From Platform Architecture to Rapid Medical Innovation: Technological Redeployability and Public Support under Emerging Health Threats, with Evidence from Ebola

Tripti Paul[1], **Sandip Rakshit**[1]

[1]University International de Rabat, Rabat Business School

Abstract

Medical preparedness depends not only on developing effective technologies, but also on whether prior technological capabilities can be redirected when a new health threat emerges. We examine this problem through a framework linking Platform Technology Architecture, Technological Redeployability, Rapid Medical Innovation Response, and Coordinated Public Innovation Support. Drawing primarily on Real Options Theory and complemented by insights from Technological Innovation Systems, we test the framework across three studies. Study 1 uses interviews with 23 experts from Uganda, Nigeria, Ghana, Morocco, and the United Kingdom to ground the proposed technological and institutional mechanisms. Study 2 employs a randomized 2 × 2 experiment with 312 respondents from Nigeria, Ghana, and Uganda. Platform architecture significantly increased technological redeployability, technological redeployability was positively associated with rapid medical innovation response, and the indirect effect of platform architecture on rapid medical innovation response through technological redeployability was supported. Evidence for coordinated public innovation support as a boundary condition was positive but less conclusive in the primary specification. Study 3 analyzes 107 interventional Ebola medical-countermeasure trials from ClinicalTrials.gov and documents substantial observable patterns of technological reuse, repurposing, recurrence, and recombination. Together, the findings suggest that preparedness value lies not only in current medical products, but also in the technological options and redeployable capabilities preserved for uncertain future threats. The study offers implications for how the U.S. medical innovation system evaluates platform investments and preparedness capacity.

Keywords: platform technologies; technological redeployability; medical innovation; preparedness; Real Options Theory; public innovation support

1. Introduction

Medical preparedness poses a distinctive innovation problem. Major investments in science, technology, manufacturing, and clinical development often have to be made before the identity, timing, and scale of the next health threat are known (Leonardi & Leavell, 2026). Yet the value of those investments becomes visible only when a new threat appears and existing capabilities can be mobilized quickly enough to matter. Recent outbreaks have made this tension difficult to ignore. The challenge is not simply whether a medical innovation system can generate new vaccines, therapeutics, or diagnostics. It is whether prior investments leave behind technological capabilities that can be redirected when uncertainty resolves into an actual emergency (Doms et al., 2026; Kapacinskaite, 2026).

This particular issue is of major concern to the U.S. biomedical innovation system. Biomedical research, the development of new countermeasures, regulation, clinical testing, manufacturing, and procurement in relation to vaccines and other products are all managed through a variety of means by multiple organizations; i.e., public agencies (such as FDA), private companies, universities, hospitals, and various types of research networks (Heydari et al., 2026). A promising technology may already exist, yet adaptation can still be delayed if development has to restart, manufacturing knowledge cannot be transferred, regulatory expectations are unclear, or trial and procurement systems move separately (Qu et al., 2026; Ringov et al., 2026). Preparedness therefore concerns more than the stock of technologies available before a crisis. It also concerns the capacity to reuse what has already been built.

Platform technologies offer one possible response to this problem. Unlike product-specific approaches developed around a single disease target, platform architectures retain a technological core that can be adapted to different applications (Berends et al., 2026). Reusable delivery systems, development routines, manufacturing processes, analytical methods, and accumulated safety knowledge may allow subsequent innovation to begin from a more advanced starting point (Desyllas et al., 2026). This logic has become increasingly visible in vaccines and other biomedical technologies (Feldmann et al., 2018). Still, the existence of a platform does not by itself explain rapid response. Some platform technologies may be technically reusable but difficult to redirect in practice (Kernstock et al., 2026). Others may preserve knowledge and infrastructure that can be transferred quickly across threats (Khan et al., 2026). The distinction between possessing a platform and being able to redeploy its capabilities is therefore central.

We address this distinction through the concept of Technological Redeployability (TR). TR captures the extent to which accumulated technological knowledge, development processes, manufacturing capabilities, and supporting infrastructure can be redirected toward a new medical target (Sakhartov & Helfat, 2026). This separates the architecture of a technology from the practical flexibility that architecture creates. Platform Technology Architecture (PTA) describes the reusable design in which flexibility is embedded, whereas TR captures whether that flexibility can actually be exercised when the target changes. We further distinguish the technological mechanism from its downstream consequence, Rapid Medical Innovation Response (RMIR), which reflects the capacity to move quickly from an emerging threat toward the development and advancement of a usable medical countermeasure.

This technological pathway, however, operates within an institutional system. Redeployable capabilities may still remain idle or move slowly when funding, regulation, clinical-trial infrastructure, procurement, and implementation support are fragmented (Arslan & Tarakci, 2022). We therefore introduce Coordinated Public Innovation Support (CPIS) to capture the degree to which these forms of public support are aligned around the innovation process. The central argument is that technological flexibility creates response possibilities, but the surrounding institutional environment affects how effectively those possibilities can be converted into action.

This leads to two research questions:

RQ1. *How do platform technology architectures create technological redeployability that enables rapid medical innovation response under emerging health threats?*

RQ2. *How does coordinated public innovation support shape the translation of technological redeployability into rapid medical innovation response?*

We develop the framework primarily through Real Options Theory (ROT) (Trigeorgis & Reuer, 2017), complemented by insights from Technological Innovation Systems (TIS) (Bergek et al., 2008). ROT is useful because preparedness investments are made under uncertainty and can create options that become valuable only when future conditions are revealed (Sakhartov et al., 2026). From this perspective, platform architecture can preserve technological options before the next pathogen is known, while redeployability captures the ability to exercise those options when a threat emerges. TIS adds an institutional dimension by

recognizing that innovation outcomes depend on the wider system of funding, regulation, experimentation, infrastructure, and public support (Alao et al., 2026). Through the combination of each perspective we can study both if there is a level of technological flexibility in existence and if that flexibility can be made operational.

We examine the framework through three complementary studies. Study 1 uses interviews with 23 experts from Uganda, Nigeria, Ghana, Morocco, and the United Kingdom to ground the four focal constructs and their proposed relationships. Study 2 uses a randomized 2 × 2 scenario experiment with 312 respondents from Nigeria, Ghana, and Uganda. Platform Technology Architecture and Coordinated Public Innovation Support are experimentally varied, while Technological Redeployability and Rapid Medical Innovation Response are measured. This design provides a controlled test of the core technological pathway and the proposed institutional boundary condition. Study 3 then moves to archival evidence from 107 interventional Ebola medical-countermeasure trials registered in ClinicalTrials.gov. Rather than treating registry variables as direct measures of the theoretical constructs, the archival analysis examines whether reuse, recurrence, repurposing, and technological recombination are observable features of real-world medical innovation.

The evidence is strongest for the core technological mechanism. In Study 2, assignment to the platform condition increased Technological Redeployability, and TR was positively associated with Rapid Medical Innovation Response. The indirect PTA to TR to RMIR pathway was also supported. Evidence for the institutional boundary condition was more qualified. The TR × CPIS pattern was positive and stronger under coordinated support, although the primary interaction and moderated mediation tests did not provide equally strong support. The adjusted specification, however, showed a significant positive interaction. Study 3 adds external context to these findings. Of the 107 Ebola trials, 78 involved reusable platform architectures, 88 were classified as reusable or repurposed, and 32 combined multiple technological architectures. Recurrent use of technologies such as rVSV, MVA, Ad26, and chimpanzee adenovirus further indicates that medical innovation often builds on technological elements that extend beyond a single intervention.[1]

[1] rVSV refers to recombinant vesicular stomatitis virus, MVA to modified vaccinia Ankara, and Ad26 to adenovirus serotype 26. These, together with chimpanzee adenovirus vectors, are viral-vector technologies used as adaptable platforms in vaccine development (Feldmann et al., 2018; Henao-Restrepo et al., 2017).

Three major contributions were made by this paper. First, this paper distinguishes architectural design for a platform from redeployment of an existing capability. It is important that there be a difference in whether one has an architectural structure that can be used as is or redirected when new capability is needed. Therefore, the framework goes beyond what was previously referred to as either platform technology or non-platform technology; it views the use of previous investments toward future threats based upon the mechanisms that allow such past investments to have continued value.

Second, the study extends the real-options logic of preparedness. Prior investment creates value not only through the product initially developed, but also through the technological pathways that remain available for future use (Sakhartov et al., 2026). TR identifies the mechanism through which this option value becomes operational. In this sense, preparedness value lies partly in what an innovation system preserves for the next threat, not only in what it produces for the current one.

Third, the study brings the institutional environment into that mechanism. Coordinated public support is not treated simply as another resource input. It represents the set of institutional conditions that can help technological options move from latent flexibility to clinical and operational action (Guo et al., 2026). This relationship among architectural aspects in technology, capability for redeployment, and the process of coordinating with the public can provide an additional perspective on how to assess preparedness throughout the U.S. Medical Innovation System.

A broader implication from this relationship is that preparedness for medical emergencies cannot simply be measured through the number of products being developed, nor can it be determined solely by the quantity of product already available in inventory. A system may also be prepared when prior scientific and technological investments leave behind capabilities that can be redirected quickly, and when public institutions are organized to activate those capabilities. The remainder of the paper develops this argument in detail. Section 2 describes the institutional and medical innovation context. Section 3 develops the conceptual framework and hypotheses. Section 4 explains the multi-study research design. Sections 5 through 7 present the qualitative, experimental, and archival studies. Section 8 integrates the evidence across studies, and Section 9 discusses the theoretical and policy implications.

2. Institutional and Medical Innovation Context

2.1. The U.S. Medical Innovation System Under Emerging Health Threats

The U.S. medical innovation system combines public research funding, private-sector R&D, regulatory oversight, clinical development, manufacturing, and procurement. Its strength comes from the interaction of these elements rather than from any single institution (Audretsch & Belitski, 2026; Zhang et al., 2026). NIH supports basic and translational biomedical research, BARDA helps advance medical countermeasures for emerging infectious diseases and other public-health threats, and FDA provides the regulatory framework through which vaccines, therapeutics, diagnostics, and other countermeasures are evaluated and, when necessary, made available under emergency authorities (Biomedical Advanced Research and Development Authority, 2026; National Institutes of Health, 2026; U.S. Food and Drug Administration, 2026).

Emerging health threats place unusual demands on this system (Wright et al., 2024). The pathogen, timing, scale, and geographic origin of the next outbreak are difficult to predict, while conventional medical-product development can require substantial scientific, clinical, manufacturing, and regulatory investment before a countermeasure becomes usable (Mueller et al., 2026). The problem is therefore not simply whether the system can generate innovation. It is whether prior scientific and technological investments can be mobilized quickly enough when the nature of the threat becomes clearer (Doms et al., 2026). This makes preparedness an innovation problem as much as a public-health problem.

The challenge also extends beyond U.S. borders. Outbreaks that initially emerge elsewhere can generate scientific, economic, and health consequences for the United States, while U.S.-funded science, firms, regulatory institutions, and development infrastructure often contribute to the global response.

Against this background, an important question is whether the system should rely primarily on technologies developed for specific diseases or invest more heavily in technological architectures that preserve the capacity to respond across uncertain future threats (Tatarinov et al., 2023). This distinction motivates our focus on platform-based medical innovation.

2.2. Platform Technologies and the Shift from Product-Specific to Reusable Innovation

Traditional medical innovation is often organized around a specific product for a specific disease target. This model can produce highly specialized solutions, but much of the underlying development work may need to be repeated when a new pathogen emerges (Mueller et al., 2026). The scientific validation for a new product, its formulation, manufacturing process and clinical protocol are all inextricably linked to the first product. This makes it difficult to carry over prior investments when there is a recurring series of unclear health risks (Tatarinov et al., 2023).

A platform technology represents an alternative form of innovation. Instead of developing each new medical product with almost no shared knowledge from other products developed by the company, a platform shares most or all of the underlying technology (the 'platform') with many of the subsequent products (Berends et al., 2026; Ozcan et al., 2026). Examples include reusable vaccine platforms, nucleic-acid technologies, viral-vector systems, and other modular biomedical architectures (Feldmann et al., 2018; Henao-Restrepo et al., 2017). The disease-specific component may change, while parts of the delivery system, manufacturing process, analytical methods, safety knowledge, and development infrastructure remain available for reuse (Desyllas et al., 2026).

