since it is by far the largest type of pharmacy in the US and in the rest of the world.

1.1.2 Historical evolution of compounding in the U.S

Albeit a small part today, compounding was not only important, but essential in the preindustrial era of the United States. Due to the nature of the time, pharmacists mixed different substances in order to achieve a finished therapeutic drug. There were no automatic machines that would pump out thousands of pills or vials a minute. In fact, before the 1920s, compounding was the standard method pharmacists used to prepare drugs for their patients. However, as technology improved "*proprietary products began to replace those which the pharmacist used to make himself, merchandising in pharmacies began to increase*" (Urick & Meggs, 2019). The transition to manufactured products instead of the pharmacist compounding drugs led to confusion in what the pharmacist's official role was. By the 1920s and 30s, pharmacies compounded 75% of their drugs, but only 1% of pharmacies had more than 50% of their sales from compounding (Urick & Meggs, 2019). These numbers kept decreasing to 25% in the 1950s and 1% in the 1970s (Watson et al, 2020).

It is interesting to analyze the change in preparation which did not seem to stem from internal pressures or changes, but from an overlaying industrial change in the United States. Just as many industries experienced radical change during the industrial revolution period, pharmacy operations were no different.

[2] OTC or non prescription drugs are available to consumers without a prescription and can be safely and effectively used without the supervision of a healthcare provider (FDA. 2025)

Of course, compounding did not disappear entirely, its role was just transformed into a more specialized function similar to what we see today. This has brought us to the modern landscape which provides a clear segmentation between patient-specific compounding practices and larger-scale facilities. This segmentation matters because it creates different incentives and constraints for digital investment. Smaller patient-specific environments may prioritize efficiency and focus heavily on its day to day processes, while larger operations may focus on standardized production and consistent outputs across higher volumes.

1.1.3 Types of Compounded Preparations

Compounded products will usually begin with bulk ingredients purchased from a wholesaler. These are also referenced as *active pharmaceutical ingredients*[3], or APIs for short. These are then mixed with inactive ingredients. Furthermore, there are sterile and non-sterile products that differ in preparation. Sterile products are those that need to be prepared in a clean room to ensure they are free of microorganisms. Non-sterile products are prepared without aseptic techniques (Mattison et al., 2020).

The main differences here would be the type of product being created:

Sterile:

Sterile products are those where patients or providers may need to administer based on their administration route. Some examples may be injectables (such as a weight loss medication) implants (such as certain contraceptives), and ophthalmic (such as eye drops).

[3] The main ingredient in a medicine that causes the desired effect of the medicine. Some medicines contain more than one active pharmaceutical ingredient that act in different ways in the body. Also called API, drug substance, and pharmacologic substance (National Cancer Institute, 2011).

Non-sterile:

Non-sterile products represent products that most people may take on a day-to-day basis such. Their administration route may be capsules, solutions, suspensions, ointments, creams, or suppositories.

Hazardous drugs also exist and are defined as drugs that have “carcinogenicity, teratogenicity or developmental toxicity, reproductive toxicity, organ toxicity at low doses, genotoxicity, or structure and toxicity profiles of new drugs that mimic existing hazardous drugs” (USP General Chapter, 2016). These are also compounded by pharmacies but must adhere to strict USP 800 standards.

1.1.4 Typical compounding workflow

Although each compounding pharmacy differs in workflow, there is always a broad workflow that must be followed, whether the pharmacy is large or small. A standard workflow is described below:

Order Entry:

The pharmacy can receive an order from the provider or the patient through a variety of ways; e-prescriptions, calls, patient walk-ins, faxes, and more. Regardless of the order source, the pharmacy will review the order and ensure it is correct.

Initial Pharmacist Check:

After order entry the pharmacist may review the clinical information of the order to ensure it is correct to move forward. They may fail the prescription and have a technician make changes before re-checking the prescription.

Compounding Process:

At this point the pharmacy may already have stock or may need to compound the product in order to move forward. This will depend on if the pharmacy is filling a fast mover or very custom compound that is rarely created. The process will involve the creation of a lot (sterile or nonsterile) and eventually releasing it after the preparation and validation is completed. There may be extra quarantine or testing steps for specific products.

Fulfillment and Verification:

The fulfillment process is when a fulfillment technician fills the prescription and prints out the prescription label. The pharmacist will then verify the clinical aspects of the prescription before it moves on to the next step.

Shipping or Pickup

Depending on the delivery type, the pharmacy may either ship the order to the patient or provider's office or may prepare the order for the patient to come and pick up the order.

1.2 The U.S. sector map: compounding, specialty, hospital, retail

As indicated previously, the compounding sector in the entire United States pharmacy sector composes just a small part. In this study, we will focus on the main sectors below:

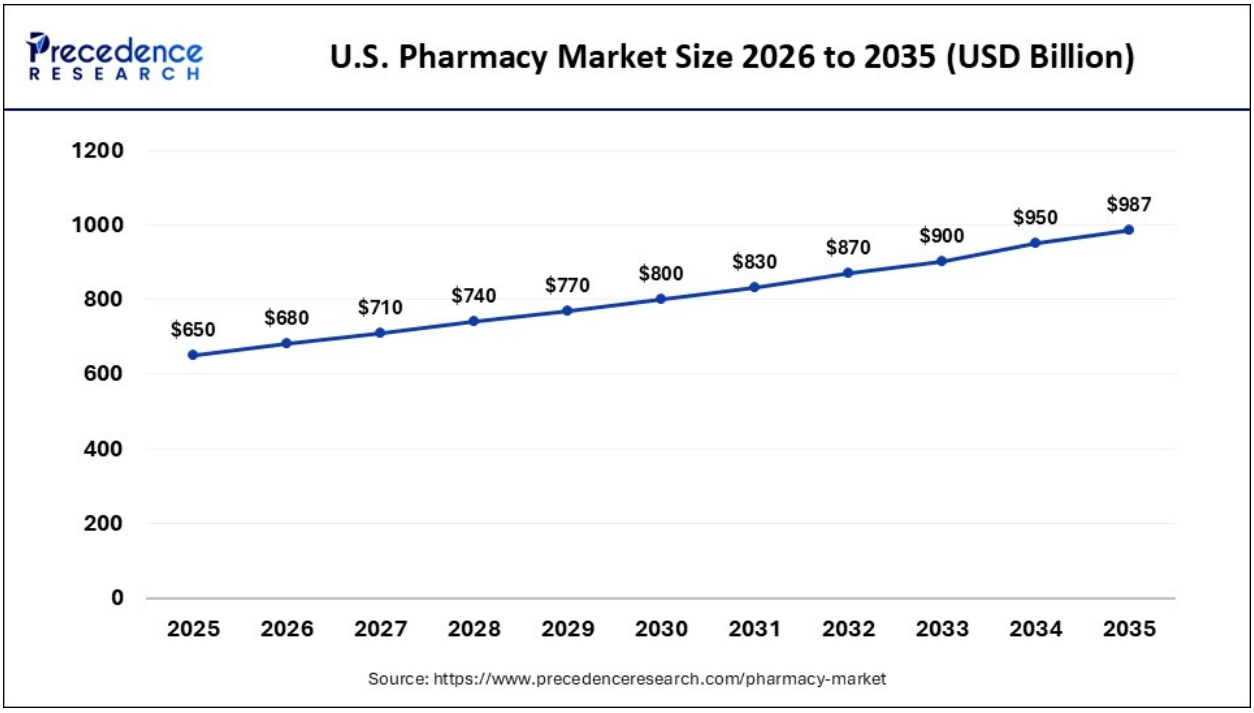
- 503A Compounding pharmacies
- 503B Compounding pharmacies
- Commercial retail pharmacies

Adding commercial pharmacies allows us to use them as a benchmark. Additionally, it allows us to have context, how do smaller compounding pharmacies fare against the traditional, large retail pharmacies. And more importantly, do we see specific, empirical differences between their digital maturity, governance signals and sustainability results.

1.2.1 Market Composition

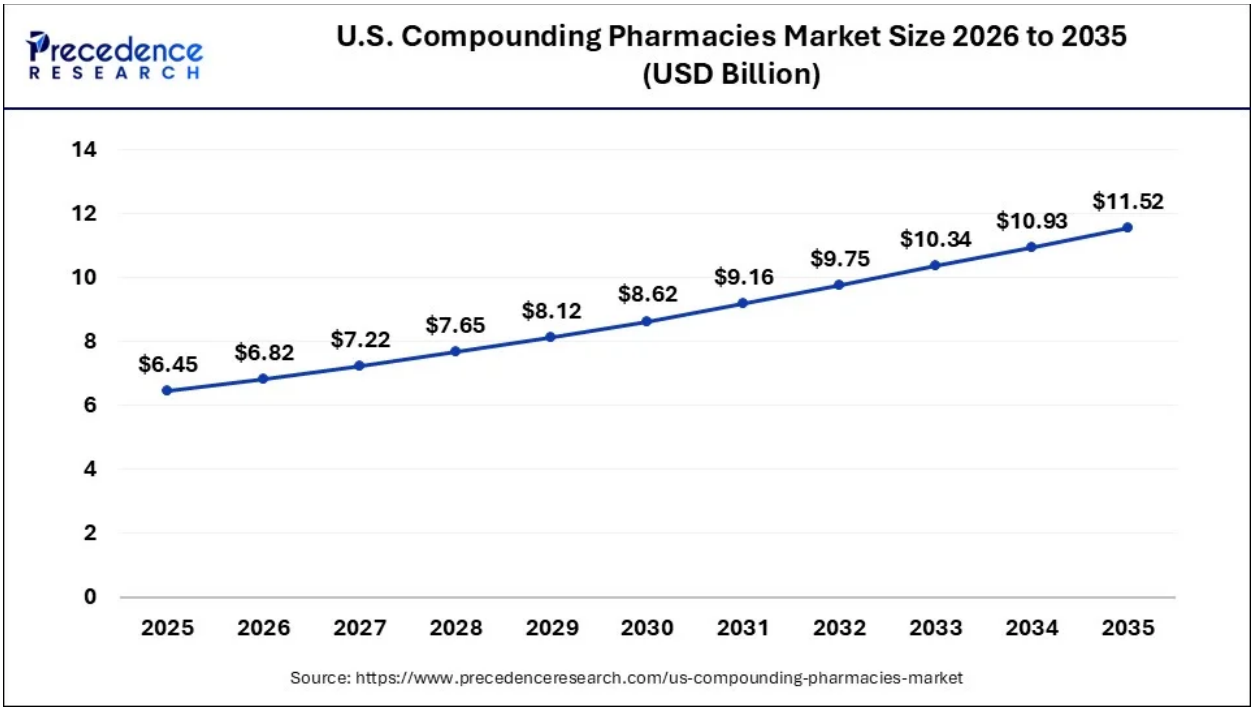
The compounding pharmacy market, albeit large, is still a very small percentage of the total pharmacy market size. As shown in Figure 1.1 and 1.2 below, the entire pharmacy market size is at $650 billion, whereas the compounding pharmacy market sits at a much lower $6.45 billion. This accounts for roughly 1% of market share

Figure 1.1



Note. From Precedence Research. Pharmacy Market Size, Share, Growth, Trends, Report 2022-2030. (n.d.).

Figure 1.2



Note. From Precedence Research. (2025). Compounding Pharmacy Market Size to Worth USD 31.77 Bn by 2034. Precedenceresearch.com; Precedence Research

Within the compounding market, 503A pharmacies accounted for greatest market share totally at 73% in 2023 (U.S. Compounding Pharmacies Market Size to Hit USD 10.76 Billion by 2033, 2025).

1.3 What is digital transformation?

According to *IBM*[4], digital transformation is a "*business strategy initiative that incorporates digital technology across all areas of an organization*" (IBM, 2024). This is a very broad definition, no doubt. However, we can use this base to determine how this definition relates to

[4] IBM stands for International Business Machines and was one of the leading pioneers in early digital adoption with their personal computer.

the healthcare industry and pharmacies specifically. And it may come as a surprise but using digital tools is not always a given in healthcare as it may be in many other areas. By using the definition given as a base, we can determine that digital transformation refers to the adoption of digital tools that change the way pharmacy performs, controls, documents, and improves its compounding and dispensing operations. This is not merely replacing paper records with computer records; it would result in an application of digital tools deeply embedded throughout workflows and pharmacy responsibilities.

Since compounding pharmacies are generally smaller and privately held, finding detailed published operational metrics may not be as measurable as the larger commercial pharmacies that we will also review. Because of this, we will treat digital transformation as a measurable organizational capability via a digital maturity approach. Digital maturity can be described in this case as how deeply integrated digital tools are across all operational workflows. We will attempt to focus on tools that are typically referenced in public documents, accreditation requirements, and other consistent observations.

1.3.1 Healthcare relevance

Digital transformation in healthcare has always been slower than in other sectors. Respected European scholar Andreas Charalambous put it this way: "*In fact Notwithstanding significant advances and even more significant potential, health care is not one of those dramatically transformed industries. A number of reasons can explain the slow pace in adopting digital innovations in health and their poor digital transformation*" (Charalambous A, 2024). Although these reasons will not be the focus of this study, they may be important to understand as to solidify a better general understanding of the historical relevance of digital transformation in this

sector. According to the *NIH* [5]study: poor governance, user acceptance, and effectiveness doubts as main factors. However, despite these concerns, the study does emphasize a need for digital transformation in order to improve outcomes and overcome challenges. The results of this study can be used as a stepping stone to bring us to the more specific elements of pharmacy.

The importance for pharmacies lies in a few main points: QA, compliance, and growth and sustainability. We will begin with the first point, quality assurance. Compounding in pharmacy involves many steps where human error can occur, and human error at these steps can lead to serious consequences. These steps include weighing out and selecting ingredients, calculations, labeling, and documenting steps. Certain areas where digital tools may be present are the following:

- Electronic batch records and compounding logs
- Barcode verification of ingredients and lots
- Image capture for verification
- Various alerts if certain parameters are not met
- Standardized management systems
- Robust reporting capabilities for recalls, audits, etc.

Additionally, compliance plays a big role in pharmacy compounding. In fact, because of the nature of compounding (where products are not FDA approved) compounding pharmacies may sometimes be under heavier scrutiny than traditional retail pharmacies. Compliance is supported

[5] The National Institute of Health conducts research as part of the US Department of Health and Human Services

by digital transformation in a variety of ways, including complete and available documentation and audit trails and user training. Additionally, corrective action processes and fast retrieval of records for inspections, audits may also be present.

Finally, growth and sustainability are areas where pharmacy's internal processes can be greatly aided by digital tools to ensure efficient processes are being run and unnecessary work is being avoided. Certain examples may include outward-facing services such as offering integrated services for patients and providers. Utilization of automatic preparation settings may also be used to ensure the correct number of products are being created in order to avoid waste. There also may be aid in ensuring accreditation and certification procedures are being followed correctly and sustainably.

1.3.2 Economics and drivers

High volume commercial pharmacies differ greatly in costs of operations. Here economies of scale are achieved by very large batch sizes and industrial type manufacturing lines. Compounding however is more focused on custom preparations that involve significant human interactions and various verification checks. This makes economics and capacity management central to understanding why digital transformation matters. Cost drivers for compounding pharmacies revolve around skilled labor time, environment overhead, materials, and possible rework and waste. Labor requires skilled technicians and even pharmacists to ensure that not only is the physical process followed correctly, but that all records, documentation, and cleaning procedures are followed. Environmental overhead is always a factor in all pharmacies, however it can be especially relevant for sterile products, because of the need of a clean room. Materials and inventory are more difficult to manage in compounding because inventory consists of finalized compounded products, active ingredients, and inactive ingredients. All of which vary in

shelf life and storage requirements. Because of this reason, rework and waste is a factor that many compounding pharmacies must manage. Deviations, failed checks, expired preparations, and re-preparation events consume capacity and result in increased costs. In sterile workflows, rework can be particularly expensive because it consumes labor time and time in the clean room.

Digital tools matter economically greatly in this area. In fact, in almost all areas of the world they hope to achieve results in a more efficient manner. Not necessarily by always eliminating labor, but by how effective that labor may be. Reducing rework, error rates, waste, workflow bottlenecks are all specific areas in pharmacy where this may be relevant. The results of a potentially increased efficiency would not necessarily mean a reduction of employees, but an ability to use them in other areas or simply increasing volume without the need of increasing headcount.

1.4 Managerial and policy relevance

Here we will describe the perceived relevance that we will eventually explore throughout this investigation. The below sections will outline the key players here and explore how digital transformation can be potentially important. This is not an anticipation of eventual empirical findings; however an explanation of why this topic warrants the research that will be outlined later.

1.4.1 Patients and Providers

For patients, compounding is often used when standard retail medications are not feasible. Digitalization can support patient safety through improved accuracy, documentation, and standardization, while also improving other factors such as turn around time and communication. For prescribers, digital maturity may translate into easier prescribing knowledge, easier

pharmacy communication, and order tracking and reporting. It is no secret in the compounding world that prescribers have difficulty prescribing compounded medications. In fact, many doctors do not ever prescribe compounds. Although the data may be lackluster, estimates range the percentage of compounded medications to be from 2.3% to 12.2% of all medications (McPherson et al., 2016 p173). Because of this compounding pharmacies many times may need to clarify what is being sent over by the doctor to ensure comprehension and accuracy.