The economic value of such platforms therefore extends beyond the first product they generate. Investment in one application can create knowledge and capabilities that remain relevant to later applications (Lehmann et al., 2025). This can reduce duplication, preserve learning, and make it easier to redirect scientific and development resources when a new threat appears (Koporcic et al., 2026; Magrelli et al., 2026; Qu et al., 2026). The primary benefit is not that each successive product will be simple or without risk. Instead, platform technologies can provide a foundation for innovation based on a large existing body of technology rather than having to start all over again with no prior experience. This distinction has importance in terms of preparedness policy; as mentioned previously, product specific investments are used to mitigate known threats while reusable architecture allows for value retention in response to unknown (future) threats (Tatarinov et al., 2023). The central question is therefore not only whether a platform produces successful products, but whether its underlying technological capabilities can be redeployed when the target changes. This issue provides the institutional

basis for our focus on Platform Technology Architecture and Technological Redeployability in the conceptual framework that follows.

2.3. Public Coordination and the Translation of Preparedness into Rapid Response

Preparedness investments create value only when they can be activated quickly during a health emergency (Gsell et al., 2017). In practice, this requires more than scientific readiness (Zheng et al., 2026). Funding decisions, regulatory guidance, clinical-trial capacity, manufacturing support, procurement, and implementation often sit across different agencies and institutions. When these elements move at different speeds, even a promising technology can lose time during translation (Alao et al., 2026; Arslan & Tarakci, 2022; Geiger & Harborth, 2025).

Public coordination can help to lessen friction. Clear regulatory guidance clarifies evidentiary requirements. Funding provided quickly enough will allow for a continued level of productivity from the developers. The availability of clinical trial resources should expedite the testing of new drugs. Procurement commitments by government may also be used as an incentive for drug companies to produce their product at commercial scale and have it available when needed (Merisalo et al., 2026; Osterholm et al., 2016). The contribution of public support therefore lies not only in the amount of resources provided, but also in how effectively different forms of support are aligned (Acerenza et al., 2026; Randhawa et al., 2026).

This coordination problem is especially important for platform technologies. A reusable technological base may create the capacity to respond to a new threat, but that capacity remains latent until institutions enable rapid adaptation, testing, production, and deployment (Guo et al., 2026). Fragmented support can weaken the practical value of technological preparedness by introducing delays at precisely the stages where speed matters most. Coordinated support, by contrast, can help convert prior investments into an operational response (Ranganathan et al., 2025).

For the U.S. medical innovation system, the central issue is therefore not simply whether preparedness capabilities exist. It is whether scientific, regulatory, financial, and implementation systems can work together when an uncertain threat materializes (Jiang et al., 2026). This distinction motivates our focus on Coordinated Public Innovation Support (CPIS) as a key institutional condition shaping the translation of technological redeployability into rapid medical innovation.

2.4. Research Gap and Study Positioning

Although prior research provides important insights into platform technologies, resource redeployment, real-options logic, and public support for innovation, these streams remain only partially connected in the context of medical preparedness. Research on platforms emphasizes reusable technological architectures and accumulated capabilities (Berends et al., 2026; Lehmann et al., 2025), while research on resource redeployment highlights the value and organizational conditions of moving existing resources toward new uses (Sakhartov & Helfat, 2026). Real Options Theory explains how investments under uncertainty can preserve future opportunities (Sakhartov et al., 2026; Trigeorgis & Reuer, 2017), but less attention has been given to the specific technological mechanism through which such options become usable when a new health threat emerges. Similarly, research on public innovation support emphasizes funding, procurement, scaling, and institutional coordination (Merisalo et al., 2026; Osterholm et al., 2016), but these mechanisms have not been fully connected to technological redeployability. Table 1 summarizes these gaps and positions the present study.

Table 1. Research Gaps and Study Positioning

Research stream	What prior research establishes	What remains unresolved	How this study responds
Platform architecture and reusable innovation	Platform-based innovation can preserve common technological components, knowledge, and architectural capabilities across applications (Berends et al., 2026; Lehmann et al., 2025).	A reusable architecture does not necessarily mean that its accumulated capabilities can be redirected effectively when the target changes.	Separates Platform Technology Architecture (PTA) from Technological Redeployability (TR). PTA captures reusable architecture; TR captures the practical ability to redirect accumulated capabilities.
Resource redeployment and innovation under uncertainty	Resource redeployment can create value by transferring existing resources toward new uses, while Real Options Theory explains how investments under uncertainty preserve future opportunities (Sakhartov & Helfat, 2026; Trigeorgis & Reuer, 2017).	The literature provides less explanation of how technological options embedded in prior medical investments become operational when an uncertain health threat materializes.	Conceptualizes TR as the mechanism through which technological option value becomes operational, linking PTA to Rapid Medical Innovation Response (RMIR).
Public support and innovation coordination	Public funding, procurement, regulatory support, and other institutional mechanisms can facilitate innovation development, scaling, and deployment (Merisalo et al., 2026; Osterholm et al., 2016).	These mechanisms are often examined as individual support instruments rather than as a coordinated institutional condition surrounding technological redeployment.	Introduces Coordinated Public Innovation Support (CPIS) as an institutional condition shaping how effectively redeployable capabilities can be translated into rapid response.
Medical preparedness	Medical preparedness depends on technological, scientific, clinical, and	Less attention has been given to whether preparedness investments	Reframes preparedness around preserved and redeployable technological

and rapid response	institutional capabilities developed before and during health emergencies (Feldmann et al., 2018; Osterholm et al., 2016).	preserve capabilities that remain useful across changing threats rather than only producing products for a specific threat.	capability, rather than only the stock of products or technologies available before a crisis.
Evidence on technological reuse in medical innovation	Ebola vaccine and countermeasure research demonstrates the practical importance of reusable and adaptable technological approaches (Feldmann et al., 2018; Henao-Restrepo et al., 2017).	The observable recurrence, repurposing, and recombination of technological architectures across medical countermeasure development remain less directly integrated into a broader theoretical model of redeployability.	Combines qualitative, experimental, and archival evidence to connect technological architecture, redeployability, institutional support, and rapid response.

3. Conceptual Framework and Hypotheses

3.1. Theoretical Foundations: Real Options Theory (ROT) and Technological Innovation Systems (TIS)

This study draws primarily on ROT to explain why platform-based medical technologies can be especially valuable under uncertainty. ROT views prior investments as creating options that can be exercised when future conditions become clearer (Sakhartov et al., 2026). In medical innovation, platform technology architectures can serve this role by preserving reusable technological components, scientific knowledge, development routines, and infrastructure across disease threats. Their value therefore lies not only in what they produce today, but also in the flexibility they retain for future, uncertain health emergencies (Kapacinskaite, 2026).

The ability to do that is captured by TR. A platform architecture produces value as long as the underlying capabilities of that architecture can be redirected toward new, emerging threats without having to restart the innovation process. Redeployability represents the practical capability of exercising the technological options that were embodied within prior platform investments from an ROT perspective (Trigeorgis & Reuer, 2017). This distinction is important because possessing flexible technology is not the same as being able to convert that flexibility into a rapid medical response.

To explain that conversion, we complement ROT with insights from TIS (Bergek et al., 2008). TIS emphasizes that innovation outcomes depend not only on technological characteristics but also on the institutional structures surrounding development, financing, regulation, experimentation, and diffusion (Chen et al., 2026). In our framework, CPIS represents this

institutional layer. Taken together, ROT explains how platform architectures create technological options, while TIS helps explain the conditions under which those options can be translated into rapid medical innovation (Table 2).

Table 2. Core Constructs, Theoretical Grounding, and Role in the Framework

Construct	Concise definition	Theoretical grounding
Platform Technology Architecture (PTA)	A technological design built around a reusable core that can support multiple medical products or disease targets while retaining common technological components, knowledge, routines, and infrastructure.	ROT: Prior platform investments preserve technological options and flexibility under uncertainty.
Technological Redeployability (TR)	The extent to which accumulated technological knowledge, development processes, manufacturing capabilities, and related infrastructure can be redirected or adapted to a new medical target.	ROT: Represents the practical capacity to exercise technological options when a new threat materializes.
Rapid Medical Innovation Response (RMIR)	The capacity to advance a medical countermeasure quickly enough to remain relevant to an emerging health threat.	ROT-informed outcome: Captures the realized response value created when technological flexibility is put into use.
Coordinated Public Innovation Support (CPIS)	The extent to which public funding, regulatory guidance, clinical-trial infrastructure, procurement, and related support are aligned around the innovation process.	TIS: Captures the institutional conditions that enable technological capabilities to move through development and translation.

Note. ROT provides the primary theoretical explanation for how platform architectures create and preserve technological options, and how redeployability enables those options to be exercised. TIS provides the complementary institutional lens for explaining how coordinated public support facilitates the translation of redeployable capabilities into rapid medical innovation.

3.2. Platform Technology Architecture and Technological Redeployability

PTA refers to a technological design built around a reusable core that can support multiple medical products or disease targets (Berends et al., 2026; Cao et al., 2026). Unlike pathogen-specific approaches, where much of the development process may need to be recreated for each new threat, platform architectures retain common technological components, production knowledge, development routines, and supporting infrastructure. The disease-specific element can change while important parts of the underlying system remain usable (Re et al., 2026; Yayavaram & Shi, 2026).

This distinction matters during outbreaks because uncertainty concerns not only when the next threat will occur, but also which pathogen will emerge. From a real-options perspective, investment in a platform therefore preserves future technological choices. The value of that flexibility becomes visible when a new threat appears and existing capabilities can be redirected rather than rebuilt (Kapacinskaite, 2026).

We capture this property through TR. TR reflects the extent to which accumulated technological knowledge, development processes, manufacturing capabilities, and related infrastructure can be adapted to a different medical target (Hoch et al., 2026; Kapacinskaite, 2026). PTA and TR are therefore related but distinct. PTA describes the architecture in which flexibility is embedded, whereas TR captures whether that flexibility can actually be used across threats.

Modularity, standardized processes, and a reusable technological backbone should reduce the amount of new development required when the target changes (Magrelli et al., 2026). Platform architectures should therefore increase the scope for transferring prior investments and capabilities to an emerging health threat (Schweitzer et al., 2026). This leads to our first hypothesis:

H1: *Platform Technology Architecture (PTA) positively affects Technological Redeployability (TR).*

3.3. Technological Redeployability and Rapid Medical Innovation Response

TR becomes valuable when previously developed knowledge, routines, infrastructure, and production capabilities can be applied to a newly emerging health threat (Sakhartov & Helfat, 2026). In such settings, innovation does not begin from a blank slate. Existing protocols, manufacturing processes, technical know-how, and development experience can be carried forward, reducing the amount of work that must be repeated (Qu et al., 2026; Ringov et al., 2026).

This reuse should matter directly for the speed of medical innovation. When a technology can be redeployed, development teams can move more quickly from threat identification to candidate adaptation, testing, manufacturing preparation, and clinical evaluation (Qu et al., 2026; Ringov et al., 2026). By contrast, low redeployability requires more extensive redesign and rebuilding, which can slow the response precisely when time is most valuable. We refer to this downstream capacity as RMIR, defined as the ability to advance a medical countermeasure quickly enough to remain relevant to an emerging health threat.

From a real-options perspective, TR represents the mechanism through which the flexibility embedded in prior technological investments becomes operationally useful (Trigeorgis &

Reuer, 2017). Platform architecture may create the option to respond, but the option has little value unless underlying capabilities can actually be redirected. Redeployability therefore provides the link between technological design and response speed.

This reasoning also implies an indirect relationship. Platform Technology Architecture should improve RMIR because it increases the extent to which prior capabilities can be redeployed. The effect of PTA on rapid response is therefore expected to operate, at least in part, through TR.

H2: *Technological Redeployability (TR) positively affects Rapid Medical Innovation Response (RMIR).*

H3: *Technological Redeployability (TR) mediates the relationship between Platform Technology Architecture (PTA) and Rapid Medical Innovation Response (RMIR).*

3.4. Coordinated Public Innovation Support as a Boundary Condition

Technological redeployability does not by itself guarantee a rapid medical response (Kruse et al., 2026). A technology may be adaptable, yet its development can still be slowed by fragmented funding, uncertain regulatory pathways, limited trial capacity, weak procurement signals, or poor coordination across public agencies (Arslan & Tarakci, 2022; Doms et al., 2026). The value of redeployability therefore depends partly on the institutional environment in which it is exercised (Acerenza et al., 2026; Grimshaw & Miozzo, 2026).

We define CPIS as the extent to which public funding, regulatory guidance, clinical-trial infrastructure, procurement, and related support are aligned around the innovation process. This coordination matters because redeployment often requires several complementary actions to occur within a short period. Funding must become available, regulatory expectations must be clear, trial infrastructure must be accessible, and organizations need confidence that development efforts can progress beyond the laboratory (Merisalo et al., 2026; Osterholm et al., 2016).

The Technological Innovation Systems perspective helps explain this boundary condition. Innovation depends not only on the availability of technology, but also on whether supporting institutions reduce uncertainty and connect complementary resources (Alao et al., 2026; Bergek et al., 2008). When CPIS is high, redeployable capabilities will be less difficult to turn on and

deploy through a development process. However, under a fragmented support environment, this technological flexibility could also be underutilized, or it could take longer for an appropriate response to occur.

The above reasoning indicates that CPIS should improve the relationship between TR and Rapid Medical Innovation Response. It also extends to the full mechanism proposed in this study. If PTA creates greater redeployability, and coordinated public support helps convert that redeployability into action, then the indirect effect of PTA on RMIR through TR should be stronger when CPIS is high.

H4: *Coordinated Public Innovation Support (CPIS) positively moderates the relationship between Technological Redeployability (TR) and Rapid Medical Innovation Response (RMIR), such that the relationship is stronger when CPIS is high.*

H5: *The indirect effect of Platform Technology Architecture (PTA) on Rapid Medical Innovation Response (RMIR) through Technological Redeployability (TR) is stronger when Coordinated Public Innovation Support (CPIS) is high rather than low.*

Figure 1 integrates the proposed relationships among Platform Technology Architecture, Technological Redeployability, Rapid Medical Innovation Response, and Coordinated Public Innovation Support. The model illustrates TR as the central mechanism linking platform architecture to rapid response and CPIS as the proposed institutional boundary condition.

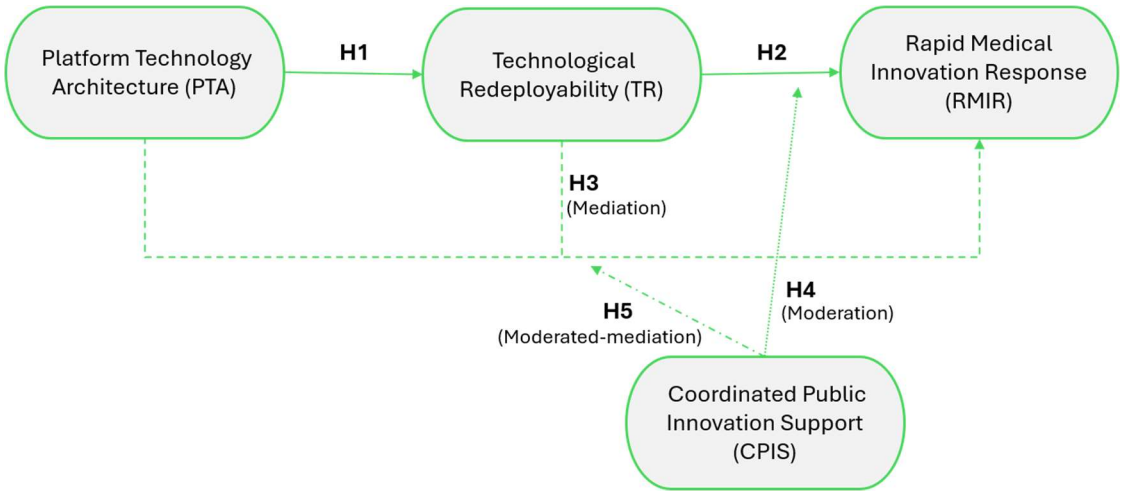


Figure 1. Conceptual Model

4. Multi-Study Research Design

4.1. Study Sequence and Evidentiary Logic

This study uses three complementary designs to examine the proposed mechanism from different forms of evidence. The studies were organized sequentially, moving from qualitative grounding to controlled testing and then to real-world archival validation. This structure was chosen because no single method can establish whether platform-based medical innovation is meaningful to practitioners, whether the proposed relationships can be detected under controlled conditions, and whether related technological patterns are visible in actual medical innovation.

Study 1 uses expert interviews to ground the constructs and clarify how technological architecture, redeployability, rapid response, and public coordination operate in practice. Study 2 then moves to a randomized 2 × 2 scenario experiment in which Platform Technology Architecture and Coordinated Public Innovation Support are manipulated while the broader outbreak setting is held constant. The experiment therefore provides a more controlled test of the proposed mechanism. Because Technological Redeployability is measured rather than experimentally assigned, the mediation evidence is interpreted as evidence on the mechanism rather than as a fully identified causal effect of TR.

Study 3 shifts from respondent-level evidence to observable medical innovation activity. Using interventional Ebola trials registered in ClinicalTrials.gov, we examine the presence and recurrence of reusable technological architectures, repurposing, and technological recombination. The archival indicators are not treated as direct measures of PTA, TR, or RMIR. Instead, Study 3 asks whether the technological patterns motivating the framework are visible in real-world countermeasure development. The three studies therefore contribute different but complementary evidence rather than serving as direct replications of one another. All quantitative analyses for Studies 2 and 3 were conducted using R (R Core Team, 2026).

4.2. Context Selection and Cross-Study Complementarity

The empirical settings also vary intentionally across studies. Study 1 includes 23 experts from Uganda, Nigeria, Ghana, Morocco, and the United Kingdom. The sample provides variation in outbreak-response experience, preparedness, biomedical research, clinical development, regulation, and public innovation policy. Uganda and Nigeria contribute substantial direct

response perspectives, while Ghana and Morocco broaden the preparedness and biomedical-development context. The United Kingdom adds expertise from biotechnology, clinical development, and global health policy. The purpose of this variation is analytical breadth rather than national representativeness.

For Study 2, the country sample was limited to Ghana, Nigeria, and Uganda. The final sample consisted of 312 participants who were approximately evenly distributed across Nigeria (n = 105), Ghana (n = 104), and Uganda (n = 103), and evenly distributed across the four treatment conditions (n = 78 per condition). Limiting the number of countries selected reduced cross-country variability from the qualitative study but retained respondents with relevant knowledge of the biomedical field, public health, regulation, and preparedness. More importantly, random assignment allows the experiment to separate the effects of the focal technology and public-support conditions from differences in the underlying scenario.

Study 3 does not select respondents by country. It follows the technology itself through 107 interventional Ebola medical-countermeasure trials. This shift is useful because it moves the analysis beyond perceptions and experimentally constructed scenarios to documented innovation activity. Taken together, the design combines contextual depth, experimental control, and archival realism. Convergence across these forms of evidence provides a stronger basis for evaluating the proposed mechanism than reliance on any one study alone (Table 3).

Table 3. Multi-Study Research Design and Evidentiary Role

Study	Design and setting	Primary purpose	Evidentiary contribution
Study 1	23 expert interviews: Uganda (7), Nigeria (6), Ghana (4), Morocco (3), UK (3)	Ground constructs and clarify technological and institutional mechanisms	Contextual and construct grounding
Study 2	Randomized 2 × 2 experiment, (N=312): Nigeria (105), Ghana (104), Uganda (103)	Test PTA, TR, RMIR, CPIS, and the proposed mediation/moderation mechanism	Controlled experimental evidence
Study 3	107 interventional Ebola medical-countermeasure trials from ClinicalTrials.gov	Examine reusable architectures, repurposing, recurrence, and technological recombination in real-world development	Archival validation

Note. The three studies provide complementary rather than identical tests. Study 3 uses observable archival indicators and does not treat registry-based measures as direct equivalents of the constructs examined in Study 2.

5. Study 1: Expert Interviews and Model Development

5.1. Research Design and Expert Sample

Study 1 used a qualitative expert-interview design to identify the technological and institutional mechanisms that shape rapid medical innovation under outbreak conditions. Potential participants were identified through institutional contacts and the researchers' existing professional contacts in relevant biomedical, public-health, regulatory, policy, and innovation domains (Appendix A). The aim was not statistical representation, but to capture informed views from actors involved in different parts of the medical innovation and preparedness system.

The final sample comprised 23 experts from five countries: Uganda (n = 7), Nigeria (n = 6), Ghana (n = 4), Morocco (n = 3), and the United Kingdom (n = 3). Participants included infectious-disease physicians, biomedical and clinical researchers, epidemiologists, public-health and health-policy professionals, regulatory specialists, NGO and global-health experts, and professionals working in pharmaceutical, biotechnology, and clinical development. Their experience ranged from 8 to 19 years, with a mean of approximately 13 years.

The sample combined respondents with direct outbreak-response experience with others engaged in vaccine and therapeutic development, clinical trials, regulation, health policy, and platform-technology innovation. This heterogeneity allowed us to examine the proposed mechanism from scientific, operational, regulatory, and public-support perspectives rather than from a single professional setting (Table 4).

Table 4. Expert Interview Sample

Characteristic	Category	*n*
Country	Uganda	7
	Nigeria	6
	Ghana	4
	Morocco	3
	United Kingdom	3
Organization type	Government	7
	University	5
	Hospital/research center	3
	Pharmaceutical firm	3
	NGO	2
	CRO	1
	Biotechnology firm	1
	Research institute	1
Interview mode	Face-to-face	12
	Online	11

Note. $N = 23$. Professional experience ranged from 8 to 19 years ($M = 13.09$). Interviews lasted 39–54 minutes ($M = 45.96$ minutes).

5.2. Interview Procedure and Data Collection

Interviews were conducted between 8 March and 20 May 2026 using a semi-structured format. Twelve interviews were conducted face-to-face and eleven online. Sessions lasted between 39 and 54 minutes, with an average duration of approximately 46 minutes. The interview guide focused on how medical technologies can be adapted across disease threats, what enables or constrains technological redeployment, how public institutions support this process, and how these conditions affect the speed of medical innovation.

Participants were encouraged to draw on concrete experience from outbreak response, biomedical R&D, clinical development, regulation, and health-system preparedness. The semi-structured format provided consistency across interviews while leaving room for respondents to elaborate on mechanisms and examples relevant to their own professional settings. Transcripts were available for all 23 interviews and formed the basis for the subsequent qualitative analysis.

5.3. Qualitative Coding and Analytical Procedure

We analyzed the interview material using a Gioia-inspired coding procedure. The first stage stayed close to participants' language and identified first-order concepts around technology reuse, modularity, redeployment, innovation speed, and public coordination. Related concepts were then grouped into second-order themes and progressively consolidated into broader aggregate dimensions. This process yielded four central dimensions: Platform Technology Architecture (PTA), Technological Redeployability (TR), Rapid Medical Innovation Response (RMIR), and Coordinated Public Innovation Support (CPIS). A smaller set of observations captured the conditional role of CPIS in translating redeployability into rapid innovation response.

From the 23 (interview) transcripts, we selected forty representative quotes to be used in our qualitative coding framework. The number of quotes per individual (interview) ranged from one quote to multiple quotes; each quote was treated as an independent coding unit which was then categorized into a first-order concept, a second order theme, and an aggregate dimension. Two coders independently coded all forty coded units (Appendix A, Table A2). Initial

agreement was reached for 38 excerpts, corresponding to 95% agreement. The two disagreements concerned the distinction between technology architecture and redeployability, and between redeployability and institutional support. These cases were revisited using the quotation context and coding memos until a common interpretation was reached. The resulting structure linked informant-level observations to the constructs and relationships examined in the subsequent experimental study (Table 5).

Table 5. Qualitative Data Structure and Emergent Constructs

Representative first-order concepts	**Second-order themes**	**Aggregate dimension**	**Theoretical role**
Reuse of common technological core; changing disease-specific modules; shared development infrastructure; avoiding complete redesign	Modularity, adaptability, reusable architecture, platform continuity	Platform Technology Architecture (PTA)	Technological architecture enabling reuse
Transfer of existing knowledge; reuse of protocols and know-how; redirecting technology with limited changes; transferable clinical and manufacturing knowledge	Cross-pathogen transferability, capability redeployment, operational flexibility	Technological Redeployability (TR)	Mechanism linking platform architecture to response
Faster movement from threat identification to development; accelerated clinical progression; timely translation into operational response	Innovation translation speed, clinical acceleration, rapid translational activation	Rapid Medical Innovation Response (RMIR)	Outcome
Coordination of funding, regulation, trials, and procurement; shared priorities across agencies; aligned preparedness infrastructure	Integrated public innovation support, policy coordination, institutional enablement	Coordinated Public Innovation Support (CPIS)	Institutional boundary condition
Technology works faster when regulatory and funding systems support redeployment; flexible platforms need coordinated institutional activation	Technology-policy complementarity; exercise of technological options	Conditional Translation of Redeployability	Empirical basis for CPIS moderation

5.4. From Expert Evidence to the Conceptual Model

The interviews provided a consistent account of how technological flexibility becomes useful during an emerging health threat. Experts distinguished between technologies built around a single pathogen and architectures designed around a reusable technological core. The latter were seen as preserving knowledge, development infrastructure, delivery systems, and other capabilities that could be redirected rather than rebuilt. This distinction gave empirical grounding to PTA and its proposed link with TR.

One vaccine researcher explained, "A platform is useful because the same core technology can be adjusted rather than rebuilt from the beginning" (INT03, Uganda).