1.4.2 Hospitals

Hospitals and clinics may depend on compounded medications for sterile preparations and shortage mitigation. Outsourcing decisions, supplier selection, and contracting processes increasingly require quality systems and governance. Digitalization and credentials (accreditations/certifications) can function as credibility signals that reduce costs and risks.

1.4.3 Government Regulation

For regulators, digital tools can support better documentation, traceability, and consistent enforcement. However, heavy reliance on formal ESG scoring or extensive reporting requirements may be unrealistic for small private pharmacies. Compounding pharmacies usually fall within this area. Larger retail pharmacies (CVS, Walgreens, etc) may be able to provide more realistic and accurate scores. This does then result in a need for balance in order to not need to impose unrealistic burdens that smaller pharmacies cannot meet.

1.4.4 Why these questions remain open

As we have learned in section 1.3, digitalization has not been a simple “one and done” process for healthcare. Quality, efficiency, regulation and more poses significant challenges and it

remains unclear how digital maturity in pharmacy relates to organizational structure, governance mechanisms, and market positioning across different types of compounding pharmacies. These unresolved questions underscore the need for a systematic and empirically grounded investigation. This study will contribute to these discussions by showing what can be measured empirically today (via public evidence and certifications) and where disclosure gaps may exist.

1.5 Review and bridge to literature

After reviewing the multiple sectors in the pharmacy ecosystem, it is clear that we are able to have a strong setting to begin studying digital transformation in this space. The significant variety of the different pharmacies covered (503A, 503B, large retail, etc.) shows a significant difference between them and allows us to eventually see how results may differ. Using the non-compounding pharmacies as a benchmark will allow us to gain very detailed, insightful information (due to their large size and easily accessible scores, reports and more) to compare the smaller, more niche pharmacies to them. This information allows us to move on to the next chapter where we will focus on the very specific and intricate governance laws and regulations. Accreditations, certifications, reporting, and more all play a key role in all pharmacies in the U.S. Once these important prerequisites are accurately studied and discussed, we will be able to move on to the critical review of digital transformation and its results.

2 U.S. Regulatory & Governance Landscape

2.1 Practice Standards and Laws - Overview

Compounding pharmacies in the United States are not governed by a single system, rather multiple administrations that each have their own role in governance. As described in chapter 1, compounded products are not approved by the FDA. However, the federal government does define the difference between 503A and 503B pharmacies. Commercial products (that are dispensed by retail pharmacies) must go through lengthy FDA approval processes. Figure 2.1 describes the federal government's distinction. Because of this, state boards of pharmacy have much more regulatory impact on compounding pharmacies. These regulations vary (sometimes even significantly) by state. Because of the vast number of regulations, there are no official public guides to this, however Figure 2.2 below displays a few differences between a few states. Finally, there are professional compounding practice standards that specify how the compounding process should be followed. Each of these regulatory standards will affect the documentation, controls, internal processes and more. Digital maturity, in this setting, is partly an operational capability and partly a response to governance expectations.

Figure 2.1

Note. From Jackson, L. M., & Schwinn, D. A. (2020). Compounded topical pain creams: review of select ingredients for safety, effectiveness, and use. The National Academies Press.

Figure 2.2

Rule Area	California (CA)	Texas (TX)	Florida (FL)	New York (NY)
Pharmacist-to-Tech Ratio	1:1 (for sterile compounding), 2:1 (otherwise)	1:6 (if techs are registered)	1:6 (can be up to 1:8 with board approval)	2:1 (up to 4:1 with board approval)
Minimum Age for Shots	3 years+ (with exceptions)	7 years+ (for flu), 14 years+ (others)	7 years+	2 years+ (flu), 18 years+ (others)
Controlled Substance Refills (CIII-CV)	Max 5 refills in 6 months	Max 5 refills in 6 months	Max 5 refills in 6 months	Max 5 refills in 5 months
Telehealth Rx for Controls (Post-Flexibility)	Requires in-person visit for initial Rx	Requires in-person visit, some exceptions	Controlled by specific telehealth provider registration	Strict limits, generally requires in-person visit

Note. From Pharmacy Regulations by State: Complete 2026 Guide. (2026, February 8).

2.1.1 USP compounding practice standards

USP stands for United States Pharmacopeia, which is an "*an independent, scientific nonprofit organization focused on building trust in the supply of safe, quality medicines. The USP is committed to the quality of medicines and to protecting patients, helping build trust and confidence in drug therapies, and enabling people to live longer and healthier*" United States Pharmacopeia (USP, 2019). These guidelines are the frameworks for compounding standards that all compounding pharmacies aim to follow. There are three core chapters in USP guidelines: USP <795> (Nonsterile Compounding), USP <797> (Sterile Compounding), and USP <800> (Hazardous Drugs). These guidelines are important since they shape the operational reality of compounding. Formula documentation, stability criteria for ingredients, compounding equipment and facilities, training, and quality control are all significant factors in day-to-day operations for pharmacies. When these requirements are operationalized at scale, they naturally create "information problems" that digital tools can address. Examples may include standardized recordkeeping, audit trails, or structured workflows (USP General Chapter, 2016). Here, USP standards will be treated as a foundational reference for what compounding practice requires. The empirical analysis does not attempt to audit USP compliance; rather, the standards provide context for why documentation intensity and traceability needs are high, especially for sterile and hazardous work.

2.1.2 The Drug Supply Chain and Security Act

The Drug Supply Chain and Security Act (or DSCA for short) defines steps to achieve a way to electronically identify certain prescription drugs. The goal is to prevent harmful drugs from entering the drug supply chain and to detect harmful drugs if they do enter the supply chain. Additionally, it outlines a rapid response to remove harmful drugs from the supply chain to

protect patients (Center for Drug Evaluation and Research, 2018). These are federal requirements that don't pertain specifically to compounding pharmacies, but to all pharmacies in general. DSCA is relevant here as contextual background and infrastructure since it forces an environment in which traceability, standardized data exchange, and verification are expected across pharmacies and manufacturers. This act reinforces the digital direction in the U.S. healthcare system. DSCA is our first regulatory act that we are covering that has significance in why digital traceability systems have strategic importance for pharmacies. This is especially true regarding organizations operating across multiple sites or working with institutional customers that demand strong documentation and verification practices.

2.1.3 Current Good Manufacturing Practice (CGMP) Regulations

Current Good Manufacturing Practice regulations or CGMP for short, are regulations set forth by the FDA to ensure drug quality. These controls are enforced for the manufacturing, processing, and packing of drugs. Due to this definition, standard retail pharmacies and 503A pharmacies are generally not required to follow CGMP regulations. 503B pharmacies and large commercial manufacturing facilities are, however, required to meet these standards. As described by the FDA, "The CGMP regulations for drugs contain minimum requirements for the methods, facilities, and controls used in manufacturing, processing, and packing of a drug product. The regulations make sure that a product is safe for use, and that it has the ingredients and strength it claims to have" (Food and Drug Administration, 2023).

2.2 State boards of pharmacy and variability in requirements

As described before, the federal government leaves much discretion (regulation-wise) up to each individual state. Because of this, there is (sometimes) significant variability in regulatory policies.

2.2.1 The role of state boards in U.S. pharmacy governance

In the U.S., each state has their own state board that is part of the National Association of Boards of Pharmacy (or NABP for short). The NABP's role is to work with each state's board to support their individual practices such as licensures, accreditations, inspections, and more. They identify their mission as "*...help support patient and prescription drug safety, through examinations that assess pharmacist competency, pharmacist licensure transfer and verification services, and various pharmacy accreditation programs*" (National Association of Boards of Pharmacy | NABP, 2016).

The interaction between state boards and the federal government is important and albeit separate, both governments share information and collaborate in different ways. As the federal government states: "*It is critical that FDA and the states continue to work together to identify and take appropriate action against compounders whose practices present the greatest risk to public health*" (Research, 2021). The FDA may also receive reports from state boards that express actions taken against compounding pharmacies.

2.2.2 Why variability across states matters

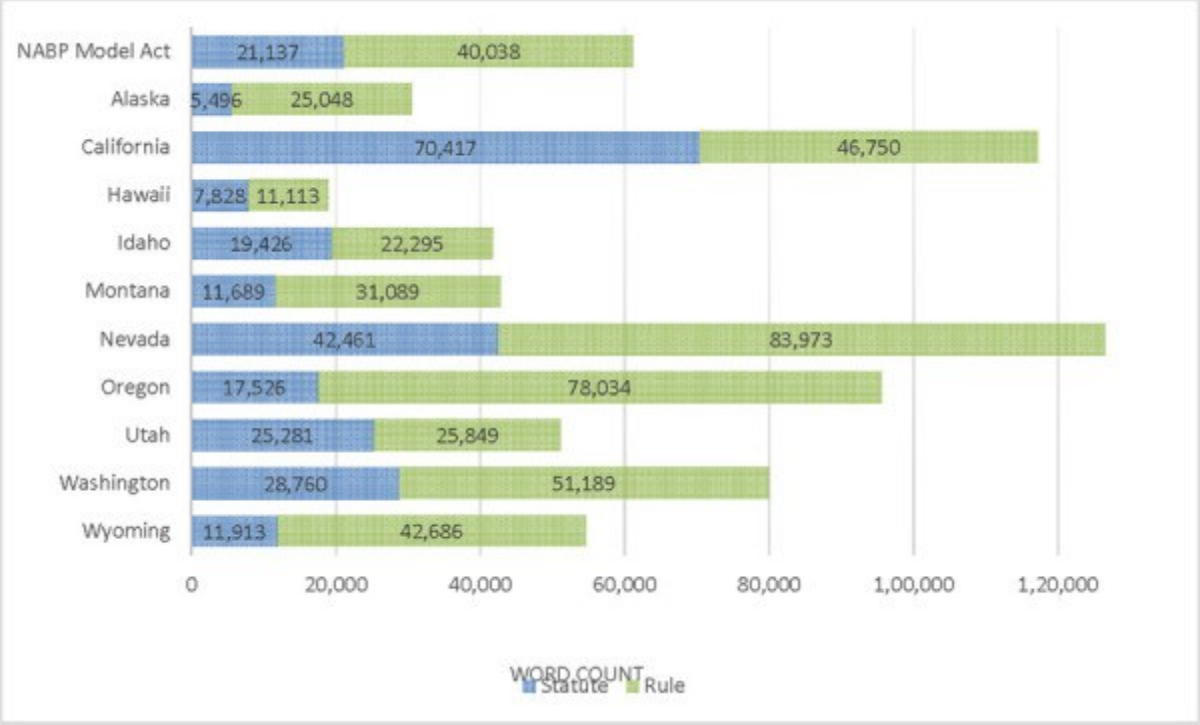
Although many states have similar structure regarding their acts and regulations, many differences can still occur between states. This follows the same idea with each state's laws in other aspects such as minimum wage, alcohol, taxes, firearms and more. Each one of these things

may have large variability between one state and another. When looking at the details, pharmacy regulations between states do contain significant variability. In Alex J Adams' study *Regulating Pharmacy Practice: Analysis of Pharmacy Laws in Ten States,* Adams compared pharmacy laws across ten states in response to the NABP's task force to develop regulations based on standards of care instead of prescriptive regulations (Adams, 2020). This study took a deep dive into different state's regulations and which ones have the biggest regulatory burden for pharmacies. It found that there was a major variation in between states and that the largest part of them was due to practice and facility standards.

In Figure 2.3 below, the total word count (for pharmacy law) for the ten states is shown below. There is additionally the *NABP Model Act* [6]as reference. As shown clearly, there is a significant difference between certain states; Nevada has 6.68 times as many words as Hawaii, and California has 9.1 times as many restrictions as Hawaii.

[6] The act "provides the boards of pharmacy with model language that may be used when developing state laws or board rules. The Model Act is based on the principle that safeguarding the public interest is the foremost compelling reason for regulating the practice of pharmacy and the distribution of drugs and related devices" (Model Pharmacy Act/Rules, n.d.)

Figure 2.3



Note. From Adams, A. J. (2020). Regulating Pharmacy Practice: Analysis of Pharmacy Laws in Ten States. INNOVATIONS in Pharmacy, 11(4), 20.

Examples of specific differences include California's strict 12-point font regulation for prescription labels, and Ohio's positive ID requirements that details that systems must capture positive identification during certain pharmacy steps.

This variability has important consequences in this thesis since it affects operational design and therefore its digitalization pathway. For example, pharmacies that operate across different states will need to comply with licensing requirements, inspections, and documentation practices that will differ. This state level variation will greatly influence how pharmacies invest in standardized digital workflows, digital recordkeeping, reporting, and multi-location practices.

2.3 Accreditation and certification ecosystem

Accreditations and certifications function as market facing governance signals. They are normally voluntary, but they can become practically necessary when customers (especially large institutional customers) require evidence of process control, documentation, or compliance discipline. In sectors dominated by private firms with limited public disclosure, these credentials provide a standardized way to compare organizations using evidence that is visible and verifiable. Also, there may be regulatory significance for specific accreditations and certifications. Basic requirements will be reviewed in the early stages of opening a pharmacy and these (or additional) requirements may also be reviewed during onsite inspections by the board of pharmacies.

These accreditations will not be treated as proof of a certain service quality, but as observable indicators that can be empirically given. Therefore, they can be used as inputs into an empirical governance profile and compared against digital maturity patterns.

2.3.1 Compounding-focused credentials

ACHC/PCAB

The Accreditation Commission for Health Care (ACHC) administers the PCAB accreditation. A PCAB accreditation "*provides compounders with the resources to guide them through complex and sometimes competing regulations. Perhaps best of all, ACHC's program staff shares deep expertise and experience with PCAB customers to solve practical implementation challenges*" (ACHC, 2024). This process helps compounding pharmacies manage FDA and state regulations. This brand is recognized as the "internationally-recognized benchmark for excellence" (ACHC, 2024).

NABP Compounding Pharmacy Accreditation

NABP's compounding pharmacy accreditation is a 3-year accreditation for compounding pharmacies that is available for all compounding pharmacies in the U.S. Obtaining this certification demonstrates the pharmacy's alignment with USP <795>, <797>, and <800> standards (NABP Eligibility, 2024).

2.3.2 Commercial and specialty pharmacy credentials

URAC

URAC describes themselves as the nation's largest healthcare accreditation organization. While not specific to compounding, they have a multitude of accreditation ranging from specialty pharmacy accreditations to mail service pharmacy accreditations (URAC, 2019).

NABP Digital Pharmacy

NABP's digital pharmacy accreditation is 3-year accreditation for pharmacies that offer at least one online interactive pharmacy component. This can include patient or provider portals which can be accessed online. This of course may still apply to compounding pharmacies; however eligibility requirements are much broader than the compounding accreditations (NABP Eligibility, 2024).

2.3.3 ISO and digital information security attestations

ISO

ISO management system standards are often used in healthcare and non-healthcare sectors as verifiable evidence of structured management systems. These standards are internationally agreed upon by experts and cover a large array of different processes and activities. Some of

these include quality management standards, environmental standards and health and safety standards (ISO Standards, n.d).

SOC 2 and HITRUST

SOC 2 examinations are reports that are “relevant to security, availability, processing integrity, confidentiality, or privacy” (SOC 2, n.d.). These are intended to show information and assurance regarding security and processing integrity of systems. This may be especially relevant because of the delicate nature of patient and provider data in pharmacy. HITRUST on the other hand describes its framework as “a portfolio of assessments and certifications to validate the security of your systems, data, and environments” (Cybersecurity Frameworks and Compliance Solutions HITRUST, 2025).

2.4 Sustainability and disclosure frameworks used in the U.S.

Sustainability and disclosure frameworks will be discussed in a pragmatic way due to some potential limiting factors for some pharmacies. Many U.S. pharmacies (especially independent compounding pharmacies) do not publish sustainability reports or receive mainstream ESG ratings. However, larger healthcare organizations and public parent companies often disclose sustainability information using recognized frameworks. The key goal will be to identify which frameworks appear in disclosures and to treat them as observable governance practices.