A second pattern concerned what happens after a technology becomes redeployable. Participants associated reuse of accumulated knowledge, protocols, manufacturing capabilities, and development processes with faster movement toward clinical evaluation and usable countermeasures. These observations informed RMIR as the downstream outcome of redeployability.

A clinical researcher noted, "We respond faster when protocols, assays, and development know-how can be reused with only limited modification" (INT05, Uganda).

At the same time, respondents repeatedly stressed that technological readiness alone was insufficient. Fragmented funding, regulatory processes, trial infrastructure, and institutional priorities could slow an otherwise adaptable technology. Conversely, coordinated public support helped convert technological flexibility into action.

A health-policy expert observed, "A flexible technology creates possibilities, while coordinated public support determines how quickly those possibilities become real programs" (INT13, Nigeria).

This evidence sharpened the role of CPIS as a boundary condition on the TR to RMIR relationship.

Taken together, the qualitative evidence supported a process in which platform architecture creates redeployment potential, redeployability facilitates faster medical innovation, and coordinated public support affects how effectively that potential is realized. Study 1 therefore provided empirical grounding for the four constructs and the mechanism examined more formally in Study 2.

6. Study 2: Randomized 2×2 Experiment

6.1. Experimental Design and Procedure

Study 2 used a randomized between-subjects 2 × 2 factorial experiment to test how technology architecture and public innovation support shape medical innovation responses. The technology architecture factor was manipulated as a first factor through two different

approaches: by developing a ‘pathogen specific’ approach versus a ‘platform based’ approach. The public innovation support factor was manipulated in the second factor through two different types of public innovation support: ‘fragmented support’ versus ‘coordinated support’. Thus, four experimental conditions resulted from the manipulation of these factors: (1) Pathogen Specific / Fragmented; (2) Pathogen Specific / Coordinated; (3) Platform / Fragmented; and (4) Platform / Coordinated.

Participants were randomly assigned to each of the conditions, and then participants received a case description that described an emerging infectious disease threat, and how a medical countermeasure could be developed. The underlying outbreak context, development stage, organizational setting, resource availability, and time pressure were held constant across conditions. Only the two focal elements, technology architecture and the structure of public innovation support, varied between scenarios. This design allowed us to isolate the effects associated with each experimental factor while limiting alternative explanations arising from differences in the scenario itself.

After reading the assigned scenario, participants completed manipulation-check items assessing their perception of the technology architecture and public support environment. They then evaluated TR and RMIR using multi-item measures. Scenario realism, clarity, and credibility were assessed separately, followed by an attention check and background questions. Responses were recorded on seven-point scales unless otherwise specified.

The factorial design was chosen because it permits simultaneous examination of the effect of platform technology on redeployability and whether coordinated public support changes the extent to which redeployable technological capabilities translate into rapid medical innovation.

6.2. Sample and Data Screening

The experiment initially included 332 respondents drawn from Ghana, Nigeria, and Uganda. After data-quality screening, 20 cases were removed, leaving a final analytical sample of 312 respondents. The retained sample was evenly distributed across the four experimental conditions, with 78 respondents in each cell.

The screening process removed eight respondents who failed the attention check, five incomplete responses, four incomplete manipulation-check responses, and three cases where

straightlining was found. The sample was approximately evenly distributed across countries, with 105 respondents from Nigeria, 104 from Ghana, and 103 from Uganda. The randomization checks indicated no significant differences between conditions for years of experience, country, role of respondent, or type of industry, thus supporting that the assignment procedure was sufficient.

For the main analyses, we therefore used the final sample of N = 312. This sample provided a balanced basis for estimating the main, mediation, and interaction effects specified in the study.

6.3. Experimental Manipulations and Measures

The experiment manipulated two features of the innovation environment. Technology Architecture contrasted a pathogen-specific architecture with a platform architecture. In the pathogen-specific condition, the technology was developed around a single disease target. The platform condition instead described a reusable technological base that could be adapted across pathogens. CPIS contrasted fragmented public support with an environment in which funding, regulatory guidance, trial infrastructure, and related support were coordinated around the innovation process.

Two items assessed each manipulation. TR was measured with four items capturing the extent to which an existing technological base could be adapted, reconfigured, and reused for a new health threat. RMIR was measured with four items assessing the capacity to move rapidly from an emerging threat toward the development and advancement of a medical countermeasure. Composite scores were calculated by averaging the respective items.

We also measured scenario realism, clarity, and credibility to assess whether participants viewed the experimental setting as plausible and understandable. Unless otherwise noted, all perceptual measures used seven-point response scales.

6.4. Measurement Quality and Manipulation Checks

6.4.1. Measurement Quality

The measurement model performed well. Cronbach's alpha was .936 for TR and .950 for RMIR, and all standardized factor loadings were high, ranging from .871 to .903 for TR and from .904 to .916 for RMIR. Composite reliability was .936 for TR and .950 for RMIR, while

AVE values were .786 and .825, respectively. The latent correlation between TR and RMIR was .464, below the square roots of AVE for both constructs (.886 and .908), supporting discriminant validity. A two-factor CFA also fit the data well, $X^2(19) = 35.01$, $p = .014$, CFI = .993, TLI = .990, RMSEA = .053, and SRMR = .027. The competing one-factor model fit substantially worse, with CFI = .562, TLI = .387, RMSEA = .409, and SRMR = .234, providing further evidence that TR and RMIR capture distinct constructs (Fornell & Larcker, 1981) (Table 6).

Table 6. Measurement Quality

Panel A. Reliability and Convergent Validity

Construct	Items	Loading range	α	CR	AVE	√AVE
TR	4	.871–.903	.936	.936	.786	.886
RMIR	4	.904–.916	.950	.950	.825	.908

Panel B. Confirmatory Factor Analysis

Model	χ^2	df	CFI	TLI	RMSEA	SRMR
Two-factor TR–RMIR	35.01	19	.993	.990	.053	.027
One-factor model	1096.90	20	.562	.387	.409	.234

6.4.2. Manipulation and Scenario Checks

The experimental manipulations were effective. Participants in the platform condition reported much higher perceived platform architecture than those in the pathogen-specific condition (M = 5.82 vs. M = 2.16; mean difference = 3.66, p < .001). Similarly, perceived public-support coordination was higher in the coordinated condition than in the fragmented condition (M = 5.76 vs. M = 2.19; mean difference = 3.57, p < .001). The nonfocal factor was nonsignificant in both manipulation checks, and the interaction between the two experimental factors was also nonsignificant (PTA check: p = .054; CPIS check: p = .247). The manipulation-check scales showed high reliability (Spearman–Brown = .957 for PTA and .959 for CPIS). Both experimental manipulations were successful and operated as intended.

Scenario evaluations were also favorable. Mean ratings for realism, clarity, and credibility were 5.60, 5.88, and 5.43, respectively, and none varied significantly across the experimental conditions. Together, these tests indicate that the measures were reliable, empirically distinct, and responsive to the intended manipulations (Table 7).

Table 7. Manipulation and Scenario Checks

Panel A. Manipulation Checks

Manipulation	Low condition M	High condition M	Mean difference	*p*	SB
PTA	2.160	5.817	3.657	<.001	.957
CPIS	2.189	5.760	3.571	<.001	.959

Panel B. Scenario Checks

Check	M	SD	PTA *p*	CPIS *p*	PTA × CPIS *p*
Realism	5.596	.659	.274	.713	.864
Clarity	5.878	.650	.324	.332	.389
Credibility	5.433	.754	.917	.281	.710

6.5. Empirical Strategy

We estimated the experimental effects using linear regression with HC3 heteroskedasticity-robust standard errors. For H1, TR was regressed on the randomized technology-architecture treatment while controlling for the second randomized factor, CPIS. For H2 and H4, RMIR was modeled as a function of PTA, TR, CPIS, and the TR × CPIS interaction. CPIS was effect-coded as −0.5 for fragmented support and +0.5 for coordinated support. This coding makes the coefficient on TR interpretable as its average association with RMIR across the two support conditions.

Mediation and moderated mediation were evaluated using 5,000 nonparametric bootstrap replications. H3 was assessed from the bootstrapped indirect effect of PTA on RMIR through TR. For H5, we estimated conditional indirect effects under fragmented and coordinated support and used the bootstrap confidence interval for the index of moderated mediation as the formal test. H4 was further examined through simple slopes of TR on RMIR at each CPIS condition.

The primary specifications rely on randomized assignment to PTA and CPIS. Because TR is measured rather than experimentally assigned, the mediation estimates are interpreted as evidence on the proposed mechanism rather than as a fully identified causal effect of TR. As supplementary checks, we re-estimated the main models with country, professional experience, respondent role, and industry controls (Appendix B).

6.6. Hypothesis Tests

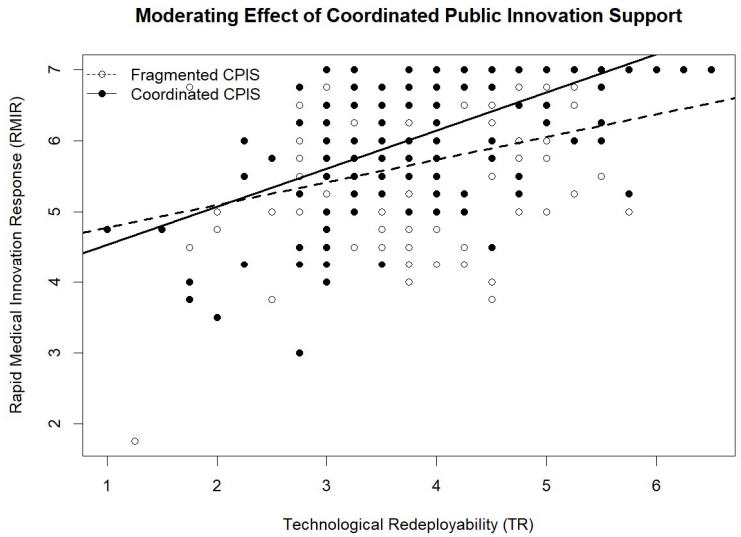
The hypothesis tests produced a clear but mixed pattern of results. First, assignment to the platform-technology condition increased Technological Redeployability. The estimated effect

of PTA on TR was positive and significant (b = .277, HC3 SE = .105, p = .009, 95% CI [.071, .483]), supporting H1. TR, in turn, was positively associated with Rapid Medical Innovation Response (b = .428, HC3 SE = .059, p < .001, 95% CI [.312, .543]), providing support for H2.

The mediation test also supported the proposed mechanism. The average indirect effect of PTA on RMIR through TR was .119, with a 95% bootstrap confidence interval of [.028, .218]. Because the interval excluded zero, H3 was supported. Notably, the total effect of PTA on RMIR was not statistically significant, which does not preclude mediation when the indirect pathway is estimated directly.

Evidence for the moderating role of Coordinated Public Innovation Support was weaker. The TR × CPIS interaction was positive (b = .218) but did not reach the conventional significance threshold (p = .061, 95% CI [−.010, .446]). H4 was therefore not supported in the primary specification. The simple-slope estimates nevertheless followed the predicted direction. TR was positively related to RMIR under fragmented support (b = .319, p = .001) and the association was larger under coordinated support (b = .537, p < .001) (Figure 2).

Figure 2. Moderating Effect of Coordinated Public Innovation Support on the Relationship Between Technological Redeployability and Rapid Medical Innovation Response



Note. Solid line represents coordinated CPIS and dashed line represents fragmented CPIS. The interaction pattern is consistent with the hypothesized direction, although the primary TR × CPIS interaction did not reach the conventional significance threshold (b = .218, p = .061).

A similar pattern emerged for H5. The indirect effect of PTA through TR was significant under both fragmented support (b = .088, 95% bootstrap CI [.015, .190]) and coordinated support (b

= .149, 95% CI [.036, .266]). However, the index of moderated mediation was .060 and its confidence interval crossed zero (95% CI [−.003, .145]). H5 was therefore not supported.

Overall, the results support the core pathway from platform architecture to redeployability and from redeployability to rapid innovation response, while the evidence for CPIS as a boundary condition is suggestive rather than conclusive in the primary model (Table 8).

Table 8. Summary of Study 2 Hypothesis Tests

H#	Hypothesized relationship	Estimate	SE	95% CI	Evidence	Conclusion
H1	PTA → TR	.277	.105	[.071, .483]	$p = .009$	Supported
H2	TR → RMIR	.428	.059	[.312, .543]	$p < .001$	Supported
H3	PTA → TR → RMIR	.119	.049†	[.028, .218]†	Bootstrap CI excludes 0	Supported
H4	TR × CPIS → RMIR	.218	.116	[−.010, .446]	$p = .061$	Not supported
H5	Index of moderated mediation	.060	.039†	[−.003, .145]†	Bootstrap CI includes 0	Not supported

Note. N = 312. Regression estimates use HC3 heteroskedasticity-robust standard errors. † Bootstrap standard errors and percentile 95% confidence intervals are based on 5,000 bootstrap replications. H3 and H5 are evaluated from whether the respective bootstrap confidence intervals exclude zero.