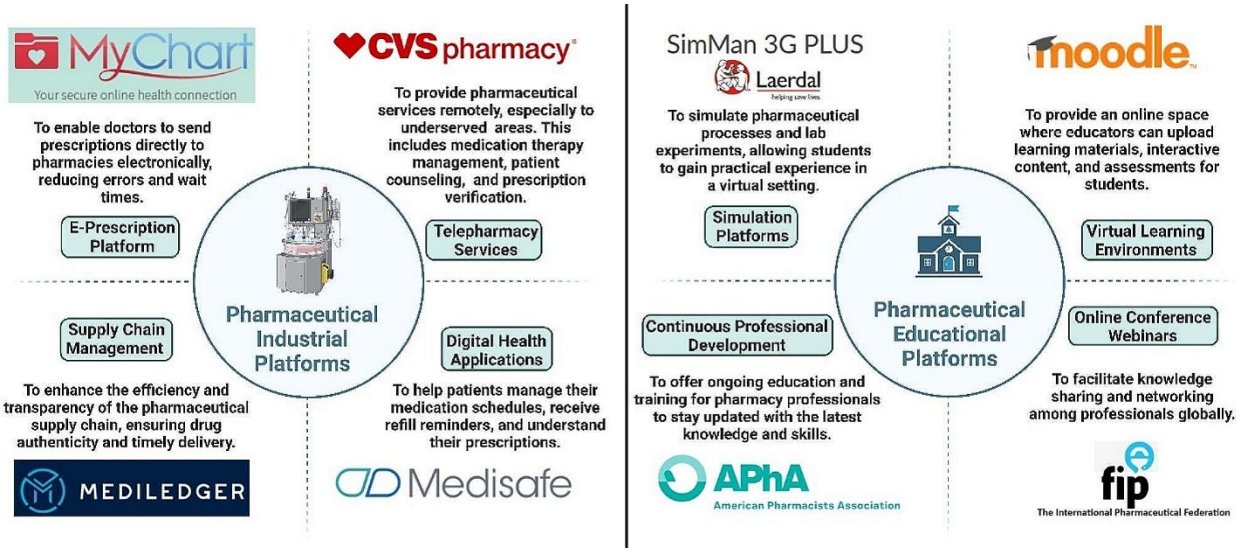
3 Literature Review

This chapter will review literature for three main aspects: digital tools and information systems in pharmacy, sector specific business models, and governance signals. While compounding is often viewed as a clinical and regulatory practice, it also functions as a complex system where documentation, traceability, and error-prevention controls are vital aspects. The regulatory distinction between 503A compounding pharmacies and 503B outsourcing facilities, together with the presence of large-scale non-compounding commercial pharmacy companies gives us a strong setting. This setting will help us study how digital maturity varies across sectors and how it relates to observable organizational characteristics.

3.1 Digital tools in pharmacies

Digital tools in pharmacies are not only relevant in customer-facing channels, but also (and maybe more importantly) in internal processes controls, data integrity, and verification under conditions of high operational risk. The latter is especially true for compounding pharmacies that may deal with sensitive sterile preparations. The impact of digital tools is far and widespread, certainly more than what will be covered in this thesis. Below is a very high-level overview of different digital platforms that are present in the pharmaceutical industry.

Figure 3.1 Comprehensive overview of different platforms in the pharmaceutical industry and education illustrating purposes and exemplary cases



Note. From Almeman, A. (2024). The digital transformation in pharmacy: Embracing online platforms and the cosmeceutical paradigm shift. Journal of Health, Population and Nutrition

3.1.1 Electronic documentation and records

A vital aspect in digital transformation has been the transition from a paper-based environment into a digital one. Paper-based master formulation records, compounding logs, and more have become a vital part in the digital maturity transition. The move from these being paper records to digital records has become a foundation for achieving a basis in digital maturity. In the U.S., electronic record trustworthiness is captured in federal regulation on electronic records and electronic signatures which is described in the *21 CFR Part 11*[7]. These guidelines describe a benchmark for electronic documentation and to "set forth the criteria under which the agency considers electronic records, electronic signatures, and handwritten signatures executed to

[7] This is a federal regulation from 1997 describing electronic record and signature use (Federal Register, 1997).

electronic records to be trustworthy, reliable, and generally equivalent to paper records and handwritten signatures executed on paper" (Federal Register, 1997).

The *ISMP*[8] held a summit in 2022 with various expert panel members where technology and automated were reviewed and discussed specifically to compounding pharmacy environments. This summit yielded crucial information for current and future digital technologies in pharmacy. Electronic data integrity was discussed with an emphasis in systems that "*document all steps and components of the compounding process (e.g., products used, the practitioner who performed the compounding, the primary engineering control, machine-readable code scans, date and time of preparation, alerts or warnings presented during the process, the practitioner who verified the preparation), and the information is available to users in a log and/or report*" (ISMP, 2022). Additionally, incorrect actions that have taken place can be captured and reported "*compounding events (e.g., wrong drug scans) intercepted by the technology are captured in a report to facilitate compounding error analysis and process improvement*" (ISMP, 2022).

3.1.2 Verification and technology assisted workflow

In addition to reporting and transitioning to digital recording-keeping, digital tools for verification have also been a key area where digital technology has been present. "Machine-readable coding (e.g., barcode scanning, RFID) and/or image capture for non-barcoded items, is used to verify products, including diluents, during the compounding process" (ISMP, 2022). The ISMP describes the use of barcodes and digital capturing as a growing standard in pharmacy. Barcode verification steps can be used at many different levels of pharmacy workflow. Compounding, fulfillment, verification, and shipping processes can all be utilized with the aid of

[8] Institute for Safe Medication Practices (ISMP, 2022).

barcode and image capture technologies. In compounding, technology-assisted workflow systems are often described as combining barcode verification, standardized step sequencing, photo/image capture for verification, and gravimetric (or density-based) documentation to verify volumes and detect deviations. Empirical evidence on technology-assisted workflow systems is growing but remains unclear. A review of the systems synthesized a limited set of studies and highlighted that the evidence base is concentrated in specific settings and outcomes, often emphasizing documentation and safety measures rather than business-model implications across sectors (Farcy et al., 2021).

3.1.3 Automation and robotics

In addition to verification, literature also examines automation as a response to workload, accuracy, and safety concerns. This is especially true in hazardous drug preparations. A study *Evaluation of Robotic Systems on Cytotoxic Drug Preparation* focused on systematic review and meta-analysis for the use of compounding robots for cytotoxic injectable drugs. This reflected a positive outcome for the use of robotics and was done in partnership with Seoul National University in Korea. Results showed improved accuracy, reduced workload and contamination risk. However, evaluations are still limited and context-dependent because of the limited scope (Shin et al., 2023).

Robotics in compounding are still limited and are largely situational and dependent on preparational context. Automation may be used for efficiency as well as standardization and safety. Specific high-risk compounding workflows may see benefit from automated standardized workflows.

3.1.4 Digital tools specific to large commercial pharmacies

Unlike compounding, large commercial pharmacies and manufacturers are able to scale automation technologies due to their standardized business models. Digital stacks are shaped by volume, multi-site operations, and logistics. A simulation-based study describes robotic dispensing systems as ones that "plays a crucial role by automatically storing, counting, and dispensing various medication pills to enable CFPS to fulfill high-volume prescriptions safely and efficiently" (Ciao et al., 2022). Automated systems in commercial pharmacies have played a significant role in high volume pharmacies. It is important to note that based on these studies, digital maturity is likely multi-dimensional across the different sectors being studied. Compounding organizations may show maturity in workflow control and traceability, while large commercial pharmacies may show maturity in centralized fulfillment and operational capabilities. This does suggest the need for a maturity framework that may be broader than just one narrow definition.

3.1.5 Patient and provider facing tools

Patient and provider facing tools are relevant in all areas of pharmacy, however there may be certain key differentiating factors between sectors. The largest e-prescribing network in the nation, *Surescripts*[9]*,* allows providers to electronically send prescriptions to nearly all pharmacies in the U.S. According to the company, the Surescripts network is used by 2.32 million healthcare professionals and provider organizations (Annual Impact Report 2025, 2026). Providers can send these prescriptions utilizing their electronic health record system that stores and manages their internal information. This type of e-prescribing is very common and efficient for large

[9] Surescripts is the most commonly used transmission type for e-prescribing.

commercial pharmacies that send *single-NDC* [10]products, however sending compounded products through the network is not as streamlined. In addition to Surescripts, there are other e-prescribing tools that cater more to specialty and compounding pharmacies. These are usually offered by their pharmacy software and can usually be accessed through the pharmacy's commercial website or through a link they provide to their doctors directly. A systematic review titled *Benefits and Barriers Associated with e-prescribing in Community Pharmacy* attempted to find a relationship between e-prescribing and pharmacy productivity. It grouped 28 studies that focused on e-prescribing and its effect on pharmacy workflow and productivity. The results highlighted a potential negative impact on quality of care depending on the design of the e-prescribing system. This was due to potential poor technological support and slow user acceptance. Conversely, a well-designed system has the potential for significant improvements (Hareem et al, 2023).

Patient-facing access is also a digital tool that is shared between pharmacy sectors, albeit with varying investments. Large commercial pharmacies invest greatly in patient communication tools which include apps, portals, and messaging options. Compounding pharmacies do also utilize these options, however because the market is commonly divided between both patients and providers, it may not always be the primary focus. In literature, these are viewed as tools to support medication compliance and communication. Evidence from systematic review and meta-analysis suggests apps can support medication compliance under certain designs, though effects vary across populations (Armitage et al., 2020).

[10] Single-NDC products refer products that can be identified by their unique 11-digit NDC code for commercial products. Compounded products do not fall under this category.

3.2 Business-model implications

Business models for all sectors have always been shaped by various elements, both internal and external ones. A 2023 study titled *Digital technology and business model innovation: A systematic literature review and future research* reviewed a collection of publications and looked at how digital technologies are changing the way companies are trying to capture markets and value. It found a significant impact on how digital technology can shape business models, however there may be cases where companies fall into a digitalization paradox. This is when "*digital-enabled transformations do not yield the benefits that leaders expect, and many executives express concerns that they are actually falling behind in making the important choices that lead to differentiation"* (Ancillai et al., 2023). A second study: *Digital business model innovation: toward construct clarity and future research directions* also emphasized the importance digital tools have on business models. It argued that digital transformation is managerial issue that requires redesigning the business model to stay competitive (Trischler, et al., 2023). This information is a good base to have as the study focuses on more pharmaceutical specific reviews.

The pharmacy specific literature reviewed suggests that digital tools and their adoption vary depending on the pharmacy sector, resulting in differences based on their business model configurations. What is being produced (compounds or commercials) and who it is being produced for (patients, providers, hospitals, etc.) seems to bring forth different opportunities and within the digital repository.

3.2.1 Patient-specific compounding and the 503A operating logic

503A compounding pharmacies are constrained to patient specific prescriptions conducted under state and federal oversight. There are constraints in place to ensure that it does not step into manufacturing-like distribution like 503B pharmacies. From a digital transformation standpoint, patient-specific models can prioritize systems that support intake efficiency. This means receiving prescription, order entry, processing, clinical communication and refill and *autorefill* [11]tools are all relevant. Ensuring quick turnaround time for orders emerges as a priority when evaluating digital tools. Recently, connections to telehealth organizations have also been a stark priority and a shift in many business models. Managing orders directly through large telehealth clinics has shifted some focus into charging and communicating with clinics more directly than what was done before. Charging clinics directly on rotating accounts and managing orders directly without the same level of patient interaction has led the way for new digital tools to follow. This of course has not replaced the traditional, small pharmacy that dealt with patients and their accounts directly, however it has added a sector that has in turn added new need and availability for more custom digital tools. The order volume however, still does not compare to the outsourcing facilities due to the nature of the business.

3.2.2 Outsourcing facilities and the 503B logic

503B facilities frequently operate in a more production-oriented manner. These facilities serve larger institutions, therefore there is a stronger incentive to invest in quality systems, auditability, and workflow standardization. Digital tools that aid these pharmacies into following the Current Good Manufacturing Practice regulations are prioritized. The internal processes remain relatively

[11] Autorefills refer to when a patient opts to be put in a program that will automatically send any refills they have for the prescription at the end of their current days supply.

similar to 503As, due to the consistent nature of compounding sterile and non-sterile drugs. However, after COVID-19 there were many issues that plagued hospital systems and pharmacies. Medication shortages and high turnover rate for health care employees became key factors affecting companies. A study done by Marshall University in the United States in 20222 confirmed this and noted that 503B pharmacies found success in this newfound area. “In the face of these obstacles, health systems are turning to 503B compounding facilities to outsource pharmacy needs” (Clemente et. al, 2022).

3.2.3 Large commercial pharmacies

Large commercial institutions represent great structural differences from compounding pharmacies. High-volume standardized dispensing, multi-site routing, and insurance connectivity are main aspects that may otherwise not be considered in smaller compounding pharmacies. In the traditional model, the pharmacy purchases a very large number of products from a single or various manufacturers, which is then dispensed to their patients. A study describes the traditional model as “centered on fulfillment and is designed to maximize prescription fills at the highest price the market will bear. In recent years, because of declining reimbursement for prescription products by third-party payers, pharmacies have had to rely almost solely on increasing the number of prescriptions filled per employee per unit of time” (Hohmeier et al., 2023). An additional factor here are *TPPs* [12]or third-party payors which are not as commonly used in compounding environments that focus on purely cash-based transactions. This does push for more digital connectivity requirements in order to smoothly manage a large number of these types of transactions.

[12] Third-party payors are entities such as insurance companies that may pay a portion or all of a patient’s medication or treatment

In summary, business model configuration (customer type, operating scale, and governance exposure) may be a plausible driver of why different pharmacy sectors adopt different digital tools and why "digital maturity" may look different across 503A, 503B, and large commercial segments.

3.3 Governance and "score" proxies

3.3.1 Importance of governance scores in all sectors

A core methodological hurdle for research for compounding pharmacies is the lack of standardized financial and ESG reporting. ESG has three pillars which stand for environmental, social and governance. IBM describes it as pillars that have become increasingly more important in recent times: "*The impact a company can have on its surrounding ecosystem has become vividly clear, whether it's on a global scale or within its local community. At the same time, people have become increasingly concerned about ESG issues…"* (Krantz, 2024).

The reason this is a hurdle for compounding pharmacies is due to the fact that virtually all are private companies that are not in a position to share this kind of information with the public. As a result, governance and quality must often be inferred via observable signals for compounding pharmacies. These kinds of signals may include the certifications/accreditations that are were described in chapter 2. This information is consistent with what health systems are doing to determine what types of products to purchase from compounding pharmacies. The *Cleveland Clinic Health System* [13] developed an internal structure to be able to vet 503B facilities before purchasing their products. "…has developed a robust internal structure to appropriately vet 503B

[13] Cleveland Clinic is a non-profit academic medical center, provides clinical and hospital care and is a leader in research, education and health information (Cleveland Clinic, 2025).

outsourcing facilities for safety and reliability, as well as standardized criteria used to determine which products will be outsourced" (Pamphile et al., 2025). Although the context is slightly different, this kind of structure will be used in this study.

For large commercial pharmacies, finding standardized reporting will be more publicly available and will result in scores more consistent with traditional metrics. Many will publish public ESG reports each year which can be used as the basis to obtain information for these companies. These reports follow the three main pillars; however they may differ naturally due to companies positioning.

3.3.2 FDA inspections, recalls, and enforcement signals as usable empirical indicators

For compounding, the FDA provides public information streams relevant to compliance and risk such as inspections, recalls, and other corrective actions it may have imposed on pharmacies. Additionally, it also publishes lists of registered 503B outsourcing facilities.

Being able to review this publicly available information does allow the study to view specific letters that the FDA has provided to each pharmacy. Additionally, letters from board of pharmacies are also available which may include different information that the FDA would not oversee. There are certain standards that may be universally applied, however certain letters may also have very specific warnings specific to a single pharmacy. Of course, these sources are imperfect as objective score criteria, an absence of an event is not proof of quality. However, they do create a structured, publicly observable layer of governance signals that can be systematically reviewed and compared across organizations and sectors. This includes comparisons with other compounding pharmacies as well as large commercial organizations.

3.3.3 Empirical research on warning letters and enforcement themes

A study from the Journal of the American Pharmacists Association reviewed compounding warning letters to 503A pharmacies between 2017 and 2022. This provided content analysis to warning letters and found recurring themes regarding compliance. The patterns in violations can be used in illustrating how enforcement documentation can be used as empirical material and not just background information. The conclusions showed that warning letters from the FDA can be a viable learning tool for pharmacies which can be utilized to improve quality in the future (Zhang et al., 2023).

Similarly, research analyzing warning letters and cGMP-related violations in 503B outsourcing pharmacies supports the idea that "governance maturity" can be proxied using consistent categories derived from warning letters and enforcement procedures (Dmour, 2022).

3.3.4 Accreditation, standards, and certifications

A practical limitation in using scores and internal ESG reports as governance proxies is that coverage is structurally biased toward large, publicly listed companies with standardized disclosures. This feature is not a weakness of the thesis design but an important point to note when discussing the entire U.S. pharmacy sector as a whole. As described before, many independent and privately held pharmacies are not covered by mainstream ESG rating datasets, whereas large commercial pharmacy groups and their parent companies are. Many large commercial pharmacies are vertically integrated into health care conglomerates. *MSCI* [14]states that "*ESG Ratings are designed to measure companies' resilience to financially relevant,*

[14] MSCI manages multiple indexes across the world and "research-based data, analytics and indexes, supported by advanced technology, set standards for global investors and help our clients understand risks and opportunities so they can make better decisions and unlock innovation" (MSCI, 2026).

industry-specific sustainability risks and opportunities. We use a rules-based methodology to identify industry leaders and laggards, assigning each company an industry-relative letter rating from AAA to CCC based on how well they manage these risks and opportunities relative to peers" (MSCI, 2026).

For this thesis, the coverage pattern supports a dual approach to governance proxies depending on the sector being analyzed. Explicit ESG ratings will be most useful for large commercial pharmacies and organizations that publish annual reports and sustainability reports. For example, CVS Health publishes an annual "Impact Report" and related ESG reporting materials (Reporting and Governance, 2024). This kind of standardized disclosure enables third-party scoring methodologies and facilitates a standard for measurement and comparison. For smaller private compounding organizations where ESG scores are not available, other observable governance signals will be used. This may include listings and inspections, third-party accreditations, and information posted on their public forums. This information will be described in detail with sources in the upcoming chapters.

This approach aligns with how ESG rating providers position their products. These ratings are designed for broad coverage and relative benchmarking within peer groups such as MSCI's industry relative reports (MSCI, 2026). These will of course favor companies with structured reporting. As a result, the analysis can use ESG scores as a governance proxy for public, large commercial pharmacy-related companies, while using alternative governance proxies for the privately held compounding segment. It will be important to not conflate a lack of score coverage with poor governance.

3.4 Resource-efficiency review

3.4.1 Waste and rework

In compounding pharmacies, waste and rework are important factors that may otherwise have little impact on larger commercial pharmacies. Because *lots* [15] are generally created in smaller quantities and may even be patient specific, changes or errors may be more impactful. It has become vital for a compounding pharmacy to ensure correct management of orders, expiration dates, and management of inventory to ensure waste and rework is kept at a minimum. *Anticipatory compounding*[16] is a tool that some pharmacies use to prepare medications in advance of patient orders, however managing this is not always straight-forward. A hospital study evaluating a systematic framework for anticipatory compounding found that compounding ahead of patient orders can increase medication waste and examines process changes aimed at reducing expired medication waste (Toraño et al., 2023). It is important to note however that research in this area may be very pharmacy-specific, and many companies may rely on anticipatory compounding (especially higher-volume pharmacies) to ensure timely orders and patient satisfaction.

3.4.2 Cleanroom time and environmental intensity as capacity constraints

Compounding requires specific environments where capacity may be constrained by physical space and environmental controls. Cleanroom management and ventilation are significant factors in these constraints. Research on pharmaceutical cleanrooms finds that high air change rates make cleanrooms very energy intensive. However, it also notes that this does provide an

[15] Lots and lot numbers refer to the unique batch record identifying important medication information such as expiration dates.
[16] Anticipatory compounding is the act of compounding products before orders have been received for them. Usually used in high volume pharmacies for fast moving products.

opportunity for sustainable change: "…intensive energy consuming cleanrooms provide an opportunity to save large amounts of energy. As the cleanroom industry is still growing rapidly, the value of such savings is likely to be greater than estimates of the immediate effects" (Loomans et al., 2019).

3.4.3 Efficiency specific to large commercial fulfillment

Resource efficiency in large commercial pharmacies is also very relevant due to scale. Central fill systems and centralized operations are designed to reduce manual operations and stabilize and reduce bottlenecks and waste. Empirical evidence shows that centralized mail-order services can materially reduce time spent on filling and packaging tasks, thus increasing resource efficiency (Kappenman et al., 2019). A UK study tied the environmental aspect in as well stating that "Measuring and managing environmental impact is becoming an increasingly strategic business issue, which is why *Envirowise* [17]is encouraging companies in the sector to commit fully to resource efficiency. Essentially, resource efficiency means using raw materials, water and energy more effectively and cutting down on waste whenever possible" (Leaver, 2008). Albeit the age and location of the study, it does still provide very relevant ideas and information for modern pharmacies.

3.5 Gaps in literature

Sector fragmentation

Existing research on pharmacy digitalization is generally fragmented by type of pharmacy. For example, the literature reviewed by Farcy et al. in the previous sections describe not only

[17] Envirowise is a Government-funded programme dedicated to putting the sustainable use of resources (Envirowise, n.d.).

information on just compounding pharmacy, but a small niche within the compounding pharmacy sector. (Compounding in hospital pharmacies). On the contrary, the literature from Almeman focused on a very broad overview of pharmaceutical pharmacies, focusing on the standard large commercial type. Compounding technology and commercial pharmacy digitalization are rarely analyzed together, therefore this fragmentation leaves a gap in a cross-sector comparison using consistent frameworks and measurements. Additionally, there are even gaps within the compounding sector, as many studies may have a specific focus on a type of pharmacy in the sector. For example, certain studies may focus on hospital pharmacies and not community 503A pharmacies.

Safety outcomes

Many studies focus on whether a certain technology improves error detection, documentation, accuracy and other safety outcomes. This is logical since the focus for pharmacies is patient safety, especially considering potential negative outcomes. Because of this, less work explicitly connects digital maturity to business-model configuration. Yet U.S. compounding literature regarding errors suggests that harm and risk are not only technical; they also depend on volume and distribution patterns. This is shown in the literature reviewed in the earlier sections such as the studies by Mattison et al. and McPherson et al. Both studies had patient safety elements that remained prominent throughout. It is however not to say that safety will be ignored in this study, it can still be used as governance signals for both commercial and compounding pharmacies.

Governance signals are available but underused

Governance signals are readily and publicly available through government websites and publishing. These data sources are highly relevant as measurable governance proxies, but they

are not commonly integrated into digital transformation studies as variables or tools. Because of this, there is a gap that analyzes governance signals empirically.

"Digital maturity" measurement is rarely used

Digital maturity is often discussed conceptually, but operational measurement is less standardized. There are some healthcare models and matrices that exist, however it is not standardized or universally applied to compounding pharmacy across 503A and 503B models. Examples that were reviewed were in Dmour's study as well as the one published by Zhang, et al. However, digital maturity is not always a common or even relevant theme in these models. The goal in the study will not be to define a new standard model, but to begin defining potential variables that could be used in a future framework.

ESG-score coverage gap

As mentioned before, external ESG rating systems (and internal ESG reports) are designed around public disclosure and comparable data. This results in smaller compounding pharmacies may be absent. This does however, create a measurable reality. Coverage and disclosures may differ strongly by sector, and creating benchmarks requires careful design. The literature therefore leaves a gap in research that designs comparable benchmarks across sectors with very different disclosure environments. Of course it will be difficult to use identical standards, however this will be further detailed in the upcoming chapter.

3.6 Conceptual model and hypotheses

3.6.1 Core constructs

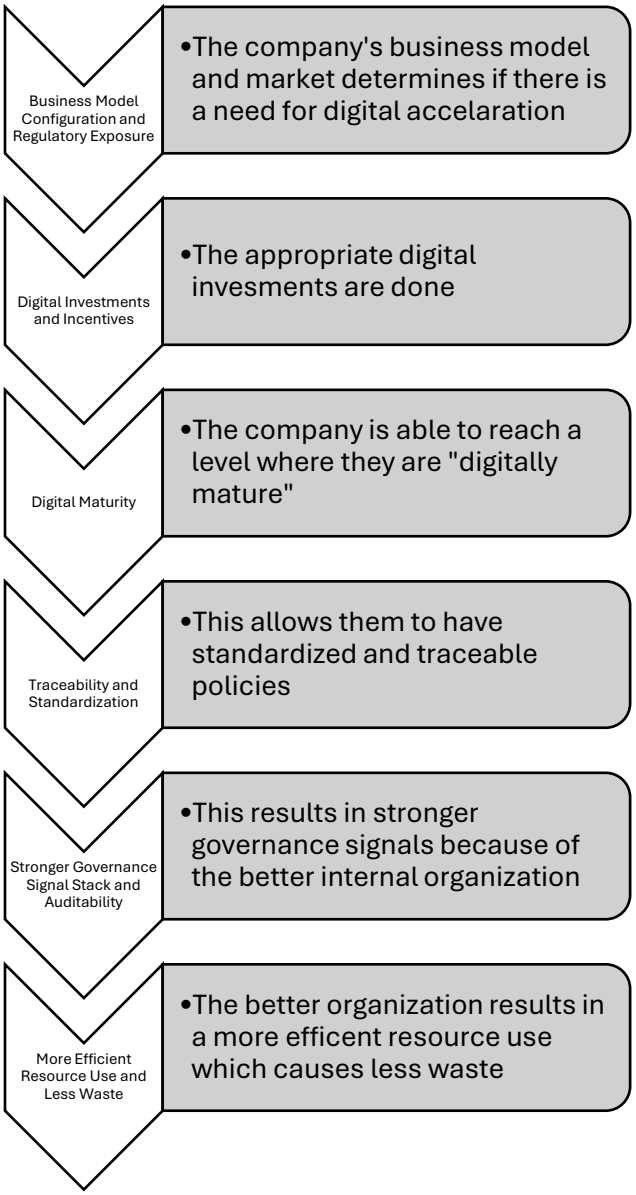
Based on the literature reviewed, we have four main constructs which are described as follows:

1. Business model type: 503A compounding pharmacies, 503B compounding pharmacies, commercial pharmacies
2. Digital maturity: Workflow, integrations, automations, outward facing channels
3. Governance stack: Regulatory signals, credentials, attestations, ESG ratings and disclosures
4. Operational implications: Waste and rework, cleanroom capacity, fulfillment systems

3.6.2 Proposed relationships

The proposed relationships will be based on our research question outlined in the introduction, which is detailed again below: How are digital maturity, governance/sustainability signals, and business model configurations related in U.S. pharmacy sectors, with a focus on compounding pharmacies?

The reviewed literature supports an idea in which digital investments and incentives are shaped by business model configuration and regulatory exposure. Digital maturity in turn supports traceability and standardization which contributes to a stronger governance signal stack and auditability. This would additionally result in a more efficient use of resources and less waste in different environments such as sterile compounding. Below is a flow chart illustrating these proposed relationships with notes for each step.



3.6.3 Hypotheses

The hypotheses below are based on the literature review and divided into different sections due to the complexity and various areas that are being covered. In general, the prediction is that higher digital maturity will be associated with greater efficiency and governance signals. This is based on the literature that was reviewed for both pharmacy specific areas and the general digital

maturity signals reviewed in the studies by Ancillai et al, and Trischler et al (Ancillai et al., 2023; Trischler, et al., 2023). Based on this information, the following hypotheses are described below:

H1: Digital maturity will differ systematically by customer model. In addition to the difference in publicly available data between commercial and compounding pharmacies, there will also be stark differences between 503A compounding pharmacies and 503B pharmacies.

H2: Higher digital maturity will be positively associated with stronger sustainability/governance signals. This will be true for all types of pharmacies regardless of the variables used and types of data reviewed.

H3: There will be an increase in digital technology and sustainability/governance signals in recent years compared to publicly available information that has been published in earlier years.

4 Research Methodology

4.1 Methodological approach

This study adopts a two-layer research design which will examine digital transformation, business models, and sustainability themes. The research will explore how these themes are communicated, structured and made visible across different segments of the U.S. pharmacy and healthcare landscape. The need for the dual approach stems from the inherent differences in the structure of the sector itself. On the one hand, large commercial healthcare and pharmacy-related companies frequently publish sustainability, ESG, integrated, or impact reports and are often included in external datasets and benchmark universes. On the other hand, most compounding pharmacies do not produce comparable public reporting over time. This is because most are much smaller, privately held companies that do not have an external force driving the need to publish standardized reports. Therefore, they cannot be analyzed through the same standardized report-based method without creating severe comparability problems.

The empirical strategy is therefore divided into two complementary components. The first component will be a content analysis of reporting for large healthcare and pharmacy-related companies that are selected based on the USA Health Care MSCI Index. The study will compare the reporting years 2017 and 2024. These two years were selected purposely since they highlight two distinct phases relating to both digitalization and sustainability. 2017 is an important starting year because of regulatory directives that affected both sustainability reporting as well as the healthcare sector. A non-financial reporting directive was implemented which set suggested guidelines for sustainability disclosures for companies. Although these guidelines were set by the European commission, large commercial pharmacies in the United States generally have a global

presence, therefore this would still be a relevant year (European Commission, 2017). 2024 of course represents the present time where significant technological advancements have been made in all sectors throughout the world. Additionally, there has been a new reporting directive that companies must track called the corporate sustainability reporting directive. It "*requires companies above a certain size to disclose information on what they see as the risks and opportunities arising from social and environmental issues, and on the impact of their activities on people and the environment*" (Corporate sustainability reporting, 2025).

The second component is a descriptive analysis of U.S. compounding pharmacies, both 503A and 503B organizations. This analysis will be using other forms of publicly available evidence. Because this thesis has a focus on compounding, it was important to review the data and information actually available and accessible to be able to develop a meaningful review. Of course, only using pharmacies that publish standardized public reporting would have been a more streamlined approach, however we would skip over a very interesting and perhaps under analyzed area compared to that of large companies. The study treats this lack of disclosure as a structurally meaningful feature of the sector and examines compounding organizations through alternative public signals such as websites, quality and service descriptions, FDA registration and oversight information, and other accessible documents.

This overall design is exploratory and comparative. The thesis will not and does not seek to establish causal relationships. Instead, it aims to identify patterns governance signaling, visible digitalization, and sustainability metrics across sectors that differ significantly in size, and reporting capacities.

4.1.1 Layer 1: Commercial pharmacy analysis

The first empirical layer analyzes the companies where we will find publicly available data for both years that were mentioned previously. Because realistically we will only find commercial pharmacy companies here, the section has been titled as such. Because this area will focus on companies for which comparable public reporting exists for both 2017 and 2024. Each selected company selected will contribute documentation. One will be reports covering the 2017 reporting year, and the other will be reports covering the 2024 reporting year. These reports will be based on different published reports that use standardized metrics.

The purpose of this layer is to see how digital and sustainability themes appear between the two periods of time in standardized reporting. There won't be a particular emphasis on intensity or a type of measurable "intensity" since although potentially measurable, this would stray away from the focus of this study. Instead, there will be a focus on the presence or absence of specific concepts and issue categories in company narratives. This type of approach makes sense and is appropriate because the goal is to seek and identify broad changes in disclosure priorities and visibility, rather than to perform subjective or sentiment-based textual modeling.

4.1.2 Layer 2: Compounding pharmacy analysis

The second layer focuses on the compounding sector and is designed to preserve the nature of compounding pharmacies within the thesis. Certain reporting metrics in smaller, private companies usually make little sense for business owners or employees to run. Therefore, this layer is not structured as a two-year report panel because such documents are typically unavailable for 503A and 503B compounding pharmacies. Instead, the compounding sector is analyzed through a complementary, literature review-based approach based on publicly observable documents and signals. Because of this we will examine evidence such as if the

pharmacy is a 503A/503B, sterile/non-sterile/hazardous compounding, digital ordering options, workflow technologies used, FDA inspections, recalls, warnings, and more. The goal of this second layer is not to replicate the report-based analysis exactly, but to create a comparable descriptive profile using the kinds of evidence that are realistically available for the compounding pharmacy sector.

4.1.3 Rationale for the dual layer design

The dual layer design is methodologically justified because it incorporates the actual disclosure practices for each sector instead of trying to artificially force a uniform standard between all areas. If we restricted the study to only companies that produce standardized reports, we would effectively make all compounding pharmacies disappear from our list despite being a primal focus point. Conversely, if the study attempted to force compounding firms into a report-based panel, comparability would be weak and the analysis would rest on non-equivalent evidence which would produce distorted results.

This study uses appropriate evidence based on the sector while preserving comparability at a broader level. In other words, the individual indicators are not identical across the two samples, but they are grouped into common conceptual categories. These are the same main idea that we have perpetuated in this study which include digitalization, governance signaling, and sustainability-related orientation. This enables the study to compare organizational patterns instead of identical data points.

4.2 Population and sample

4.2.1 Population definition

The broader population relevant to this thesis consists of organizations operating within the U.S. healthcare and pharmacy value chain. This includes large commercial pharmacy-related firms, specialty and mail-service providers, healthcare distributors, integrated healthcare service companies, and compounding pharmacies. However, the population that will be reviewed differs by layer being analyzed. As described previously the first layer will be defined by the large pharmaceutical companies that publish comparable reports for the years 2017 and 2024. For the second layer, the population will be defined as 503A and 503B compounding pharmacies.

4.2.2 First sample: Benchmark commercial pharmacy companies

The core sample is built from a pool of large healthcare-related firms identified through official MSCI index resources. MSCI describes the MSCI USA Health Care Index as “designed to capture the large and mid cap segments of the US equity universe” (MSCI USA Health Care Index, 2026). MSCI also provides official index search and constituent tools that can be used to identify candidate companies for benchmark selection. In addition, they also provide the index methodology. This makes the MSCI USA Health Care Index a useful and transparent starting point for the benchmark sample because it contains companies large enough to publish both non-financial reports that we can utilize. MSCI indexes have been used in many other studies of various sectors. For example, a study comparing ESG and MSCI indices was conducted in 2019 that determined sustainable investment strategies can lead to positive financial results (Jain et al., 2019).