6.7. Robustness and Additional Analyses

We examined whether the main findings were sensitive to observed respondent characteristics. The models were re-estimated with controls for country, years of professional experience, respondent role, and industry type. The PTA effect on TR remained positive and significant ($b = .261$, $p = .020$), and the association between TR and RMIR was also stable ($b = .421$, $p < .001$). These estimates closely track the primary results, suggesting that H1 and H2 are not driven by differences in respondent composition.

The moderation result showed greater sensitivity to specification. Once the same covariates were included, the TR × CPIS interaction became positive and statistically significant ($b = .277$, $p = .022$). This result is consistent with the proposed moderating pattern, but we treat it as supplementary evidence because the interaction did not reach the conventional significance threshold in the primary specification ($p = .061$). The inference for H4 therefore remains based on the primary model.

We also examined model diagnostics. The Breusch–Pagan test yielded $p = .377$ for the H1 model and $p = .063$ for the H2/H4 model. Accordingly, all focal regressions were estimated using HC3 heteroskedasticity-robust standard errors. Cook's distance was used to identify

potentially influential observations; these diagnostics were treated as sensitivity indicators rather than grounds for mechanical case deletion. Finally, the total effect of PTA on RMIR was not statistically significant, consistent with an indirect rather than simple direct-effect pattern (Table 9).

Table 9. Covariate-Adjusted Robustness Models

Effect	Primary estimate	Adjusted estimate	Robust SE	95% CI	*p*	Interpretation
PTA → TR	.277	.261	.111	[.042, .479]	.020	Remains significant
TR → RMIR	.428	.421	.061	[.302, .540]	< .001	Remains significant
TR × CPIS → RMIR	.218	.277	.120	[.041, .513]	.022	Significant in adjusted model

7. Study 3: Archival Validation Using Real-World Ebola Medical Innovation

7.1. Data Source and Sample

Study 3 provides an archival check of whether the technological patterns identified in Studies 1 and 2 are visible in real-world medical innovation. We used ClinicalTrials.gov (U.S. National Library of Medicine, 2026), a public registry of clinical studies, and focused on studies related to Ebola virus disease. This setting is useful because Ebola response has involved repeated efforts to develop vaccines and therapeutics under substantial time, scientific, and coordination constraints (Mulangu et al., 2019; Wright et al., 2021).

The initial search returned 130 registered studies. We applied predefined eligibility criteria to retain interventional studies involving Ebola medical countermeasures. We excluded 23 records comprising observational studies, expanded-access records, and interventions unrelated to Ebola countermeasure development, including three interventional records focused on psychosocial support, cataract surgery among Ebola survivors, and a non-Ebola respiratory viral intervention. This screening produced a final analytical sample of 107 trials.

The sample covers several forms of medical innovation. Vaccines account for 81 trials (75.7%), followed by drug or antiviral therapies (14; 13.1%), antibody therapies (9; 8.4%), and plasma or blood-based therapies (3; 2.8%). Rather than treating each trial as evidence of a unique innovation, we subsequently coded the underlying technological architecture and whether technologies appeared in reusable, repurposed, or multi-technology configurations. This allows

the archival analysis to examine observable manifestations of technological reuse and redeployment without treating registry indicators as direct measures of the Study 2 constructs.

7.2. Archival Operationalization

Because registry data do not directly measure the constructs examined in Study 2, we operationalized observable technological indicators rather than treating them as equivalent measures of PTA, TR, or RMIR. Coding drew on study titles, registered interventions, and brief study descriptions. Each trial was first classified by countermeasure type and primary technology family. We then identified whether the intervention used a reusable technological architecture, including viral-vector, DNA, and mRNA platforms, or involved the repurposing of an existing therapeutic for Ebola. Specific technology architectures were coded separately from this broader classification; consequently, the presence of a specific architecture indicator did not by itself determine whether a trial was classified as reusable/platform.

To capture technological reuse more directly, we also coded the presence of specific architectures independently rather than forcing each trial into a single category. These included rVSV, Ad26, Ad5, chimpanzee adenovirus, MVA, HPIV3, DNA, mRNA, and antibody technologies (Zhu et al., 2017). This non-mutually-exclusive coding matters because a single trial can combine several technological components. We therefore identified multi-technology trials as those containing two or more coded technologies. Finally, technology recurrence across registered trials was used as archival evidence that an architecture was repeatedly deployed rather than appearing as a one-off intervention.

These indicators provide a real-world complement to the experimental evidence. They capture observable patterns of technological reuse, repurposing, and recombination, while avoiding the stronger claim that archival records directly measure the latent mechanisms tested in Study 2 (Appendix C).

7.3. Analysis and Results

We first examined the prevalence and recurrence of reusable technologies, followed by trial-level comparisons between platform-based and other countermeasures. Of the 107 trials, 78 (72.9%) used a reusable platform architecture, while 10 (9.3%) involved repurposed therapeutics. Overall, 88 trials (82.2%) met the broader reusable-or-repurposed technology

indicator. Recombination was also common: 32 trials (29.9%) incorporated two or more coded technologies.

The architecture-level results show that reuse was not concentrated in a single technology. rVSV appeared in 27 trials (25.2%), followed by MVA (24; 22.4%), Ad26 (23; 21.5%), and chimpanzee adenovirus (21; 19.6%). Among multi-technology trials, Ad26 + MVA was the most frequent configuration (20 of 32; 62.5%). Multi-technology configurations were observed in 19.6% of Phase 1, 37.1% of Phase 2, and 47.1% of Phase 3 trials, showing that technological combination was represented across multiple development phases (Table 10).

Table 10. Archival Profile of Technology Reuse and Recombination in Ebola Medical Innovation

Archival indicator	*n*	% of trials
Panel A. Sample and countermeasure profile		
Final analytical sample	107	100.0
Vaccine	81	75.7
Drug/antiviral therapy	14	13.1
Antibody therapy	9	8.4
Plasma/blood-based therapy	3	2.8
Panel B. Reuse and recombination indicators		
Reusable/platform architecture	78	72.9
Repurposed therapeutic	10	9.3
Reusable-or-repurposed technology	88	82.2
Multi-technology trial	32	29.9
Multicountry trial	18	19.4
Panel C. Technology architectures*		
rVSV	27	25.2
MVA	24	22.4
Ad26	23	21.5
Chimpanzee adenovirus	21	19.6
Antibody	9	8.4
Ad5	4	3.7
DNA	4	3.7
HPIV3	2	1.9
mRNA	2	1.9

Notes. *N* = 107 interventional Ebola medical-countermeasure trials. Percentages in Panel A are mutually exclusive and sum to 100%. Technology architectures in Panel C are coded independently and are therefore not mutually exclusive; a trial may contain more than one architecture. Reusable-or-repurposed technology is an archival indicator and should not be interpreted as a direct measure of technological redeployability (TR). Multicountry status was available for 93 trials; the multicountry percentage is therefore based on the 93 trials with nonmissing information.

We next compared platform/reusable trials with other countermeasures. Platform trials had larger median enrollment (113.5 vs. 38 participants; Wilcoxon $p = .002$) and longer median registered duration (14.6 vs. 9.3 months; $p = .039$). Development phase did not differ between the groups (median = 2.0 in both; $p = .910$), nor did multicountry participation (Fisher's exact $p = 1.000$). These patterns should not be read causally. Rather, they show that reusable

architectures were represented in trials spanning different development phases and were not confined to trials with smaller enrollment or shorter registered duration (Table 11).

Table 11. Platform Architecture and Trial Characteristics

Trial characteristic	Platform/reusable (*n* = 78)	Other countermeasure (*n* = 29)	Test	*p*-value
Enrollment, median	113.5	38.0	Wilcoxon rank-sum	.002
Trial duration (months), median	14.6	9.3	Wilcoxon rank-sum	.039
Development phase, median	2.0	2.0	Wilcoxon rank-sum	.910
Multicountry trial, *n/N* (%)	14/70 (20.0%)	4/23 (17.4%)	Fisher's exact	1.000

Notes. *N* = 107. Platform/reusable status identifies trials involving a coded reusable technological architecture. Enrollment, trial duration, and development phase are reported as medians. Wilcoxon rank-sum tests are used for continuous/ordinal comparisons; Fisher's exact test is used for multicountry status. Tests are two-sided. These comparisons are observational and should not be interpreted as causal effects. For multicountry trials, n/N denotes the number of multicountry trials divided by the number of trials with nonmissing multicountry information (70 platform/reusable and 23 other countermeasure trials).

The prevalence of technological reuse was also robust to excluding the four records whose technology family remained unspecified. In this restricted sample (N = 103), 75.7% used reusable/platform architectures and 85.4% met the broader reusable-or-repurposed indicator. Taken together, the archival evidence complements Studies 1 and 2 by showing that reuse, recurrence, and technological recombination are observable features of real-world Ebola medical innovation.

8. Integrating Evidence Across Studies

Across the three studies, a common pattern emerges: the value of platform-based medical innovation lies not simply in having a reusable technology, but in whether prior technological capabilities can be redirected when a new health threat appears. Each study approaches this mechanism differently. Study 1 provides the qualitative grounding, Study 2 tests the proposed relationships under controlled conditions, and Study 3 examines whether related patterns of technological reuse and recombination are visible in actual medical-countermeasure development. The studies therefore offer complementary rather than identical tests of the framework.

Study 1 shows how experts distinguish technological architecture from its practical redeployment. Respondents described reusable technological cores, transferable development

knowledge, and the ability to retain manufacturing, clinical, and scientific capabilities across changing disease targets. They also emphasized that technological readiness alone may be insufficient when funding, regulation, trial infrastructure, and other forms of public support are fragmented. These observations provided empirical grounding for PTA, TR, RMIR, and CPIS, as well as for the proposed role of public coordination in translating technological flexibility into response.

Study 2 provides the clearest test of the core mechanism. Assignment to the platform-technology condition increased Technological Redeployability, supporting H1, and TR was positively associated with Rapid Medical Innovation Response, supporting H2. The indirect effect of PTA on RMIR through TR was also significant, providing support for H3. Evidence for the institutional boundary condition was less definitive. The TR × CPIS interaction followed the predicted positive direction but did not reach the conventional significance threshold in the primary specification, and the index of moderated mediation also included zero. H4 and H5 were therefore not supported in the primary analysis. At the same time, the simple slopes were stronger under coordinated support, and the interaction became significant in the covariate-adjusted specification. We therefore interpret CPIS as a plausible boundary condition for which the present evidence is suggestive rather than conclusive.

Study 3 shifts the analysis to documented Ebola medical innovation. Of 107 interventional medical-countermeasure trials, 78 involved a reusable platform architecture and 10 involved repurposed therapeutics. Overall, 88 trials met the broader reusable-or-repurposed criterion, while 32 combined two or more coded technologies. Recurrent use of rVSV, MVA, Ad26, chimpanzee adenovirus, and other architectures further shows that technological reuse was not confined to isolated interventions. These archival patterns do not directly measure PTA, TR, RMIR, or CPIS, nor do they provide a causal test of the relationships examined in Study 2. They do, however, show that reuse, recurrence, and technological recombination are observable features of real-world countermeasure development.

Taken together, the evidence is strongest for the central technological pathway. Platform architecture appears to create value when it preserves capabilities that can be redeployed across uncertain threats, and redeployability is associated with faster innovation response. The evidence also points to an institutional qualification: technological flexibility may create an option to respond, but exercising that option can depend on the surrounding support system. The studies thus shift attention from whether a platform exists to a broader question of whether

technological and institutional capabilities can be mobilized together when uncertainty resolves into an actual health emergency (Table 12).

Table 12. Integrated Evidence and Main Findings Across Studies

Study	Empirical basis	Main findings	What the study adds
Study 1: Expert Interviews	23 experts across Uganda, Nigeria, Ghana, Morocco, and the UK	Experts consistently identified reusable technological cores, transferable development knowledge, redeployable capabilities, rapid-response value, and the importance of coordinated public support	Grounds PTA, TR, RMIR, and CPIS in practitioner experience and clarifies the mechanism linking technology architecture to rapid response
Study 2: Randomized Experiment	2 × 2 experiment, N=312, Ghana, Nigeria, and Uganda	Platform architecture increased TR; TR was positively associated with RMIR; the indirect PTA → TR → RMIR pathway was supported. The coordinated-support pattern was stronger in the predicted direction and became significant in the adjusted specification	Provides controlled evidence for the core technological pathway and shows how public coordination may strengthen the conversion of redeployability into rapid response
Study 3: Archival Validation	107 interventional Ebola medical-countermeasure trials from ClinicalTrials.gov	78 trials used reusable/platform architectures, 88 were reusable or repurposed, and 32 combined multiple technologies. Recurrent use of rVSV, MVA, Ad26, and other architectures was visible across development activity	Shows that reuse, recurrence, repurposing, and technological recombination are observable features of real-world medical innovation

Note. The three studies use different forms of evidence and are designed to complement one another. Study 3 provides archival validation of observable technological patterns rather than direct measurement of the Study 2 constructs.