From this index, the companies will be selected purposely instead of a random selection. The selection criteria are not merely "being in health care," but having a clear connection to the pharmacy and healthcare services relevant to the thesis. Because of this the benchmark group of companies may include retail pharmacies, pharmacy services companies, mail-service pharmacies, healthcare distribution companies, and large vertically integrated healthcare companies with pharmacy operations. Other types of companies will not be used due to low relevance to this study. 21 companies were chosen from the index.

This benchmark sample is intended to serve two purposes. First, it provides a robust reporting panel for the manual content analysis. Second, it provides the group for which ESG scores and other external comparative indicators are most likely to be accessible in the later stages of the thesis. Lastly, it will allow us to compare two distinct years and see the differences in reporting signals between them.

4.2.3 Inclusion and exclusion criteria for the first sample

Because the MSCI Index chosen has a larger umbrella than what is being analyzed in this thesis, the companies will need to be analyzed to ensure they are compatible and appropriate for this thesis. A company is included in the first sample if all the following conditions are met:

1. The company is relevant to the U.S. pharmacy value chain.
2. The company has a report for the 2024 reporting year. 2017 will be used but will not be a prerequisite to utilize the company. If no public 2017 report is found, then it will be noted as such.
3. The company's reporting is attributable to the company itself or to a parent company or conglomerate where the relevant pharmacy activities are clearly included.

4.2.4 Compounding sample

The compounding sample will be constructed separately from the first sample. 503B compounding pharmacies can be found using the publicly accessible FDA list of registered outsourcing pharmacies. This is important since these are official sources that provide an appropriate basis for identifying and validating 503B pharmacies.

503A pharmacies are identified through public company websites and other public sources such as the Alliance for Pharmacy Compounding find a compounder website[18]. Because 503A pharmacies may be smaller and potentially less visible than 503B pharmacies, the selection is based on whether enough public information exists to code the variables defined in this chapter. This means that the compounding sample is not meant to be exhaustive, rather it is intended to create a meaningful descriptive window into the compounding segment. However, the minimum here will be to have a public website in order to find information for the pharmacy. Once this has been found, everything will be included in order to omit potential biases. The sample size will be kept the same as the commercial sample for consistency.

4.2.5 Inclusion and exclusion criteria for the second sample

A compounding organization is included if all the following conditions are met:

1. It is clearly identifiable as either a 503A or 503B pharmacy.
2. It provides enough public information to allow a *search* for coding of digital, governance, and business-model signals relevant to the study.

[18] The Alliance for Pharmacy compounding has a website that allows users to publicly search for compounding pharmacies in the Untied States (Alliance for Pharmacy Compounding, 2025).

4.3 Data sources

4.3.1 Sources for the commercial sample

The main data sources for the commercial sample will be based on reporting from the various companies chosen. These will include their end of year ESG/integrated/annual/impact report. The name and type may differ depending on the type of company.

4.3.2 Sources for the compounding sample

The main data sources for the compounding sample will be based on broader and potentially more flexible sources. This will be done through a descriptive analysis from public sources such as websites.

4.4 Variables and coding

This study will use a coding strategy with dummy variables. Each report will be coded with either a 0 or a 1 depending on if the concept is absent or present. Using the data sources described in the previous section, we will review to confirm to see if the concept is present and relevant to the context within the study. There will be three separate themes that each variable will fall into. The first will be digital technology themes for the commercial pharmacy sample. The second will be the sustainability and governance themes for the same commercial pharmacy sample. The third and final theme will be variables that apply to the compounding pharmacy sample. These won't be split up in the same way as the commercial sample, rather they will be based on a broader scope including digitalization, governance, and sustainability. Although the scope is broader, some variables may be very specific to compounding pharmacies. Some variables may be shared in name, however they may differ in practical application due to the nature of the sector.

4.4.1 Digital technology variables (commercial sample)

Below is a table with the digital technology variables that are relevant to the commercial pharmacy sample. The variables that have been selected are designed to capture strategic visibility of digital innovation rather than operational performance in a narrow sense.

Variable	**Relevant terms**	**Coding rule**	**Source**
Artificial_intelligence	AI, machine learning, automation	Dummy variable, 1 if used in relevant operational sense, 0 if not	(World Health Organization, 2024) (FDA, 2025)
Data_analytics	Data analytics, big data	Dummy variable, 1 if discussed as a tool used, 0 if not	(National Institutes of Health Office of Data Science Strategy, n.d.)
Robots	Robotics, filling robot,	Dummy variable, 1 if discussed as a significant or limited part in operations or workflow, 0 if not	(Cao et al., 2023)
Digital_healthcare	Digital health, health technology, virtual care, telehealth	Dummy variable, 1 if the company mentions a transition or use of digital healthcare technology and operations for patients, providers. Etc.	(U.S. Food and Drug Administration, 2025)
Software_technology	Pharmacy software, software project	Dummy variable, 1 if the company mentions software technology being used as a core element, 0 if not.	(U.S. Food and Drug Administration, 2018)

Technology_partnerships	Collaboration, partner, (with technology context)	Dummy variable, 1 if there is a technology partnership with a 3rd party mentioned, 0 if not.	(World Health Organization Regional Office for Europe, n.d.)
Digital_workflowtools	Digital workflow, digital records	Dummy variable, 1 if digital workflow functions and records are mentioned, 0 if not	(American Society of Health-System Pharmacists, 2025) (Alshahrani et al., 2026)

Note: Source is own author's work

4.4.2 Rationale and sources for digital variables

Artificial Intelligence: This was included as a variable because both the World Health Organization and the FDA identify AI as a relevant theme. The WHO mentions that AI has the potential to enhance health outcomes, (World Health Organization, 2024) and the FDA recognizes AI is transforming health care in areas such as medical devices (FDA, 2025).

Data Analytics: Data analytics was selected as a variable because the NIH frames data science and analytics as key elements and capabilities health systems and health related software (National Institutes of Health Office of Data Science Strategy, n.d.).

Robots: Robotics were selected because the literature reviewed mentions robots in both commercial and compounding settings. Robotic dispensing and automation are mentioned as playing crucial roles in pharmacy (Cao et al., 2023).

Digital Healthcare: Digital healthcare was included because both the WHO and FDA identify this variable as a major and growing concept for health systems and innovation. This includes

potentially improving outcomes and supporting access to healthcare (U.S. Food and Drug Administration, 2025).

Software Technology: Software technology was included as a variable because the FDA explicitly treats healthcare software and digital health software functions as important categories within the healthcare sector (U.S. Food and Drug Administration, 2018).

Technology Partnerships: Again, the WHO and FDA both explicitly state digital health and technology partnerships as playing an integral role in the healthcare industry (World Health Organization Regional Office for Europe, n.d.).

Digital Workflow Tools: Digital workflow tools were included because of pharmacy-specific guidance from the American Society of Health-System Pharmacists[19] identifies workflow technologies as central to pharmacy operations (American Society of Health-System Pharmacists, 2025). In addition, medical journal entries such as *Digital Transformation and Team-Based Care: Pharmacists in Multidisciplinary Models – A Narrative Review* by Alshahrani et al, highlight digital workflow tools and integrations as important aspects in healthcare (Alshahrani et al., 2026).

4.4.3 Sustainability and governance variables (compounding sample)

Below is a table with the variables relevant to sustainability and governance for the compounding sample. These variables were selected to adapt the sustainability analysis to a healthcare context instead of only using more generic ESG and governance scores. This will

[19] The American Society of Health-System Pharmacists is the "*largest association of pharmacy professionals in the United States, representing over 65,000 pharmacists, student pharmacists, and pharmacy technicians in all patient care settings, including hospitals, ambulatory clinics, and health-system community pharmacies"* (https://www.ashp.org/about-ashp).

allow us to not only find the information for the companies, but also to ensure that the information provided is relevant to the study.

Variable	Relevant terms	Coding rule	Source
Patient_safety	Patient safety, medication safety	Dummy variable, 1 if patient safety is mentioned as a key benchmark, 0 if not.	(World Health Organization., n.d.)
Accessible_care	Access to healthcare, access to medicine, health equity	Dummy variable, 1 if access to healthcare is mentioned and expressed as a priority, 0 if not.	(World Health Organization., n.d.)
DrugAffordability_reference	Affordability, affordable care	Dummy variable, 1 if affordability or pathways to affordable care are mentioned, 0 if not.	(World Health Organization., n.d.
DataPrivacy_reference	Data privacy, data protection, information security, data integrity	Dummy variable, 1 if data security is mentioned, 0 if not.	(U.S. Department of Health and Human Services, n.d.)
WasteHazardous_reference	Waste reduction, hazardous waste, packaging waste	Dummy variable, 1 if waste and tools to reduce waste are mentioned, 0 if not.	(ISO, n.d.)
Ethical_innovation	Ethical trials, ethical testing, transparency	Dummy variable, 1 if ethical considerations	(World Health Organization., n.d.)

		are mentioned, 0 if not.	
ISO_45001_Health_Safety	ISO standards met	Dummy variable, 1 if ISO standards are mentioned, 0 if not.	(ISO, n.d.)
ISO_14001_Environmental_Management	ISO standards met	Dummy variable, 1 if ISO standards are mentioned, 0 if not.	(ISO, n.d.)
GMP _Compliance	GMP compliance met	Dummy variable, 1 if GMP compliance is mentioned, 0 if not.	(Food and Drug Administration, 2023)

Note: Source is own author's work

4.4.4 Rationale for the sustainability and governance variables

Patient Safety, accessible care, drug affordability, ethical innovation:

These variables can be grouped together since each of these can be explicitly tied to a WHO source that uses and explains the importance of this variable in health care. Below are excerpts from their official forums:

Patient Safety: *Recognizing patient safety as a global health priority, and as an essential component of strengthening health systems for moving towards universal health coverage"* (World Health Organization., n.d.).

Accessible care: *"Universal health coverage can only be achieved when there is affordable access to safe, effective and quality medicines and health products"* (World Health Organization., n.d.).

Affordability: *Promoting fair prices and cost-effective interventions is central to the achievement of universal health coverage"* (World Health Organization., n.d.).

Ethical Innovation: *Innovation is critical in finding solutions to the health issues we face…Emerging technologies, such as artificial intelligence, big data…To fulfil the promise of emerging technologies and mitigate potential harms, it is essential to identify and understand the ethical issues that arise at each step, from the early developmental stage through to implementation"* (World Health Organization., n.d.).

Remaining variables:

Data Privacy: The U.S. Department of Health and Human Services has clear rules for protecting the privacy and confidentiality of patient's health information. This is in line with the HIPAA regulations signed into law in 1996 (U.S. Department of Health and Human Services, n.d.)

Waste reference and ISO_14001: Waste and hazardous materials were included because environmental management standards such as ISO 14001 focus on "*proactive approach to environmental management can result in tangible benefits, such as reduced waste, energy conservation, and cost savings*" (ISO, n.d.), which is very relevant in healthcare and pharmaceutical settings.

ISO_45001: ISO 45001 was included because it is the leading international standard for occupational health and safety management systems (ISO, n.d.). This would be relevant in all sectors, but especially in healthcare related areas because of the potential risks.

GMP_Compliance: This is important because the FDA treats current good manufacturing practice as the key ensuring products are created safely and correctly. "*The CGMP regulations for drugs contain minimum requirements for the methods, facilities, and controls used in*

manufacturing, processing, and packing of a drug product. The regulations make sure that a product is safe for use, and that it has the ingredients and strength it claims to have" (Food and Drug Administration, 2023).

4.4.5 Compounding variables

Variable	**Relevant terms**	**Coding rule**	**Comments**
Type	503A, 503B	503A or 503B depending on pharmacy type	
Sterile_reference	Sterile compounding, sterile lab, injectables	Dummy variable, 1 if sterile compounding is mentioned, 0 is no sterile is mentioned	
Hazardous_reference	Hazardous compounding	Dummy variable, 1 if hazardous compounding is mentioned, 0 is no hazardous is mentioned	
Service_type	Billing to patients, billing to clinics	A pharmacy will either have a model that bills to patients, clinics or both	Still relevant for 503A pharmacies since they may bill and ship to clinics while keeping all prescriptions still patient specific
Doctorportal_reference	Digital doctor portal, doctor log in,	Dummy variable, 1 if a provider portal is mentioned and accessible, 0 if not	
Patientportal_reference	Digital patient portal, Patient app,	Dummy variable, 1 if a patient portal or app is mentioned and	

	Patient log in, patient online refill	accessible, 0 if not	
E-prescribing	SureScripts, eRxs, online prescribing	Dummy variable, 1 if Surescripts and traditional e-prescribing is supported, 0 if not.	
Robotics_reference	Filling robot, filling automation	Dummy variable, 1 if automatic filling robots are mentioned/used, 0 if not.	
Quality_saftey_reference	Electronic batch records, electronic workflow, labeling workflow	Dummy variable, 1 if digital software is mentioned and used, 0 if not.	
Sustainability_reference	Compounding waste, sustainable compounding	Dummy variable, 1 if sustainability is mentioned, and 0 if not.	
NABP__accreditation	NABP accreditation	1 if NABP accreditation is present 0 if not.	
Affordability_accessibility_reference	Affordable or accessible medications mentioned	1 if affordability or accessibility is mentioned, 0 if not.	

Note: Source is own author's work

4.4.6 Rationale for compounding variables

Doctor and patient portal reference: The NABP explicitly lists patient and provider portals as an interactive pharmacy component and actually lists it as a requirement to be considered for a digital pharmacy certification (NABP Eligibility, 2024).

E-prescribing: As discussed in chapter 3, the Surescripts network is used by 2.32 million healthcare professionals and provider organizations (Annual Impact Report 2025, 2026).

Therefore, this is a strong disclosure variable since it directly relates to how pharmacies receive prescriptions.

Robots: The same rationale as the commercial variable applies.

Quality/Safety: The same rationale as the commercial variable applies.

Sustainability: This was chosen based on the second ESG pillar and left broad purposely in order to cast a wide net because of the perceived limited sustainability signals in compounding pharmacies.

NABP accreditation: As discussed extensively in chapter 2, an NABP accreditation is an important tool that compounding pharmacies have at their disposal that can work as a public governance signal signifying a certain level of quality for patients and providers (NABP Eligibility, 2024).

Affordability/accessibility: The same rationale as the commercial variables applies.

4.5 Coding procedure

4.5.1 Procedure for commercial sample

As described in the section above, the coding will follow a standardized procedure for each variable. For each company, their reports will be analyzed, and the relevant keywords will be searched according to the description. Then, a dummy variable (1 or 0) will be assigned. Both systematic searches and contextual relevance will be used. This is important because many times each company's reports will have certain terms (especially in the digital area) that appear in non-standard ways. The same holds true for the sustainability and governance areas although those will follow a more standardized approach in general.

4.5.2 Procedure for compounding sample

For the compounding sample, a similar approach is followed with some variance. Each pharmacy will be reviewed based on the sources found. There may be a variance of sources used here since there are no standardized reports like the first sample. Here dummy variables will also be used, but in addition there will be a few non dummy variables that were described in the previous section. These will be relevant due to categorize the type of compounding pharmacy being used.

4.6 Data Analysis

In order to address the hypotheses, the first step in data analysis will be to review and examine the difference in the first sample between the data and the 2024 data. The purpose will be to identify which concepts become more visible, which remain constant, and which potentially may have less visibility. This will be done for both sustainability/governance variables as well as the digital variables. (Both together and separate).

The analysis of the compounding sample is based on the current public evidence and because of this fact the analysis will focus on what can be realistically observed for these companies. The visibility of digital, governance, and sustainability signals will be the main focus. Although the variables are different than the other sample, we will regardless take the other sample's results into consideration in potentially limited ways.

The two layers are then interpreted together. The commercial sample will reveal how digital and sustainability concepts exist in formal corporate reporting among large firms. This can be seen as a benchmark sample for our study. The compounding sample then reveals how these same broad themes appear (or do not appear) in a much less formalized disclosure environment. The

comparison therefore will hope to find both differences in sector priorities, and differences in how evidence is made public.

5 The Empirical Results

5.1 Results from the commercial sample

5.1.1 Sample overview

The first sample consisted of large pharmaceutical companies being observed at 2 different years, 2017 and 2024. If the 2017 reports were not available, the company was still used, but all 2017 variables were entered as 0. The companies were chosen based on the information described in section 4.2.3. This resulted in 21 companies being selected. The companies that were not selected did not have enough relevance in the specific pharmaceutical area that the study is conducting. Therefore, the other companies were not selected in order to not skew the data with information that was outside of the pharmaceutical scope. Overall, the first sample reflects the type of company that is most likely to publish formal reports available to the public. This is important for the logic of the study because this sample is not intended to represent the entire pharmacy sector, but rather the part of the sector where formal digital and sustainability narratives are most visible and comparable over time.