9. Discussion and Implications

The combined evidence points to a broader way of understanding preparedness-oriented medical innovation. The central issue is not simply whether an innovation system possesses advanced technologies, but whether those technologies preserve capabilities that remain usable when the nature of the next threat changes. This shifts attention from individual products toward the architecture of technological capability and the conditions under which that capability can be activated. Our findings further suggest that technological flexibility and institutional support should not be considered separately. Platform architectures can preserve future response options, but the value of those options depends on whether accumulated capabilities can be redeployed and connected to the funding, regulatory, clinical, and implementation systems needed for action. This perspective has implications for both theories of innovation under uncertainty and the design of preparedness within the U.S. medical innovation system. We develop these implications below.

9.1. Theoretical Contributions

This study makes three theoretical contributions to research on medical innovation and preparedness. First, it shifts attention from the existence of a platform technology to the redeployability of the capabilities embedded within it. Prior work often treats platforms as reusable technological assets (Lehmann et al., 2025). Our framework separates PTA from TR. PTA captures the design characteristics that preserve flexibility, whereas TR captures whether accumulated knowledge, development routines, manufacturing capabilities, and infrastructure can actually be redirected when the disease target changes (Cao et al., 2026). This distinction helps explain why two technologies that both appear "platform-based" may differ substantially in their preparedness value (Desyllas et al., 2026).

Second, the study extends Real Options Theory by identifying technological redeployability as the mechanism through which option value becomes operational in medical innovation. Platform investments create flexibility before the nature of the next threat is known, but that flexibility becomes economically and clinically meaningful only when prior capabilities can be exercised against a newly emerging target. Study 2 provides evidence consistent with this mechanism: platform architecture increased TR, TR was positively associated with RMIR, and the indirect PTA → TR → RMIR pathway was supported. This moves the real-options argument beyond the existence of flexibility toward the process through which preparedness investments generate response capacity.

Third, we connect this technological logic with the institutional perspective of Technological Innovation Systems. Medical innovation does not unfold through technology alone. Funding, regulation, clinical-trial infrastructure, procurement, and public coordination shape whether technological flexibility can be activated (Chen et al., 2026). Our framework therefore treats CPIS as a condition surrounding the exercise of technological options rather than simply another resource input. The primary experimental evidence for this boundary condition is more qualified than for the core technological pathway, although the interaction followed the predicted direction and became significant in the adjusted specification.

Together, these contributions suggest a broader view of medical preparedness. Theoretical attention should move from asking whether a system possesses promising technologies to asking whether it has architectures that preserve options, capabilities that can be redeployed, and institutions capable of activating those options when uncertainty resolves into an actual

health threat. The archival evidence from Ebola countermeasure development strengthens the practical relevance of this perspective by showing substantial recurrence, reuse, and recombination of technological architectures in real-world innovation activity.

9.2. Implications for the U.S. Medical Innovation System

The findings have direct implications for how preparedness investments are understood within the U.S. medical innovation system. The central issue is not simply the amount of science or technology available before an emergency. It is whether prior investments preserve capabilities that can be redirected once the nature of a threat becomes clear. This matters in a system where biomedical research, advanced countermeasure development, regulation, clinical evaluation, manufacturing, and procurement involve different public and private actors. NIH supports biomedical research, BARDA focuses on advanced development of medical countermeasures, including emerging infectious-disease threats, and FDA provides regulatory and emergency-use pathways for countermeasures (Biomedical Advanced Research and Development Authority, 2026; National Institutes of Health, 2026; U.S. Food and Drug Administration, 2026).

Our results suggest that preparedness portfolios can be evaluated not only by the products they generate, but also by the redeployable capability they leave behind. Investments in reusable architectures may preserve manufacturing knowledge, development routines, regulatory experience, and technical infrastructure that remain useful when the disease target changes. Study 2 supports this distinction: platform architecture increased technological redeployability, and redeployability was positively associated with rapid medical innovation response. Study 3 reinforces the practical relevance of this logic by documenting substantial reuse, recurrence, and recombination across Ebola countermeasure trials.

A second implication concerns coordination across stages of innovation. Public support can operate through funding, regulatory guidance, trial infrastructure, manufacturing support, and procurement, but these instruments may have different effects when they operate separately rather than as part of a connected development pathway. BARDA's current countermeasure programs, for example, span advanced development, manufacturing, and procurement (Biomedical Advanced Research and Development Authority, 2026), while FDA's medical-countermeasure framework explicitly involves coordination with government, scientific, and industry partners (U.S. Food and Drug Administration, 2026).

The larger implication is that capability in terms of readiness could potentially be viewed as an organizational property or system characteristic (versus an inventory of discrete items). Investments made by science produce potential, but are contingent upon the possibility of re-deployment of those potentials; their advancement; and connection with the institutional bases for clinical and operational uses. This perspective places the application of available technological options at the core of evaluation of the U.S. medical innovation system.

9.3. Implications for Pandemic and Outbreak Preparedness

The findings also speak to a broader problem in pandemic and outbreak preparedness. Preparedness is often evaluated through inventories, pathogen-specific programs, or the number of products already in development. Our evidence points to a different question: how much usable capability survives when the threat changes? A preparedness system is more resilient when prior investments leave behind technologies, knowledge, manufacturing routines, clinical experience, and development infrastructure that can be redirected rather than rebuilt (Tatarinov et al., 2023).

This matters because emerging outbreaks are defined by uncertainty. The next threat may differ from the one for which existing products were designed, and the time available for response can be short. Platform architectures cannot eliminate this uncertainty but they do provide technological flexibility prior to knowing which exact threat will occur. In Study 1, we show the reasoning for this logic through expert accounts on reusable technological cores and transferable capabilities. In Study 2, assignment to the platform-architecture condition increased technological redeployability, and redeployability was positively associated with rapid medical innovation response.

The archival evidence provides a useful real-world complement. Across 107 interventional Ebola countermeasure trials, reusable architectures, repurposed therapeutics, recurring technology families, and multi-technology combinations were common. These patterns suggest that outbreak innovation often builds on technological elements that have value beyond a single intervention or disease target.

From an assessment perspective, the findings highlight the future redeployment value of investments alongside their current product value. Developing flexible manufacturing systems (platforms) for production; developing or acquiring transferable knowledge in production; and

maintaining trial capability, development infrastructure and other capabilities which could be beneficial in responding to an emergency will provide the potential to respond quickly and effectively to a new emergency (Guo et al., 2026). Preparedness, in this sense, is not only about being ready for a known pathogen. It is about retaining the capacity to move when the next threat is still uncertain.

9.4. Limitations and Future Research

This study has several limitations that also point to useful extensions. First, Study 1 relies on 23 experts from five countries. The sample was intentionally mixed and helpful to understand mechanisms of innovation, but was not developed as an example of a national innovation system that can be used to make statistical comparisons. Future studies may provide additional quantitative data on a larger group of actors who are directly involved in the development of U.S. biomedical innovation (e.g., federal agencies; biotech companies; clinical trial networks; manufacturers; and procurement organizations).

Second, Study 2 provides stronger control over the focal relationships, but it remains a scenario-based experiment. PTA and CPIS were randomized, whereas Technological Redeployability was measured rather than experimentally assigned. The mediation results should therefore be interpreted as evidence consistent with the proposed mechanism rather than as a fully identified causal effect of TR. The institutional part of the model also deserves further testing. The CPIS interaction followed the predicted pattern but was less stable than the core PTA to TR to RMIR pathway. Future experiments could manipulate specific coordination mechanisms separately, such as regulatory alignment, advance procurement commitments, trial-network access, or joint public funding, to identify which forms of institutional support matter most.

Third, Study 3 uses ClinicalTrials.gov records to examine real-world Ebola medical innovation. Registry data provide observable evidence of platform reuse, repurposing, recurrence, and technological combination, but they do not directly measure PTA, TR, RMIR, or CPIS. The archival comparison is an observational study. Therefore, it cannot be used to infer cause-and-effect relationships. In addition, future studies may include trial record information (e.g., NIH and BARDA funding; patent filings; publication lists; regulatory events; procurement data; and/or manufacturing investment) in order to conduct longitudinal analysis

that evaluates how previous platform investments influence later product development timelines.

Finally, the empirical setting emphasizes infectious-disease preparedness and Ebola-related innovation. The underlying logic may extend to other areas where technological uncertainty and reuse are important, including pandemic vaccines, antimicrobial resistance, oncology platforms, and diagnostic technologies. Testing the framework across different diseases and institutional settings would help establish where technological redeployability creates the greatest value, and under what public-support conditions that value is most likely to be realized (Levinthal & Rosenkopf, 2026).

10. Conclusion

Medical preparedness is often judged by the products already available when a crisis begins. This study suggests that an equally important question is what prior innovation leaves behind. Technologies, knowledge, manufacturing routines, development infrastructure, and institutional arrangements can retain value beyond the problem for which they were first created. Their preparedness value depends on whether those capabilities can be redirected when a new threat emerges.

Across three complementary studies, we find consistent support for this technological logic. Expert interviews identified reusable architecture, technological redeployment, response speed, and public coordination as distinct but connected elements of medical innovation. The experiment showed that platform architecture increased Technological Redeployability and that redeployability was positively associated with Rapid Medical Innovation Response. The indirect pathway from PTA through TR was also supported. The archival study added real-world evidence by showing that reusable architectures, repurposing, recurrence, and technological recombination are common features of Ebola countermeasure development.

The institutional findings are more nuanced. Coordinated Public Innovation Support followed the expected pattern, but the primary evidence for moderation and moderated mediation was weaker than for the core technological pathway. This matters theoretically and practically. Technological flexibility may create an option to respond, but the ability to exercise that option can still depend on funding, regulation, trial infrastructure, procurement, and coordination.

Future research should examine these institutional mechanisms more directly and with stronger longitudinal and causal designs.

For the U.S. medical innovation system, the broader implication is straightforward. The findings indicate that the value of current preparedness investments includes not only what they produce today, but also the future response options they preserve. Platform technologies may be especially valuable when they preserve reusable capabilities across uncertain threats and when the innovation system contains mechanisms to activate those capabilities rapidly. Preparedness therefore involves not only having products available for the next crisis, but also preserving the technological and institutional capacity to respond when an uncertain threat emerges.

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Online Appendix

Appendix A. Study 1 Expert Interview Sample, Qualitative Coding, and Interview Protocol

Expert Selection, Recruitment, and Sample Adequacy: Participants were purposively selected to provide informed and heterogeneous perspectives on medical innovation under emerging health threats. Potential participants were identified through institutional contacts and the researchers' existing professional contacts in fields relevant to the study. Eligibility emphasized substantive professional experience in domains directly related to the research context, including infectious-disease response and preparedness, biomedical and vaccine R&D, clinical development and trials, epidemiology, regulation, health policy, public-health program management, and platform-technology innovation. The sampling strategy deliberately sought variation across countries, organizational settings, professional roles, and forms of outbreak-related experience rather than statistical representativeness. The final sample of 23 experts provided perspectives from five countries and encompassed scientific, clinical, regulatory, policy, and innovation-system roles. Sample adequacy was assessed in terms of information richness and the breadth of mechanism-relevant perspectives represented in the dataset. Across the completed interviews, recurring evidence emerged concerning reusable technological architecture, technological redeployability, rapid medical innovation response, and coordinated public innovation support, providing sufficient qualitative grounding for the subsequent conceptual development.

Table A1. Detailed Profile of Study 1 Experts

ID	Country	Professional role	Organization	Expertise	Years of Exp	Outbreak/Ebola experience	Innovation experience
INT01	Uganda	Infectious-disease physician	Hospital/research center	Infectious disease	16	Direct response	Clinical development
INT02	Uganda	Public-health professional	Government	Outbreak preparedness	12	Direct response	Health policy
INT03	Uganda	Biomedical researcher	University	Vaccines	10	Research	Vaccine R&D
INT04	Uganda	Epidemiologist	Government	Epidemiology	14	Direct response	Surveillance and response
INT05	Uganda	Clinical researcher	Hospital/research center	Clinical trials	9	Direct response	Clinical development
INT06	Uganda	NGO/global-health specialist	NGO	Public health	11	Direct response	Outbreak program management
INT07	Uganda	Regulatory professional	Government	Regulatory science	13	Preparedness	Regulation
INT08	Nigeria	Public-health professional	Government	Outbreak preparedness	15	Direct response	Health policy
INT09	Nigeria	Biomedical researcher	University	Virology	12	Research	Vaccine R&D
INT10	Nigeria	Pharma R&D professional	Pharma	Drug development	14	Preparedness	Pharma R&D
INT11	Nigeria	Clinical researcher	CRO	Clinical trials	8	Preparedness	Clinical development
INT12	Nigeria	Epidemiologist	University	Epidemiology	17	Direct response	Surveillance and response
INT13	Nigeria	Health-policy professional	Government	Health policy	18	Direct response	Public innovation policy
INT14	Ghana	Public-health professional	Government	Outbreak preparedness	13	Preparedness	Health policy
INT15	Ghana	Biomedical researcher	University	Vaccines	9	Research	Vaccine R&D
INT16	Ghana	Clinical researcher	Hospital/research center	Clinical trials	11	Preparedness	Clinical development
INT17	Ghana	NGO/global-health specialist	NGO	Public health	10	Preparedness	Outbreak program management
INT18	Morocco	Biomedical researcher	University	Infectious disease	12	Research	Biomedical R&D
INT19	Morocco	Public-health professional	Government	Public health	16	Preparedness	Health policy

INT20	Morocco	Pharma R&D professional	Pharma	Drug development	10	None	Pharma R&D
INT21	United Kingdom	Biotech innovation professional	Biotech	Vaccines	15	Research	Platform technology R&D
INT22	United Kingdom	Global-health policy expert	Research institute	Health policy	19	Preparedness	Public innovation policy
INT23	United Kingdom	Clinical development expert	Pharma	Clinical trials	17	Research	Clinical development

Note. Respondent identifiers are anonymized.

Table A2. Supporting Qualitative Evidence and Coding

Quote	ID	Representative quotation	First-order concept	Second-order theme	Aggregate dimension
Q001	INT03	"A platform is useful because the same core technology can be adjusted rather than rebuilt from the beginning."	Reuse of a common technological core	Modular platform design	Platform Technology Architecture (PTA)
Q002	INT09	"When the underlying delivery system is already established, the scientific team mainly changes the disease-specific component."	Changing disease-specific modules	Modularity and adaptability	Platform Technology Architecture (PTA)
Q003	INT21	"Platform technologies allow multiple candidates to be developed from a shared manufacturing and development base."	Shared development infrastructure	Common technological backbone	Platform Technology Architecture (PTA)
Q004	INT15	"A pathogen-specific product can be very effective, but much of the work may need to be repeated when the pathogen changes."	Restarting development for a new pathogen	Pathogen-specific rigidity	Platform Technology Architecture (PTA)
Q005	INT10	"The more standardized the development process is, the easier it is to modify one part without changing the whole system."	Standardized development process	Architectural modularity	Platform Technology Architecture (PTA)
Q006	INT18	"A reusable architecture reduces the need to create every component from zero during an emergency."	Avoiding complete redesign	Reusable technological architecture	Platform Technology Architecture (PTA)
Q007	INT23	"The value of a platform is that prior manufacturing, safety, and delivery knowledge can carry over to the next candidate."	Carryover of prior development knowledge	Platform continuity	Platform Technology Architecture (PTA)
Q008	INT11	"If each product requires a completely different development system, rapid adaptation becomes much harder."	Different systems slow adaptation	Architectural specificity	Platform Technology Architecture (PTA)
Q009	INT01	"The critical question is whether existing knowledge can be transferred quickly to a related pathogen."	Transfer of existing knowledge	Cross-pathogen transferability	Technological Redeployability (TR)
Q010	INT05	"We respond faster when protocols, assays, and development know-how can be reused with only limited modification."	Reuse of protocols and know-how	Redeployment of accumulated capabilities	Technological Redeployability (TR)

Q011	INT12	“Some technologies are locked into one pathogen, while others can be redirected with relatively small changes.”	Redirecting technology with small changes	Adaptability across pathogens	Technological Redeployability (TR)
Q012	INT03	“If the antigen changes but the delivery mechanism remains usable, the technology is much easier to redeploy.”	Retaining delivery mechanism	Component-level redeployment	Technological Redeployability (TR)
Q013	INT16	“Existing clinical and manufacturing knowledge can shorten the pathway when it applies to the new candidate.”	Reusing clinical and manufacturing knowledge	Transferable development capability	Technological Redeployability (TR)
Q014	INT20	“Redeployability is not only technical; it also depends on whether suppliers and production processes can switch to the new product.”	Switchable suppliers and production	Operational redeployability	Technological Redeployability (TR)
Q015	INT21	“A platform has real preparedness value when it can move from one disease target to another without losing years of development.”	Moving across disease targets	Rapid cross-target redeployment	Technological Redeployability (TR)
Q016	INT09	“Prior work matters most when it remains technically relevant after the outbreak changes the target.”	Continued relevance of prior R&D	Transferability of prior R&D	Technological Redeployability (TR)
Q017	INT02	“When agencies coordinate funding, regulation, and procurement, teams can make decisions much faster.”	Coordination across public agencies	Integrated public innovation support	Coordinated Public Innovation Support (CPIS)
Q018	INT07	“Emergency development slows when regulatory guidance, funding decisions, and trial approvals move separately.”	Fragmented institutional processes	Fragmentation of public support	Coordinated Public Innovation Support (CPIS)
Q019	INT13	“Public funding is more useful when it is connected to trial infrastructure and procurement rather than delivered as an isolated grant.”	Linked funding and translation support	Policy instrument coordination	Coordinated Public Innovation Support (CPIS)
Q020	INT22	“The innovation system works better when research agencies, regulators, and health authorities share priorities and timing.”	Shared priorities across institutions	System-level coordination	Coordinated Public Innovation Support (CPIS)
Q021	INT08	“During an emergency, a clear government commitment can reduce uncertainty for organizations deciding whether to invest in development.”	Government commitment reduces uncertainty	Public support for option exercise	Coordinated Public Innovation Support (CPIS)
Q022	INT14	“Preparedness plans are strongest when funding, laboratories, surveillance, and implementation partners are connected before the crisis.”	Pre-crisis coordination	Preparedness infrastructure alignment	Coordinated Public Innovation Support (CPIS)
Q023	INT19	“Fragmented support creates delays because organizations spend time searching for approvals, resources, and responsible agencies.”	Administrative fragmentation	Coordination barriers	Coordinated Public Innovation Support (CPIS)
Q024	INT23	“Technology can be ready, but without coordinated trial sites, regulatory pathways, and financing, it may still move slowly.”	Technology ready but system not ready	Institutional enablement of redeployment	Coordinated Public Innovation Support (CPIS)
Q025	INT04	“A rapid response means moving from recognition of the threat to testing and deployment in the shortest feasible time.”	Short threat-to-deployment time	Speed of innovation translation	Rapid Medical Innovation Response (RMIR)
Q026	INT06	“Success is not only discovering something quickly; it is getting a usable countermeasure into the response system.”	Usable countermeasure reaches response	Translation into operational response	Rapid Medical Innovation Response (RMIR)

Q027	INT17	"The important outcome is whether development, trials, and implementation can advance quickly enough to matter during the outbreak."	Advancing development during outbreak	Time-sensitive clinical translation	Rapid Medical Innovation Response (RMIR)
Q028	INT05	"If an existing platform lets us enter clinical evaluation months earlier, that is a meaningful innovation response advantage."	Earlier clinical evaluation	Accelerated clinical progression	Rapid Medical Innovation Response (RMIR)
Q029	INT10	"Rapid innovation requires compressing the time between laboratory adaptation, manufacturing preparation, and clinical use."	Compressing development stages	Accelerated end-to-end translation	Rapid Medical Innovation Response (RMIR)
Q030	INT01	"A medical response is rapid when previous knowledge allows decisions to be made before the outbreak window closes."	Decision speed before outbreak window closes	Timeliness under epidemic pressure	Rapid Medical Innovation Response (RMIR)
Q031	INT22	"The system should be judged by how quickly promising science becomes a deployable medical countermeasure."	Science-to-countermeasure speed	Translation performance	Rapid Medical Innovation Response (RMIR)
Q032	INT16	"When the technology and institutional pathway are both ready, trial initiation can occur much sooner."	Earlier trial initiation	Rapid translational activation	Rapid Medical Innovation Response (RMIR)
Q033	INT12	"The reusable technology gives you a head start, but that head start only matters if the system can act on it."	Head start requires system action	Technology-policy complementarity	Conditional Translation of Redeployability
Q034	INT13	"A flexible technology creates possibilities, while coordinated public support determines how quickly those possibilities become real programs."	Flexibility creates options; support enables action	Exercise of technological options	Conditional Translation of Redeployability
Q035	INT21	"The advantage of a platform is not speed by itself; the advantage is that it preserves more pathways when the next threat is uncertain."	Preserving future pathways	Option value under pathogen uncertainty	Platform Technology Architecture (PTA)
Q036	INT07	"Even a highly adaptable candidate can be delayed if trial approvals and public financing are not coordinated."	Adaptable technology delayed by institutions	Institutional boundary condition	Coordinated Public Innovation Support (CPIS)
Q037	INT18	"Preparedness comes from having technology that can be redirected before the exact future disease is known."	Redirectable technology before threat is known	Flexibility under uncertainty	Technological Redeployability (TR)
Q038	INT08	"When the response structure already exists, redeployable technology can be translated into action much faster."	Existing response structure accelerates use	Institutional activation of redeployability	Coordinated Public Innovation Support (CPIS)
Q039	INT15	"The strongest preparedness strategy is to invest in technologies that can be reused, not only products for the last outbreak."	Investment in reusable technologies	Portfolio flexibility for future threats	Platform Technology Architecture (PTA)
Q040	INT02	"The final test is whether prior investments help deliver a countermeasure faster when a new emergency actually occurs."	Prior investment enables faster response	Realized preparedness value	Rapid Medical Innovation Response (RMIR)

Note. Two coders independently classified the 40 focal excerpts. Thirty-eight excerpts were classified consistently at the initial stage (95% agreement). Q008 and Q024 were subsequently discussed using the full quotation context and coding memos and resolved by consensus. The table reports the final agreed coding.

Table A3. Semi-Structured Interview Protocol

No.	Core interview question	Analytical focus
1	Could you briefly describe your role and experience with infectious-disease response, preparedness, or medical innovation?	Respondent context
2	From your experience, when can an existing medical technology be adapted or reused for a different disease threat?	Redeployment context
3	What characteristics of a technology make such adaptation easier or more difficult?	PTA
4	What determines whether technological knowledge, infrastructure, or development capabilities can be transferred to a new threat?	TR
5	What are the main barriers to successfully redeploying an existing technology?	Constraints on TR
6	How do public funding, regulation, clinical-trial infrastructure, procurement, and coordination affect this process?	CPIS
7	How does the ability to redeploy existing technology affect the speed of developing or advancing a medical countermeasure?	TR → RMIR
8	Can you describe a case where technological reuse worked particularly well, or failed to work? What explains the outcome?	Mechanism and boundary conditions
9	Looking ahead, what technological and institutional capabilities are most important for responding rapidly to future outbreaks?	Preparedness and model refinement

Appendix B. Study 2 Supplementary Analyses and Measurement Details

Table B1. Study 2 Participant Profile and Experimental Allocation

Characteristic	Category	*n*	%
Country	Ghana	104	33.3
	Nigeria	105	33.7
	Uganda	103	33.0
Respondent role	Biomedical researcher	52	16.7
	Clinical researcher	39	12.5
	Epidemiologist	43	13.8
	Health policy professional	53	17.0
	Pharma R&D professional	40	12.8
	Public health professional	43	13.8
	Regulatory professional	42	13.5
Organizational setting	University	77	24.7
	Government	63	20.2
	Biotech	49	15.7
	NGO	46	14.7

	Pharma	35	11.2
	Hospital/research center	32	10.3
	CRO	10	3.2
Expertise area	Drug development	51	16.3
	Infectious disease	51	16.3
	Outbreak preparedness	47	15.1
	Clinical trials	41	13.1
	Vaccines	38	12.2
	Public health	34	10.9
	Health policy	16	5.1
	Epidemiology	15	4.8
	Virology	11	3.5
	Regulatory science	8	2.6
Experimental cell	Pathogen-specific / fragmented	78	25.0
	Pathogen-specific / coordinated	78	25.0
	Platform / fragmented	78	25.0
	Platform / coordinated	78	25.0

Note. *N* = 312. Mean professional experience = 9.81 years, SD = 3.70, range = 4 to 16 years. PTA conditions contained 156 respondents each; CPIS conditions contained 156 respondents each.