5.1.2 Frequency of digital concepts

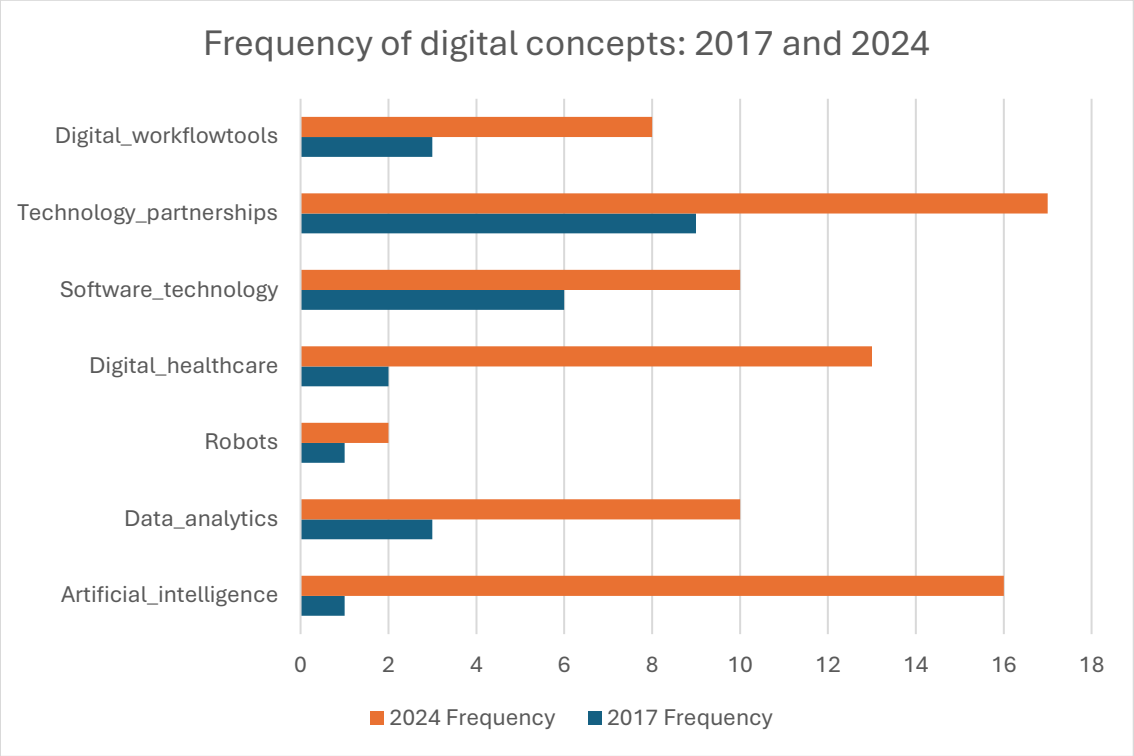
The first step was to analyze the digital concepts present in the 2017 reports and the 2024 reports for the companies. The variables described in chapter 4 were used here: Artificial_intelligence, Data_analytics, Robots, Digital_healthcare, Software_technology, Technology_partnerships, Digital_workflowtools. An initial comparison shows that digital references were substantially more frequent in 2024 reports compared to 2017 reports. This is shown in table 5.1 and Figure 5.1 below.

Table 5.1: Frequency of digital technology variables 2017 vs 2024

Variable	2017 Frequency	2024 Frequency	Change
Artificial_intelligence	1	16	+15
Data_analytics	3	10	+7
Robots	1	2	+1
Digital_healthcare	2	13	+11
Software_technology	6	10	+4
Technology_partnerships	9	17	+8
Digital_workflowtools	3	8	+5
Total number of frequencies	25	76	+51

Note: Source is own author's work

Figure 5.1: Bar chart comparing the frequency of digital concepts present in 2017 and 2024



Note: Source is own author's work

The data suggests a clear increase in the visibility of digital strategy language between 2017 and 2024. This does coincide with general expectation that digitalization became a more integral part both the healthcare market and more specifically pharmacy companies. In particular, variables such as AI and digital healthcare appear to move from very scarce concepts discussed in 2017 to a central theme in 2024. In reviewing this, it seems digitalization has become increasingly normalized within public corporate reporting. Based on the information analyzed there was a 204% increase between 2017 and 2024. This aligns with the hypothesis H3 described in the previous chapter.

5.1.3 Frequency of sustainability and governance concepts

The second step was to analyze the sustainability/governance concepts present in the 2017 reports and the 2024 reports for the companies. The variables described in chapter 4 were used here: Patient_safety, Accessible_care, DrugAffordability_reference, DataPrivacy_reference, WasteHazardous_reference, Ethical_innovation, ISO_45001_Health_Safety, ISO_14001_Environmental_Management, GMP _Compliance. An initial comparison shows that these variables were again much more frequent in 2024 reports compared to 2017 reports. This is shown in table 5.2 and Figure 5.2.

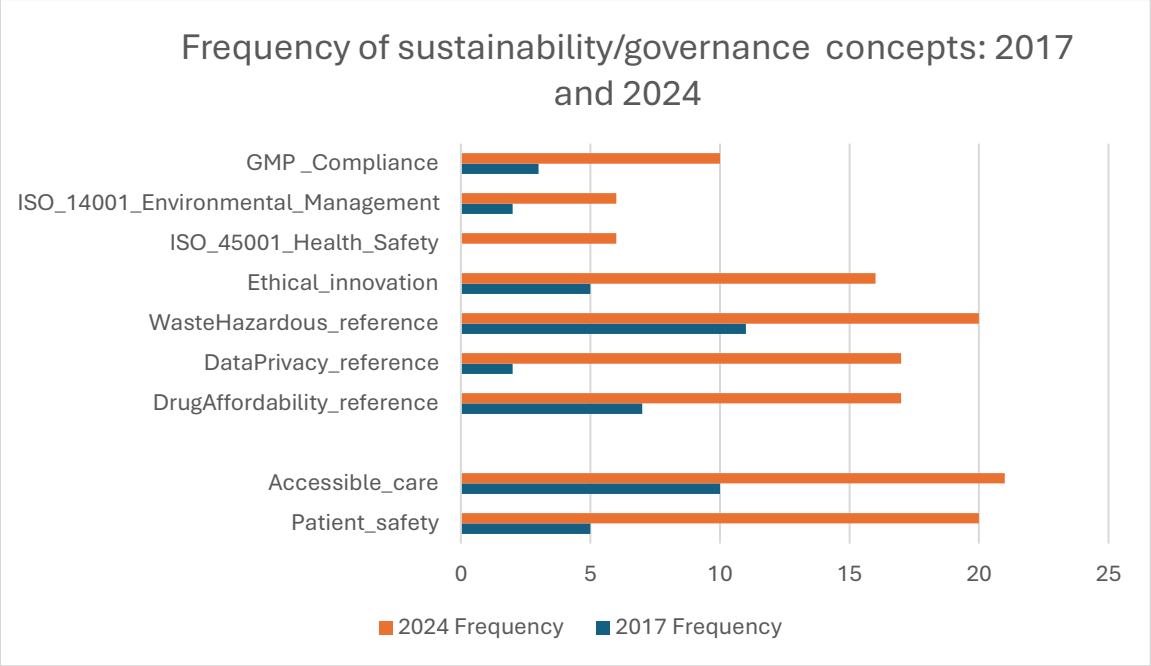
Table 5.2 Frequency of sustainability/governance variables 2017 vs 2024

Variable	**2017 Frequency**	**2024 Frequency**	**Change**
Patient_safety	5	20	+15
Accessible_care	10	21	+11
DrugAffordability_reference	7	17	+10
DataPrivacy_reference	2	17	+15
WasteHazardous_reference	11	20	+9
Ethical_innovation	5	16	+11
ISO_45001_Health_Safety	0	6	+6
ISO_14001_Environmental_Management	2	6	+4
GMP _Compliance	3	10	+7

Total number of frequencies	45	133	+88

Note: Source is own author's work

Figure 5.2 Bar chart comparing the frequency of sustainable/governance concepts present in 2017 and 2024



Note: Source is own author's work

Interestingly, the data here almost results in a very similar increase from what was seen in the digital concepts analysis. In this case, there was a 195% increase in the number of variables mentioned between 2017 to 2024. This again is consistent with hypothesis H3. The most drastic changes occurred in the data privacy and data privacy concepts. However, the difficulty of finding reports in 2017 that primarily focused on ESG standards may have had an effect on this data set. This will be discussed in further detail in the next chapter. Regardless, there did not

seem to be a clear delta between the digital variables and sustainability/governance variables in terms of increase between the two years reviewed.

5.1.4 Company changes in reporting

In addition to aggregating the frequencies for digital, sustainability, and governance related variables, it is also useful to examine how individual companies changed between 2017 and 2024. Some firms may show broader expansion across all variables, while others may remain relatively stable or selective in their types of disclosure.

The company comparison is important because the total trend can potentially conceal different reporting strategies. For example, one company may expand digital references strongly while another may expand governance references. A company could also have already a large coverage in 2017 which means there were less areas for change in 2024.

Table 5.3 Company changes in reporting from 2017 to 2024

Company	Digital variables 2017	Digital variables 2024	Sustainability/governance variables 2017	Sustainability/governance variables 2024
COMPANY 1	3	4	6	9
COMPANY 2	3	5	6	9
COMPANY 3	1	4	3	9
COMPANY 4	0	3	0	7
COMPANY 5	1	3	8	4
COMPANY 6	0	4	3	7
COMPANY 7	3	4	3	4
COMPANY 8	0	1	0	5
COMPANY 9	0	5	2	7
COMPANY 10	3	2	6	5
COMPANY 11	5	6	2	6
COMPANY 12	1	4	0	7
COMPANY 13	4	5	3	4
COMPANY 14	0	0	1	3
COMPANY 15	0	5	1	4
COMPANY 16	1	4	2	6

COMPANY 17	0	2	0	7
COMPANY 18	0	4	0	6
COMPANY 19	0	5	0	5
COMPANY 20	0	0	1	2
COMPANY 21	0	5	0	9

Note: Source is own author's work

Table 5.4 Company increase/decrease in reporting from 2017 to 2024

Company	Digital increase from 2017 to 2024	Sustainability increase for 2017 to 2024
COMPANY 1	+1	+3
COMPANY 2	+2	+3
COMPANY 3	+3	+6
COMPANY 4	+3	+7
COMPANY 5	+2	-4
COMPANY 6	+4	+4
COMPANY 7	+1	+1
COMPANY 8	+1	+5
COMPANY 9	+5	+5
COMPANY 10	-1	-1
COMPANY 11	+1	+4
COMPANY 12	+3	+7
COMPANY 13	+1	+1
COMPANY 14	0	+2
COMPANY 15	+5	+3
COMPANY 16	+3	+4
COMPANY 17	+2	+7
COMPANY 18	+4	+6
COMPANY 19	+5	+5
COMPANY 20	0	+1
COMPANY 21	+5	+9

Note: Source is own author's work

As shown in table 5.3 and table 5.4, reporting evolution is not uniform, in fact far from it. Some companies exhibit a clear broadening of disclosure across both digital and sustainability variables, while others appear to have focused on more specific areas. Furthermore, some companies even had a decrease in variables mentioned between 2017 to 2024. This result goes against the total aggregated data detailed in the previous sections. This variation reinforces the

view that even within the large pharmaceutical segment, not all companies communicate digital transformation and sustainability in the same ways.

5.2 Results from the compounding sample

5.2.1 Sample Overview

The sample consisted of 8 503A pharmacies, 8 503B pharmacies, and 5 pharmacies that had both 503A and 503B locations. Unlike the first sample, these companies were not analyzed through a 2-year sample, instead this was based on a descriptive analysis based on public facing information the company has published. This information was found using what is currently published on each company's website. Therefore, the time period for the information found in this sample was only 2026.

The data was collected and organized as shown below in Table 5.5. The columns were separated into the following: business model references, the digital references, and sustainability/governance related references.

Table 5.5 Sample Overview of Compounding pharmacies with business model reference

Company	Type	Service_type	Sterile_reference	Hazardous_reference
COMPOUNDING COMPANY 1	Both	Both	1	0
COMPOUNDING COMPANY 2	503A	Both	1	0
COMPOUNDING COMPANY 3	503A	Both	1	0
COMPOUNDING COMPANY 4	Both	Both	1	0
COMPOUNDING COMPANY 5	Both	Both	1	1
COMPOUNDING COMPANY 6	503A	Both	1	0

COMPOUNDING COMPANY 7	Both	Both	1	0
COMPOUNDING COMPANY 8	503 B	Doc	1	0
COMPOUNDING COMPANY 9	503 A	Both	1	0
COMPOUNDING COMPANY 10	503 A	Both	1	0
COMPOUNDING COMPANY 11	503 B	Doc	1	0
COMPOUNDING COMPANY 12	503 B	Doc	1	0
COMPOUNDING COMPANY 13	503 A	Doc	1	0
COMPOUNDING COMPANY 14	503 A	Pat	0	0
COMPOUNDING COMPANY 15	503 B	Doc	1	0
COMPOUNDING COMPANY 16	503 A	Both	1	0
COMPOUNDING COMPANY 17	503 B	Doc	1	0
COMPOUNDING COMPANY 18	Both	Both	1	0
COMPOUNDING COMPANY 19	503 B	Doc	1	0
COMPOUNDING COMPANY 20	503 B	Doc	1	0
COMPOUNDING COMPANY 21	503 B	Doc	1	0

Note: Source is own author's work

Additionally, there are two tables below, 5.6 and 5.7 describing the amount of digital and sustainable/governance variables present by each company.

Table 5.6 Frequency of digital variables by company

Company	Doctorportal_reference	Patientportal_reference	E-prescribing	Robotics_reference
COMPOUNDING COMPANY 1	1	1	1	1

COMPOUNDING COMPANY 2	1	1	1	0
COMPOUNDING COMPANY 3	1	1	1	1
COMPOUNDING COMPANY 4	1	1	1	0
COMPOUNDING COMPANY 5	1	0	1	0
COMPOUNDING COMPANY 6	1	1	1	0
COMPOUNDING COMPANY 7	0	1	0	0
COMPOUNDING COMPANY 8	0	0	0	0
COMPOUNDING COMPANY 9	1	1	1	0
COMPOUNDING COMPANY 10	1	1	1	0
COMPOUNDING COMPANY 11	0	0	0	1
COMPOUNDING COMPANY 12	0	0	0	0
COMPOUNDING COMPANY 13	1	0	0	0
COMPOUNDING COMPANY 14	0	1	0	0
COMPOUNDING COMPANY 15	1	0	0	0
COMPOUNDING COMPANY 16	0	0	0	0

COMPOUNDING COMPANY 17	1	0	0	0
COMPOUNDING COMPANY 18	1	0	1	0
COMPOUNDING COMPANY 19	1	0	0	0
COMPOUNDING COMPANY 20	0	0	0	0
COMPOUNDING COMPANY 21	0	0	0	1

Note: Source is own author's work

Table 5.7 Frequency of sustainable/governance variables by company

Company	Quality_safety_reference	Sustainability _reference	Affordability	NABP
COMPOUNDING COMPANY 1	1	0	1	1
COMPOUNDING COMPANY 2	1	0	1	1
COMPOUNDING COMPANY 3	1	0	0	1
COMPOUNDING COMPANY 4	0	1	0	0
COMPOUNDING COMPANY 5	1	1	0	1
COMPOUNDING COMPANY 6	1	0	0	0
COMPOUNDING COMPANY 7	0	0	1	0
COMPOUNDING COMPANY 8	1	0	1	0
COMPOUNDING COMPANY 9	0	0	1	1
COMPOUNDING COMPANY 10	0	0	0	1
COMPOUNDING COMPANY 11	1	0	1	0
COMPOUNDING COMPANY 12	1	1	1	0

COMPOUNDING COMPANY 13	1	0	1	0
COMPOUNDING COMPANY 14	0	0	1	0
COMPOUNDING COMPANY 15	1	0	0	0
COMPOUNDING COMPANY 16	0	0	0	1
COMPOUNDING COMPANY 17	1	0	0	0
COMPOUNDING COMPANY 18	0	0	0	1
COMPOUNDING COMPANY 19	1	0	0	0
COMPOUNDING COMPANY 20	1	0	0	0
COMPOUNDING COMPANY 21	1	1	1	0

Note: Source is own author's work

The business model variables had little variance with most companies having some reference to sterile compounding and no reference to hazardous compounding. 503B pharmacies by default only had the service type option for doctors, while many 503A pharmacies mentioned both doctors and patients as part of their service options.

5.2.2 Digital concepts from the second sample

The second sample suggests a different pattern of digital visibility across compounding pharmacies than what was seen in the first sample. Here, digitalization is more likely to appear through service signals, such as online provider and patient access and e-prescribing. These signals are much more specific to the compounding market and are based on actionable items that facilitate business. This differs from the broader digitalization terms explored in the first sample. Table 5.8 below details the frequency at which each variable was mentioned with a total of 35 times out of a possible 84.