Table B2. Study 2 Measures and Manipulation-Check Items

Variable	Item
Technological Redeployability (TR)	TR1. The technological base could be adapted to a different emerging disease threat.
	TR2. Existing technological knowledge could be reused if the disease target changed.
	TR3. The technology could be reconfigured for a new health threat without rebuilding the development approach from the beginning.
	TR4. Existing development and production capabilities could be transferred to a different disease target with limited modification.
Rapid Medical Innovation Response (RMIR)	RMIR1. The organization could initiate development of a relevant medical countermeasure rapidly.
	RMIR2. The countermeasure could move into testing within a short period.
	RMIR3. The organization could advance the countermeasure quickly enough to respond to the emerging threat.
	RMIR4. The medical innovation response could progress in time to be useful during the outbreak.
PTA manipulation check	PTA-MC1. The technology was built around a reusable platform rather than a single pathogen-specific design.
	PTA-MC2. The technology used a common technological core that could support more than one disease target.
CPIS manipulation check	CPIS-MC1. Public funding, regulatory guidance, and clinical-trial support were coordinated around the development effort.
	CPIS-MC2. Public institutions provided an aligned rather than fragmented support environment.

Note. All items were assessed on seven-point scales ranging from 1 = strongly disagree to 7 = strongly agree. TR and RMIR were measured constructs. PTA and CPIS were experimentally manipulated, and their respective items served as manipulation checks.

Table B3. Experimental Scenario and Factor Manipulations

Panel A. Common Scenario

A previously unfamiliar infectious disease has begun to spread across several communities and has the potential to create a wider public-health emergency. Health authorities have identified an urgent need for an effective medical countermeasure. A biomedical organization with experience in medical-product development is considering how to respond. The organization has access to scientific personnel, laboratory facilities, manufacturing partners, and clinical-development expertise. The countermeasure is at an early development stage, and the organization must decide how to move the program forward under substantial scientific uncertainty and time pressure.

Panel B. Experimental Manipulations

Factor	Condition	Scenario wording
Technology Architecture	Pathogen-specific	The organization is using a technology developed specifically for the current disease target. Key elements of the design, delivery approach, development process, and production system are tailored to this pathogen. If the disease target changes, substantial parts of the technological and development approach would need to be redesigned and validated.
	Platform	The organization is using a technology built around a common platform that can support different disease targets. The disease-specific component can be modified while important elements of the technological core, delivery approach, development process, and production system remain applicable.
Public Innovation Support	Fragmented	Public support is provided through several institutions operating largely independently. Funding decisions, regulatory guidance, clinical-trial infrastructure, and procurement planning are handled through separate processes with limited alignment of priorities and timelines.
	Coordinated	Public support is organized across the institutions involved in countermeasure development. Funding decisions, regulatory guidance, clinical-trial infrastructure, and procurement planning are aligned around shared priorities and development timelines.

Panel C. Experimental Conditions

Cell	Technology Architecture	Public Innovation Support
1	Pathogen-specific	Fragmented
2	Pathogen-specific	Coordinated
3	Platform	Fragmented
4	Platform	Coordinated

Note. Participants were randomly assigned to one of the four experimental conditions. The common outbreak context, development stage, organizational setting, resource availability, scientific uncertainty, and time pressure were held constant across conditions. Only technology architecture and public innovation support varied.

Table B4. Item-Level Measurement and Manipulation-Check Properties

Panel A. Measured constructs

Construct	Item	M	SD	Standardized loading
TR	TR1	3.772	1.003	.871
	TR2	3.801	1.007	.891
	TR3	3.830	1.014	.880
	TR4	3.811	1.030	.903
RMIR	RMIR1	5.875	1.015	.905
	RMIR2	5.869	.978	.907
	RMIR3	5.859	.992	.916
	RMIR4	5.821	.982	.904

Panel B. Manipulation-check measures

Manipulation check	Items	Composite M	SD	Inter-item r	Spearman-Brown
PTA	2	3.989	1.868	.918	.957
CPIS	2	3.974	1.830	.922	.959

Note. Standardized CFA loadings apply only to TR and RMIR. PTA and CPIS were experimentally manipulated, so their two items served as manipulation checks rather than latent constructs in the CFA. All TR and RMIR factor loadings were significant at $p < .001$.

Table B5. Descriptive Statistics, Zero-Order Correlations, and Discriminant Validity

Variable	M	SD	1	2	3	4
1. PTA manipulation-check score	3.989	1.868	1.000			
2. Technological Redeployability	3.804	.929	.141	1.000		
3. Rapid Medical Innovation Response	5.856	.924	.052	.440	1.000	
4. CPIS manipulation-check score	3.974	1.830	.003	.023	.210	1.000

Note. Entries are Pearson zero-order correlations. PTA and CPIS values refer to manipulation-check composite scores, not the randomized treatment indicators. For the two measured latent constructs, the latent TR-RMIR correlation was .464. The square roots of AVE were .886 for TR and .908 for RMIR, both well above their latent correlation. HTMT for TR and RMIR was .467, providing an additional discriminant-validity check.

Table B6. Detailed Primary Model Estimates

Panel A. Regression estimates

Model	Predictor	Estimate	HC3 SE	*p*	95% CI
H1: TR outcome	PTA assignment	.277	.105	.009	[.071, .483]
	CPIS assignment	.027	.105	.795	[−.179, .233]
H2/H4: RMIR outcome	PTA assignment	−.003	.092	.975	[−.185, .179]
	TR	.428	.059	<.001	[.312, .543]
	CPIS (effect-coded)	−.465	.467	.320	[−1.384, .453]
	TR × CPIS	.218	.116	.061	[−.010, .446]

Panel B. Simple slopes and indirect effects

Effect	Estimate	SE	95% CI	Evidence
TR → RMIR, fragmented CPIS	.319	.097	[.127, .510]	$p = .001$
TR → RMIR, coordinated CPIS	.537	.064	[.410, .663]	$p < .001$
Average indirect effect, PTA → TR → RMIR	.119	.049†	[.028, .218]†	CI excludes zero
Indirect effect, fragmented CPIS	.088	.045†	[.015, .190]†	CI excludes zero
Indirect effect, coordinated CPIS	.149	.059†	[.036, .266]†	CI excludes zero
Index of moderated mediation	.060	.039†	[−.003, .145]†	CI includes zero

Note. †Bootstrap standard error and percentile confidence interval based on 5,000 bootstrap replications. The formal H4 test is the interaction coefficient, not whether each simple slope is individually significant. The bootstrap results support H3 but not H5. The CPIS main-effect coefficient is conditional on TR = 0 and is included for model completeness; the interaction term provides the formal test of H4.

Table B7. Randomization, Data Screening, and Diagnostic Checks

Panel A. Randomization balance

Baseline characteristic	Balance test *p*
Years of professional experience	.654
Country	1.000
Respondent role	.318
Organizational setting / industry	.861

Panel B. Data-quality screening

Exclusion reason	*n*	% of initial $N = 332$
Failed attention check	8	2.4
Incomplete response	5	1.5
Incomplete manipulation-check responses	4	1.2

Straightlining	3	0.9
Total excluded	20	6.0

Panel C. Additional model diagnostics

Diagnostic	H1 model	H2/H4 model
Breusch-Pagan p	.377	.063
Maximum Cook's D	.034	.195
Cases with Cook's D > 4/*n*	15	12

Panel D. Additional total-effect test

Effect	Estimate	HC3 SE	95% CI	*p*
PTA → RMIR total effect	.099	.103	[−.104, .302]	.336

Note. Cook's-distance thresholds identify observations for inspection; they are not automatic deletion criteria. HC3 robust standard errors were retained for the focal regression models.

Appendix C. Supplementary Analyses for Study 3

Table C1. Operationalization of Archival Indicators in Study 3

Archival indicator	Operationalization	Coding/interpretation
Countermeasure type	Primary medical-countermeasure category	Vaccine; drug/antiviral therapy; antibody therapy; plasma/blood-based therapy
Primary technology family	Primary technological family identified from the registered intervention and study description	Mutually exclusive classification used to characterize the principal technology associated with each trial
Reusable/platform architecture	Trial uses a technological architecture coded as reusable across applications	Binary indicator: 1 = reusable/platform architecture; 0 = other countermeasure
Repurposed therapeutic	Existing therapeutic or therapeutic approach is applied to Ebola rather than developed solely as an Ebola-specific platform	Binary indicator: 1 = repurposed; 0 = not repurposed
Reusable-or-repurposed technology	Trial satisfies either the reusable/platform criterion or the repurposed-therapeutic criterion	Binary archival indicator capturing the broader presence of technological reuse or repurposing
Specific technology architecture	Presence of rVSV, Ad26, Ad5, chimpanzee adenovirus, MVA, HPIV3, DNA, mRNA, or antibody technology	Non-mutually-exclusive indicators; more than one architecture may occur in the same trial
Technology recurrence	Same coded architecture appears in at least two registered trials	Used as evidence of repeated deployment rather than a one-off technological application

Multi-technology trial	Two or more coded technology architectures occur within the same registered trial	Binary indicator of technological combination/recombination
Development phase	Registered clinical development phase	Phase 1, Phase 2, Phase 3, Phase 4, or not applicable/not reported
Trial duration	Time between registered trial start and completion dates	Continuous measure in months
Enrollment	Registered number of study participants	Trial-level enrollment
Multicountry trial	Trial has registered study locations in more than one country	Binary indicator: 1 = multicountry; 0 = single-country; missing where registered location information was insufficient to determine multicountry status

Notes. Coding was based on information contained in ClinicalTrials.gov records (U.S. National Library of Medicine, 2026), including study titles, registered interventions, and study descriptions. Specific technology architectures were coded independently so that a trial could contain multiple technological components. These indicators are observable archival proxies and should not be interpreted as direct measures of PTA, TR, or RMIR. This distinction is important because Study 3 provides external archival validation rather than an independent test of the Study 2 constructs. The analytical dataset contains 107 trials and includes the corresponding platform, repurposing, phase, enrollment, duration, multicountry, and architecture indicators.

Table C2. Technology Recurrence and Recombination in Ebola Medical Innovation

Panel A. Recurrence of coded technology architectures

Technology architecture	No. of trials	% of analytical sample	Recurring architecture
rVSV	27	25.2	Yes
MVA	24	22.4	Yes
Ad26	23	21.5	Yes
Chimpanzee adenovirus	21	19.6	Yes
Antibody	9	8.4	Yes
Ad5	4	3.7	Yes
DNA	4	3.7	Yes
HPIV3	2	1.9	Yes
mRNA	2	1.9	Yes

Panel B. Architecture combinations among multi-technology trials

Architecture combination	*n*	% of multi-technology trials
Ad26 + MVA	20	62.5
Chimpanzee adenovirus + MVA	3	9.4
rVSV + Antibody	3	9.4
rVSV + Chimpanzee adenovirus	2	6.2
Ad26 + Chimpanzee adenovirus	1	3.1
rVSV + Ad26 + MVA	1	3.1

rVSV + DNA	1	3.1
rVSV + mRNA	1	3.1
Total	32	100.0

Panel C. Multi-technology trials across development phases

Development phase	Total trials	Multi-technology trials	% within phase
Phase 1	51	10	19.6
Phase 2	35	13	37.1
Phase 3	17	8	47.1
Phase 4	3	1	33.3
Not applicable/not reported	1	0	0.0

Notes. N = 107. Architecture indicators are non-mutually exclusive, so percentages in Panel A do not sum to 100%. A recurring architecture is defined as one appearing in at least two registered trials. Panels B and C define a multi-technology trial as one containing two or more coded architectures. The underlying phase counts are 10/51, 13/35, 8/17, and 1/3 for Phases 1- 4, respectively.

Table C3. Sensitivity and Exploratory Analyses for Study 3

Panel A. Sensitivity analyses

Analysis	Analytical *N*	Indicator	*n*	%
Full analytical sample	107	Reusable/platform architecture	78	72.9
Full analytical sample	107	Other countermeasure	29	27.1
Excluding Other/unspecified technology	103	Reusable/platform architecture	78	75.7
Excluding Other/unspecified technology	103	Reusable-or-repurposed technology	88	85.4

Panel B. Exploratory model of platform/reusable architecture

Predictor	Odds ratio	95% CI	*p*-value
Start year	1.03	[0.91, 1.17]	.667
Development phase	0.66	[0.29, 1.47]	.309
Multicountry trial	0.87	[0.22, 3.79]	.842
Log enrollment	1.53	[1.08, 2.29]	.024

Notes. The exploratory logistic model was estimated using complete cases (N = 93). The dependent variable in Panel B is reusable/platform architecture (1 = reusable/platform; 0 = other countermeasure). The logistic model includes start year, development phase, multicountry status, and log-transformed enrollment. Odds ratios are exponentiated coefficients. The model is exploratory and associational and should not be interpreted causally.