Table 5.8

Variable	Frequency
Doctorportal_reference	13
Patientportal_reference	9
E-prescribing	9
Robotics_reference	4
Total number of frequencies	35

Note: Source is own author's work

It is also important to note the difference between the two major types of compounding pharmacies, 503A and 503B companies. Table 5.9 below shows the frequency for purely 503A pharmacies, purely 503B pharmacies and both. Also, there are 2 extra columns to display the total of 503A and 503B pharmacies with those that have both.

Table 5.9

Variable	503A Frequency	503B Frequency	Both Frequency	503A +Both	503B + Both
Doctorportal_reference	6	3	4	10	7
Patientportal_reference	6	0	3	9	3
E-prescribing	5	0	4	9	4
Robotics_reference	1	2	1	2	3
Total number of frequencies	18	5	12	30	17
TOTAL frequencies possible (if the frequency was 100%)	32	32	20	52	52

Note: Source is own author's work

The table above shows that once aggregated, the digital variables for 503A pharmacies were much higher than the 503B. This is consistent with H1 although it is interesting to note the drastic change found. This will be explored in greater detail in the next chapter; however the type of variables being measured, and what 503B pharmacies share publicly had a great deal of influence in these results. As explained before, most digital variables were actionable items that

encouraged patient and provider collaboration through online means. This may not be as relevant for 503B pharmacies because of changes in their business model.

5.2.3 Sustainability and governance concepts from the second sample

Because formal sustainability reporting is largely absent in the compounding segment, governance and sustainability will be most likely signaled through broader umbrella terms (such as a general sustainability pledge) or through more personal language such as quality and affordability. In addition, a compounding pharmacy specific governance metric was used which was the NABP digital accreditation. Table 5.10 below details the frequency at which each variable was mentioned with a total of 36 times out of a possible 84.

Table 5.10

Variable	Frequency
Quality_saftey_reference	14
Sustainability_reference	4
Affordability_accessibility_reference	10
NABP_digital_accreditation	8
Total number of frequencies	36

Note: Source is own author's work

Again, it is also important to note the difference between the two major types of compounding pharmacies, table 5.11 displays this information in a similar manner to table 5.9.

Table 5.11

Variable	503A Frequency	503B Frequency	Both Frequency	503A +Both	503B + Both
Quality_saftey_reference	4	8	2	6	10
Sustainability_reference	0	2	2	2	4
Affordability_accessibility_reference	4	4	2	6	6
NABP_digital_accreditation	5	0	3	8	3
Total number of frequencies	13	14	9	22	23

TOTAL frequencies possible (if the frequency was 100%)	32	32	20	52	52

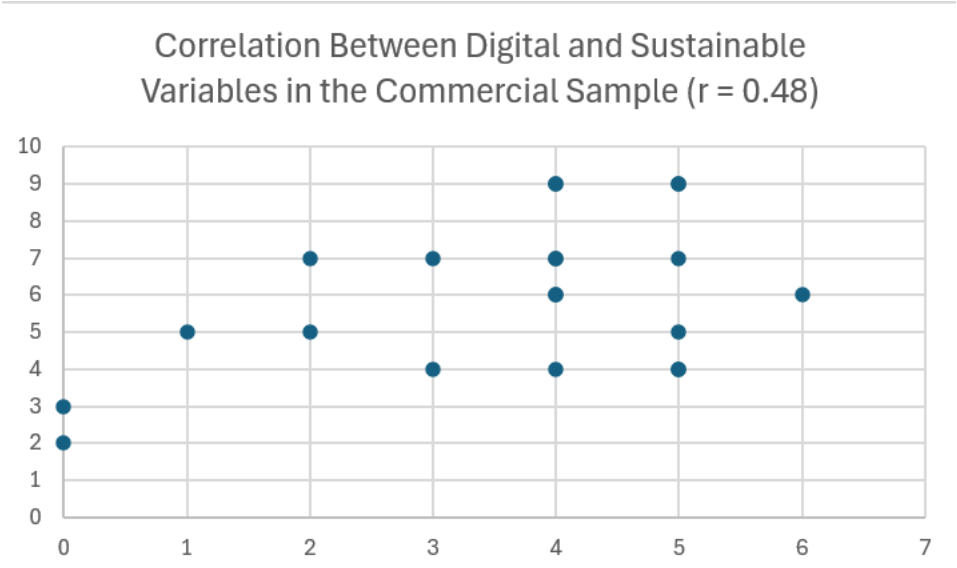
Note: Source is own author's work

The table above shows that once aggregated, the sustainability/governance variables were similar when comparing 503A and 503B pharmacies. This strays away from the digital comparison which saw a much higher output for 503A pharmacies. 503B pharmacies actually had a higher, albeit very slightly frequency when focusing purely on sustainable/governance themes. It is interesting to note the difference here and the discussion as to why will be explored in the next chapter.

5.3 Correlation between digital variables and sustainable/governance variables

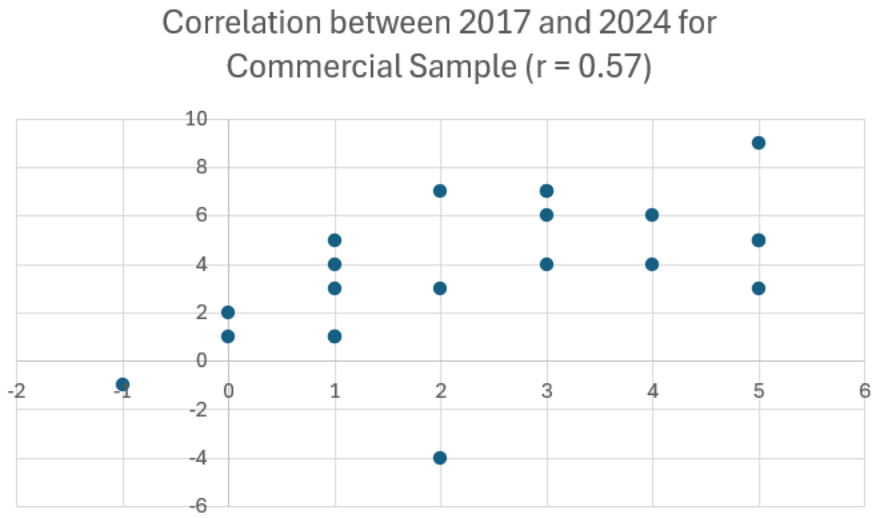
The correlation between digital variables and sustainable/governance variables is something interesting to note, as it differs between both samples reviewed. In the commercial sample, a moderate positive association was observed both in 2024 levels ($r = 0.481$) and in changes between 2017 and 2024 ($r = 0.569$). These results were obtained using the CORREL variable in excel. This indicates that in the sample size and variables reviewed, companies with more digital disclosures also tend to report more on sustainability and governance. Also, the positive correlation in changes indicates that these disclosures tend to increase together over time. In contrast, the compounding sample showed only a weak relationship ($r = 0.179$), suggesting that there was no systematic link between both types of variables chosen within the sample size that was reviewed. This partly supports H2 since one sample did align with the prediction, but the other did not. Below are three scatter plots that show the correlation for each of these results. The detailed information on the tables used in excel are described in the appendix.

Figure 5.3 Scatter plot showing the correlation between digital and sustainable variables in the commercial sample



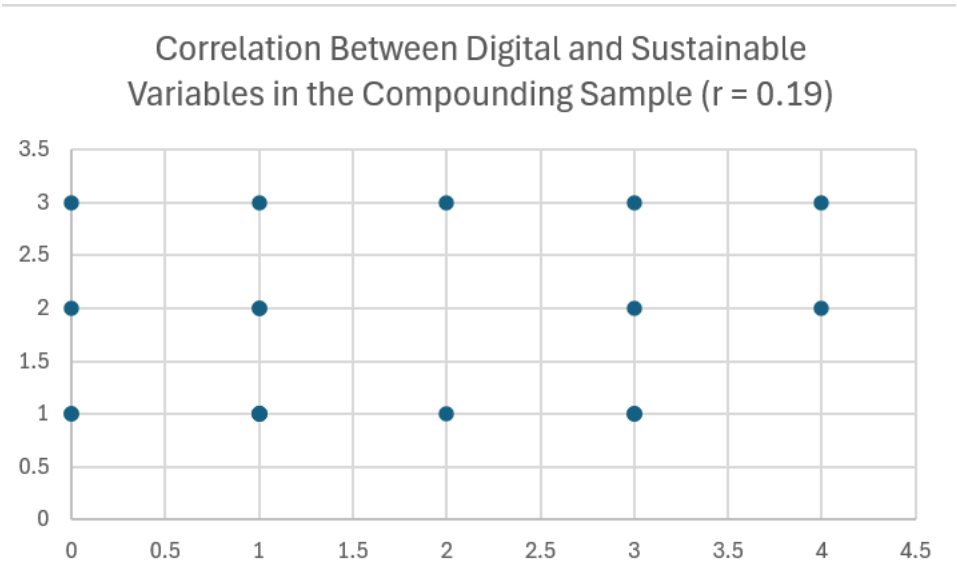
Note: Source is own author's work

Figure 5.4 Scatter plot showing the correlation between 2017 and 2024 for the commercial sample



Note: Source is own author's work

Figure 5.5 Scatter plot showing the correlation between digital and sustainable variables in the compounding sample



Note: Source is own author's work

5.4 Summary and comparative findings between both samples

The clearest finding across the two sample sizes is a disclosure gap. Large commercial pharmaceutical companies make digital transformation and sustainability clear through structured yearly reporting. These often include broad narratives covering innovation, governance, patient access, data privacy, and more. By contrast, compounding pharmacies rarely disclose such themes through formal reports. In fact, almost none publish any sort of formal report. Their public visibility is much smaller and focus more on operational and business model themes, such as connecting providers and patients. This does not automatically mean that compounding firms are less developed, it just means that their public evidence takes a different form.

For the digital variables, the commercial pharmacies saw a 51.7% reference rate out of the variables mentioned. Comparatively, the compounding sample saw a 41.6% reference rate. The sustainable variables followed the same path but at a much larger divide. The commercial pharmacies saw a 70% reference rate out of the variables mentioned. The compounding sample saw a 42.8% reference rate.[20] It is important to note and remember however that the variables used were not identical between sample sizes.

There are a few broad empirical findings that emerge from this study. First, digital transformation and sustainability/governance appear to become much more visible in commercial pharmaceutical company reporting from 2017 to 2024. However, although the increase is similar, there seem to be more public disclosure of sustainability themes than digital technology. Third, the compounding segment is characterized by a structurally different disclosure process, in which digitalization and governance are visible primarily through operational signals rather than formal reporting.

These findings provide the basis for the next chapter, which interprets the results in relation to the literature, the business-model structure of the sector, and the governance and disclosure discussed throughout the thesis.

[20] Note: These numbers are considering the 2024 results for the commercial pharmacy sample.

6 Discussion

6.1 Purpose of discussion

This chapter will interpret the results found in Chapter 5 with relation to the research question and literature review. Additionally, the hypothesis developed in Chapter 3 will be taken into account. The purpose of the discussion will not be to repeat the descriptive results discussed in Chapter 5, but to explain what those results suggest about digital maturity, sustainability/governance themes, and business-model differences across the pharmacy sector in the U.S. A key point will also be to contrast these themes between the large pharmaceutical companies and the smaller 503A and 503B companies.

The interpretation of these results is strengthened by the literature and context outlined in the earlier chapters in this thesis. Patient safety and privacy is recognized by WHO as a central health-system priority shaped by processes, technologies, and organizational controls (World Health Organization, 2023). The increase and use of digital tools fall in line with the literature detailing a need achieving a greater digital transformation and NABP's digital pharmacy accreditations (Charalambous A, 2024; NABP Eligibility, 2024). In addition, privacy requirements and external standards such as ISO 45001, ISO 14001, and GMP requirements help explain why privacy, safety, environmental management, and other compliance requirements are able to be used as important sustainable and governance signals in these environments (ISO, n.d.; FDA, 2023).

6.2 Interpretation of the first sample

6.2.1 Digital transformation reporting change

One of the clear initial findings was the reporting increase in the digital variables being analyzed from 2017 to 2024. Specifically, there was a 205% increase in the two years mentioned. This was especially true in relation to artificial intelligence, data analytics, digital healthcare, and technology partnerships. Only 3 companies out of the ones reviewed did not have an increase, with 2 staying the same and one slight decrease. The remaining saw consistent increases across the board which suggests that digital transformation and digital themes became much more central to company narratives.

This result is important because it indicates that digitalization in healthcare moved from being a much newer and scarcer topic in 2017 to a central theme in how many companies describe their current and future plans. As initially reviewed in the first chapters, healthcare has always been a sector where digital transformation tools have been slower to adopt. Although there was no cross-sector analysis in this thesis, it would interesting to see the differences between the pharmaceutical sector and other sectors that have historically adopted digital technologies quicker. Regardless, in the 2024 sample reviewed, even sustainability reports had many digital technologies where mentioned. This was not very visible in the 2017 reports, where digitalization was much more limited in scope. This implies that these types of themes have become relevant in all areas of most companies and have taken different forms in not only innovation and competition, but in how companies publicly frame themselves.

This pattern strongly supports H3, which proposed that there would be an increase in digital technology and sustainability/governance signals in recent years compared with earlier publicly

available information. At least for the first commercial sample, the evidence for digital expansion is very clear. And although some companies saw more changes than others (and there were a few minor outliers) the increase is sufficiently large and systematic so that it cannot be reduced to just a few isolated company's behaviors alone.

6.2.2 Sustainability/governance reporting change

The sustainability/governance themes also resulted in a substantial increase between the years 2017 and 2024. The increase between both years was measured at 195%, which was very similar to the digital variables. What was particularly interesting during the research was the lack of formal or separate ESG reporting in 2017. This falls in line with the literature reviewed indicating the new set of GRI standards that replaced the existing framework (European Commission, 2017). Although most companies had publicly accessible reports from 2017, many did not have a dedicated section or report for ESG themes. This certainly affected the results since there was a clear lack of these themes in 2017 compared to 2024.

This likely reflects a broader maturation of corporate reporting. As sustainability and ESG-related reports became more standard and institutionalized, companies may have felt stronger pressure to publicly address or note themes that may not have been as relevant in 2017. This is in line with the rationale discussed previously for selecting 2017 as the initial year for data review. In addition, it likely reflects a significant shift in corporate reporting, where themes such as patient safety, access, data protection, and ethical governance are increasingly treated as central parts of their pharmaceutical business model rather than generic public statements that may have had little impact on actual business operations. This type of analysis is consistent with the discussion regarding digital technology, and the results can draw many parallels between them.

This second finding also supports H3. In the commercial benchmark sample, both digital and sustainability/governance variables became more visible over time. This suggests that both digital and sustainability/governance variables have become a more central theme in public reporting. Similar to the digital variables, the change was significant enough to come to the conclusion that the change was constant between most of the companies analyzed.

6.2.3 Uniformity of change

As mentioned, the change noted for both sets of variables was a consistent theme between the companies analyzed. However, there were certain companies that did show more limited or selective growth over the years. This may be due to a variety of factors. Firstly, although all companies were in the same sector, there may be distinct business model types between these companies that may have an influence on the types of digitalization or sustainable themes that the company adopts. What may be a key factor for one company may be an afterthought for another one depending on the services and types of customers they are catering to. It would be interesting to see how each company's very specific areas of interest are correlated with the digital and sustainable themes analyzed. It may also be that there are other themes not analyzed that are more relevant to certain companies.

This reinforces one of the broader arguments of the thesis: digital maturity and governance signaling are shaped by business model and organizational context. Although the primary focus was between the distinct business model type of commercial vs compound, this also is present within the same commercial pharmaceutical companies. Even among large public companies with formal reporting, some emphasize AI and technology partnerships heavily, while others emphasize access and patient orientated themes more. Therefore, although there is a general

consistency between all of the companies analyzed, this group will still have certain areas where different signals are visible and should not be viewed as a single completely uniform block.

6.3 Interpretation of the second sample

6.3.1 Variables used and public visibility for compounding pharmacies

The compounding sample confirms that compounding pharmacies exhibit very different disclosure preferences compared to public pharmaceutical companies. Simply put, if the same variables were used throughout both samples, the study would have found close to no results for the compounding sample. Because of the vast differences in business model and reporting preferences that were explored in previous chapters, the study opted to create different, more relevant variables for the compounding sample. This was not done to be able to compare both samples side by side, but to be able to find relevant data for the second sample and analyze it in its own right.

This finding is itself significant. It suggests that the absence of ESG-style reporting in compounding is not a problem that results from a lack of data, but a feature of this sector. Compounding pharmacies, generally being smaller private organizations, do not generate the same kind of public reporting as large public benchmark companies. As a result, they must be interpreted through other signals.

6.3.2 Digital maturity differs by type of business model

These results also provide important insight into H1, which proposed that digital maturity would differ by type of business model. This included commercial, 503A, and 503B pharmacies.

The compounding sample showed that publicly visible digital signals were concentrated in variables such as doctor portals, patient portals, and e-prescribing. These variables were much more relevant and actionable for their customers, which usually provided clear information or information on how customers could order or track information related to them. These public signals seem to be much more directly related to business model and economic incentives for the pharmacy. The digital variables were particularly common in the 503A companies analyzed. By contrast, 503B firms showed fewer public-facing portals and e-prescribing signals, which is consistent with their more institutional, B2B business model. One can argue however that being more closely connected to the commercial sample, there should have been more public signals. However, although these pharmacies follow a more institutional business model, most pharmacies are not large or public enough to be incentivized to follow standardized public signaling that the first sample followed. This puts them in a sort of middle ground between the 503A pharmacies and the commercial pharmacies.

Regardless, the findings support H1. The differences between the groups do not seem random, instead follow a business-model logic:

- 503A pharmacies, which tend to operate in patient-specific and prescriber-facing environments, were more likely to display digital features that facilitate communication and digital access for their direct clients.
- 503B pharmacies, which serve larger customers and not patients, showed a different profile and did not emphasize digital access for customers in the same way found in 503A pharmacies.

Of course, these findings do not prove that one business model is inherently more digital than another. These findings were based on the digital variables selected and only took into

account public facing signals and did not analyze internal pharmacy details that are not publicly available. What can be concretely concluded is that digital signals are expressed differently between business models.

6.3.3 Sustainability/governance signals by type of business model

The compounding sample also showed that sustainability/governance variables were present, but in a narrower and more muted form than the first sample. The most visible variables related to quality and safety and affordability/accessibility signals. This was in line with the idea that these signals are more relevant to their direct customer rather than trying to adhere to large institutional standards that the average person may not recognize or appreciate. Patients and providers are able to comprehend how these signals affect them directly and how their level of service may improve because of them. Here there was not a significant change in reporting frequency between 503A and 503B pharmacies, which indicate a similar focus throughout the business models analyzed.

The result here indicates that governance and responsibility in compounding are not absent; rather, they are embedded in a different mode of communication. Although they may appear muted, these pharmacies focus on more personally relevant themes instead of broad ESG reporting. Many of these companies may not see the value or need in the type of standardized reporting seen in larger companies and instead focus on more important internal operational challenges. This is an important finding because it challenges the assumption that sustainability and governance can only be observed through standardized reporting.

6.4 Relationships between digital variables and sustainability/governance variables

6.4.1 Moderate association in the first sample

An important addition to the descriptive findings is the correlation analysis between digital variables and sustainability/governance variables. In the commercial sample, a moderate positive association was observed both in the 2024 levels ($r = 0.481$) and in the change between 2017 and 2024 ($r = 0.569$). These results indicate that the companies analyzed with a higher frequency of digital disclosures also tend to disclose more sustainability and governance themes. There is also a correlation between both themes being disclosed more over time. Of course this does not imply a causal relationship between the themes, however it does provide an interesting base to use as a starting point for potential future research.

This is a significant result because it suggests that digital transformation and sustainability/governance are not developing as separate areas in these companies' reporting tracks. Instead, they appear to co-evolve together. One potential interpretation is that the same firms that are developing broader digital strategies are also those with the organizational capacity and disclosure sophistication needed to communicate these themes in a structured way. Another rationale that could be used is that both of themes have become an important point for internal procedure as well as public signaling procedures for these companies in the pharmaceutical sector.

In either case, the benchmark correlation provides empirical support for H2, which proposed that higher digital maturity would be positively associated with stronger sustainability/governance signals.

6.4.2 Weak association in the second sample

The compounding sample however, showed a very different correlation pattern. Here the correlation between both sets of variables was only $r = 0.179$ which indicates a weak or no relationship. This means that there was little to no relationship between the digital variables produced and the sustainability/governance variables produced for the pharmacies in the compounding sample analyzed.

This weak relationship is important since it suggests that in compounding pharmacies, digitalization and governance signals are not integrated into a standardized public facing signal in the same way the commercial sample was. This is much more highly dependent on how each pharmacy chooses to operate their public signals for both digital and sustainable themes. This may depend on the pharmacies' internal process or specific area of the market they are intending to capture.

This does not necessarily mean that digital maturity and governance are unrelated internally within compounding firms. Rather, it indicates that public visibility for both of these themes is not standardized. For example, a compounding firm may publicly emphasize their digital tools such as provider and patient portals without making broader governance or sustainability claims, and another may emphasize quality and safety without highlighting digital tools.

6.4.3 What this means for H2

When using both sets of data, the correlation analysis partly supported H2. As discussed, for the commercial sample, this hypothesis was clearly supported. However, the compounding sample did not support the same pattern.

A reasonable explanation for these results is that the hypothesis is supported for sectors where public reporting is more structured and reliable. The weak correlation for the compounding sector may be due to the use of sources for the sample and the general low public disclosure habits of private companies in general.

Therefore, the hypothesis is not fully rejected by the compounding sample but does suggest that positive association between digital maturity and governance signaling appears to be much stronger when both are embedded in a formal disclosure environment.

6.5 Hypotheses summary

Below is Table 6.1 which reviews all three hypotheses describing the result described in the previous sections:

Table 6.1

Hypothesis	Accepted?	Rationale
H1: Digital maturity will differ systematically by customer model. In addition to the difference in publicly available data between commercial and compounding pharmacies, there will also be stark differences between 503A compounding pharmacies and 503B pharmacies.	Accepted	503A pharmacies, which tend to operate in patient-specific and prescriber-facing environments, were more likely to display digital features that facilitate communication and digital access for their direct clients. 503B pharmacies, which serve larger customers and not patients, showed a different profile and did not emphasize digital access for customers in the same way found in 503A pharmacies.
H2: Higher digital maturity will be positively associated with stronger sustainability/governance	Partially accepted	In the first commercial sample this was supported. Out of the companies reviewed, there was a

signals. This will be true for all types of pharmacies regardless of the variables used and types of data reviewed.		correlation of r = 0.481 which indicates a moderately positive correlation. However, in the compounding sample the correlation between both sets of variables was only r = 0.179 which indicates a weak or no relationship
H3: There will be an increase in digital technology and sustainability/governance signals in the recent years compared to publicly available information that has been published in earlier years.	Accepted	In the commercial benchmark sample, both digital and sustainability/governance variables became more visible over time. This suggests that both digital and sustainability/governance variables have become a more central theme in public reporting. (A 204% increase for digital, and a 195% increase for sustainability/governance themes)

Note: Source is own author's work

6.6 Comparative interpretation between both samples

The most important comparative result of the thesis is the existence of a disclosure gap between benchmark commercial companies and the compounding pharmacies. However, it must be considered that these themes are just public signals and do not necessarily take into account the real internal public workings and effects of these companies. Just as compounding pharmacies may not signal certain themes publicly but internally abide by them, the large public companies can do the same in the opposite manner. This will also be noted in the limitations section later.

The differences between both samples have been reviewed in the previous paragraphs but in addition to the fundamental differences in types of reporting, three themes were also present:

- Commercial companies displayed more strategic and high-level digital and sustainable narratives
- 503A firms displayed more access and communication oriented digital and sustainable signals
- 503B firms displayed a more institutional and less public-facing digital sustainable signals while not reaching the level of the commercial companies

A final important note is that H3 could not be measured for both sets of samples because compounding pharmacies do not have easily accessible public reporting records. Therefore, we can infer that these signals have increased throughout the years based on the first sample's results, however there would need to be deeper research in order to determine this. It may not be the case seeing as the same results were not found throughout each sample.

6.7 Implications

This thesis has the potential to enrich the existing literature in several ways. Firstly, it supports an argument for treating digital and sustainable maturity as a nuanced theme that cannot be blindly applied throughout different sectors, even within the same business environment. Also, it supports the use of alternative proxies for standard signaling themes that may not be commonplace in all companies. Finally, the study contributes to the literature by showing that disclosure capacity itself is meaningful. The absence of formal reporting in compounding is not merely a technical hurdle; it is part of the structure of the sector.

Another important point to note is that the results imply that governance systems based heavily on formal ESG and sustainability disclosure may work well for large companies but may have little relevance to all other small or mid-sized companies. If transparency is to be improved

across the sector, there may need to be more forms of public visibility that are feasible for smaller companies. However, this goal may put unnecessary pressure and burdens on smaller companies that do not prioritize these types of signals.

6.8 Limitations

There are several limitations that need to be acknowledged to fully understand the results of the study. First of all, the benchmark commercial sample is biased towards larger companies that prioritize reporting and public visibility. This means that it may not completely represent the entire U.S. pharmacy market and the data will be skewed to the largest firms with most exhaustive reporting. Also, the companies chosen are all based in the U.S. and although they may have certain business overseas, the main area will be limited to the United States.

Secondly, most of the variables are dummy variables which will capture the presence of a certain theme, however it may not capture the entire context. This means that the intensity, depth and other contextual factors may not be taken into account if this information is not available. These variables were chosen purposely, and specific sources were used to gather the appropriate variables before the study was conducted, however certain companies may have prioritized other themes that the study did not take into account.

Third, as highlighted already, the two samples used two different sets of variables to measure. Although the two layers are comparable at a broad level, there were no specific identical measurements compared. As discussed extensively however, having identical measurements may have had a negative impact on the study due to the differences in types of companies reviewed. In addition, there was a different time period used for the two samples. The first focused on two distinct time periods (2017 and 2024) and the second used information that is present today in

2026. Finally, the study analyzes public-facing information and outwards narratives. The operational reality of all of these companies is not being taken into account. A company may disclose extensively without necessarily implementing those ideas in practice, and the opposite may also be true for companies that do not report or under-report. In addition, this study was just limited to the United States which means the entire global pharmaceutical sector was not taken into account.

However, these limitations by no means invalidate the design of the thesis, rather it sets a limitational scope that is realistic in a study of these proportions and resources. The scope is again reiterated as how digitalization, governance, and sustainability themes become visible through different public evidence sources in the U.S. pharmacy sector with an additional focus on compounding.

6.9 Future Research

This study provides a strong base for future research. Firstly, the sample size of both commercial and compounding pharmacies could be expanded to capture a wider range of companies. The study could then see if the two themes or more (or less) aligned with a larger range of companies used. Additionally, instead of simply using publicly available data, interviews with each company could be conducted for a better and clearer understanding of the themes analyzed. This would also open the door for the intensity of the variables used instead of dummy variables.

Additionally, the variables that were used could also be reviewed and expanded, offering a wider array of areas to review for both digital and sustainability/governance themes. If a more structured use of these (or other) variables were able to be analyzed in a separate study, it could provide a stronger framework for future studies.

Finally, it would be interesting to determine causation between the variables in a future study. If there was a way to determine if digital tools have a causal relationship with sustainability/governance variables, (or vice-versa) this could open up areas for further studies.

Conclusion

This thesis examined how digital transformation and sustainability-related governance are publicly communicated across different parts of the U.S. pharmacy sector. There was a particular focus on the contrast between large commercial pharmacies and compounding pharmacies. The study was motivated by a key difference: large public pharmaceutical companies often publish pubic facing ESG type reports, while most 503A and 503B compounding pharmacies do not generate comparable public reporting.

To address this, the thesis used a two-layer empirical design. First, it conducted a manual content analysis of selected benchmark healthcare and pharmacy-related companies, comparing 2017 and 2024 reports. These companies were selected from relevant companies found in the MSCI U.S. Health Care Index. Second, it carried out a descriptive analysis of compounding pharmacies using publicly available signals such as websites and service descriptions. This design made it possible to continue to use and focus on compounding pharmacies as a central part of the research while still maintaining a structured framework that could be comparable to the first sample.

The findings showed that in the commercial sample, both digital and sustainability/governance-related variables increased clearly between 2017 and 2024. Artificial intelligence, data analytics, digital healthcare, and technology partnerships saw most change between both years. Patient safety, accessibility, data privacy, and ethical innovation were key terms that saw the most increase for the sustainability/governance variables.

In the compounding sample, public visibility followed a different pattern. First of all, there was no two-year cross analysis to be made because of the lack of historical reporting. Digitalization appeared mainly through operational and communicational signals such as portals and e-prescribing. Governance and sustainability-related themes were expressed through quality, affordability, and compliance language rather than through formal ESG reporting. The central theme here was that these companies focused on more personal communication and signaling in more real and tangible ways that patients and providers can immediately recognize.

There were also real limitations to consider for this thesis including only using public signals, other potential variables to consider in the data set, and having to use different types of variables for the different types of pharmacies.

In conclusion, this thesis shows that digital transformation and sustainability/governance signals are becoming more visible in the U.S. pharmacy sector, but that this visibility is highly uneven across the types of businesses. Large commercial companies and compounding pharmacies use very different types of signaling and at very different levels. As a result, meaningful comparison requires differentiated data sets and strategies. The study provides a strong base for future research to add valuable information such as going deeper into operational reality for each company instead of just using public signals.

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Appendix

Table A1 Sample Overview of Companies

Company	GICS Sector	2017 Report available	2024 Report available
COMPANY 1	Health Care	YES	YES
COMPANY 2	Health Care	YES	YES
COMPANY 3	Health Care	YES	YES
COMPANY 4	Health Care	NO	YES
COMPANY 5	Health Care	YES	YES
COMPANY 6	Health Care	YES	YES
COMPANY 7	Health Care	YES	YES
COMPANY 8	Health Care	NO	YES
COMPANY 9	Health Care	YES	YES
COMPANY 10	Health Care	YES	YES
COMPANY 11	Health Care	YES	YES
COMPANY 12	Health Care	YES	YES
COMPANY 13	Health Care	YES	YES
COMPANY 14	Health Care	YES	YES
COMPANY 15	Health Care	YES	YES
COMPANY 16	Health Care	YES	YES
COMPANY 17	Health Care	NO	YES
COMPANY 18	Health Care	NO	YES
COMPANY 19	Health Care	NO	YES
COMPANY 20	Health Care	YES	YES
COMPANY 21	Health Care	NO	YES

Note: Source is own author's work. Table 5.1 below describes the sample and if both 2017 and 2024 reports were publicly available, or if just 2024 reports were available. It is important to note

that many 2017 reports for these companies may have had different structure than the 2024 reports.

Table A2 Correlation between 2017 and 2024 for Commercial Sample

Company	Digital increase from 2017 to 2024	Sustainability increase for 2017 to 2024	EQUATION IN EXCEL: =CORREL(B22:B22, C2:C22) = 0.56974
COMPANY 1	1	3	
COMPANY 2	2	3	
COMPANY 3	3	6	
COMPANY 4	3	7	
COMPANY 5	2	-4	
COMPANY 6	4	4	
COMPANY 7	1	1	
COMPANY 8	1	5	

COMPANY 9	5	5
COMPANY 10	-1	-1
COMPANY 11	1	4
COMPANY 12	3	7
COMPANY 13	1	1
COMPANY 14	0	2
COMPANY 15	5	3
COMPANY 16	3	4
COMPANY 17	2	7
COMPANY 18	4	6
COMPANY 19	5	5

COMPANY 20	0	1
COMPANY 21	5	9

Note: Source is own author's work

TABLE A3 Correlation Between Digital and Sustainable Variables in the Compounding Sample

COMPANY	DIGITAL	SUSTGOV	EQUATION IN EXCEL: =CORREL(B2:B22, C2:C22) =0.179743
COMPOUNDING COMPANY 1	4	3	
COMPOUNDING COMPANY 2	3	3	
COMPOUNDING COMPANY 3	4	2	
COMPOUNDING COMPANY 4	3	1	
COMPOUNDING COMPANY 5	2	3	
COMPOUNDING COMPANY 6	3	1	
COMPOUNDING COMPANY 7	1	1	

COMPOUNDING COMPANY 8	0	2
COMPOUNDING COMPANY 9	3	2
COMPOUNDING COMPANY 10	3	1
COMPOUNDING COMPANY 11	1	2
COMPOUNDING COMPANY 12	0	3
COMPOUNDING COMPANY 13	1	2
COMPOUNDING COMPANY 14	1	1
COMPOUNDING COMPANY 15	1	1
COMPOUNDING COMPANY 16	0	1
COMPOUNDING COMPANY 17	1	1
COMPOUNDING COMPANY 18	2	1
COMPOUNDING COMPANY 19	1	1
COMPOUNDING COMPANY 20	0	1

COMPOUNDING COMPANY 21	1	3

Note: Source is own author's work

TABLE A4 Correlation Between Digital and Sustainable Variables in the Commercial

Company	Digital variables 2024	Sustainability/governance variables 2024	EQUATION IN EXCEL: =CORREL(B2:B22, C2:C22) =0.481838
COMPANY 1	4	9	
COMPANY 2	5	9	
COMPANY 3	4	9	
COMPANY 4	3	7	
COMPANY 5	3	4	
COMPANY 6	4	7	
COMPANY 7	4	4	
COMPANY 8	1	5	

COMPANY 9	5	7
COMPANY 10	2	5
COMPANY 11	6	6
COMPANY 12	4	7
COMPANY 13	5	4
COMPANY 14	0	3
COMPANY 15	5	4
COMPANY 16	4	6
COMPANY 17	2	7
COMPANY 18	4	6
COMPANY 19	5	5

COMPANY 20	0	2
COMPANY 21	5	9

Note: Source is own author's work