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GUEST EDITORIAL
Repairing (with) Algorithmic Systems

Tuukka Lehtiniemi
University of Helsinki, Finland/tuukka.lehtiniemi@helsinki.fi

Heta Tarkkala
University of Helsinki, Finland

The constant process of breakdown and repair is an inherent feature of the digital environment. Digital objects, software, and services tend to be in what is sometimes called permanent beta (Neff and Stark, 2004): they are released into the wild in a half-baked state, and developed in an iterative cycle involving failures, malfunctions, and breakdowns, learning from them, and their follow-up fixes or repairs. Testing (Marres and Stark, 2020) and gradual experimentation seem to be an important mode of operation for companies developing them. Algorithmic systems – dynamic arrangements of people and code (Seaver, 2019), including artificial intelligence (AI) applications, tools, and services – are no exception. In a sense, malfunction is even built into various AI tools and services, such as agents or chatbots. It is common knowledge that they routinely produce errors such as random falsehoods presented as facts ('hallucinations' as the industry jargon goes), and users simply need to be wary of this. While these services often improve through iterations, a pattern remains: algorithmic systems seem to perform almost miraculous feats when they work as expected, yet they often fail expectations.

This Special Issue builds on literature employing the notions of breakdown and repair (e.g., Henke and Sims, 2020; Jackson, 2014; Star, 1999) to investigate repair efforts related to algorithmic systems. The repair literature emphasizes the power of breakdown and repair as conceptual tools to focus attention: they allow probing things and reveal aspects that would otherwise remain hidden. Breakdown brings invisible things to attention, showing where things go wrong, how expectations are not met, or when progress stops. Repair, in turn, helps point out acts of restoration, but also the development, transformation, or renewal that can take place as a result of breakdown. As algorithmic systems never seem to be quite finished, they appear to be a prime example of objects of a broken world that is always-almost-falling-apart and under a constant process of fixing and reinvention (Jackson, 2014).

The Special Issue brings together a series of empirical articles that, together, allow us to examine how the notions of breakdown and repair fit in with an examination of algorithmic systems. These articles share an empirical focus on algorithmic systems in the public sector. As an empirical context, the public sector allows teasing out aspects that might otherwise be difficult to pin down. Here, the stakes of breakdown and repair can be serious. Public sector actors, their services, and their decision-making processes often operate with a distinct ethos and a basis of core values, involving a focus on rights and entitlements of citizens and a commitment to democratic processes. When public sector algorithmic systems break down, the results can at worst involve dire social and societal consequences: rehashing of old biases and creating new ones, unequal treatment of citizens, and novel forms of discrimination (e.g., Allhutter et al., 2020; Broussard, 2023; Eubanks, 2018; Marjanovic et al., 2021; Rachovitsa and Johann, 2022). This can cause further domino-like breakdowns: of public trust, of social care processes, or of the lives of citizens or families. Development through breakdown and repair, typical as it may be in the digital domain, sits uncomfortably in the public sector context, where they might threaten something fundamental, such as the value basis of a service or process.

While algorithmic systems regularly break down, they are often also framed as a means to repair something in the public sector. Strategies and policy documents paving the way for algorithmic systems in the public sector tend to involve techno-optimism, with AI proffered as a source of positive social change, efficiency, and other public sector improvements (e.g., Bareis and Katzenbach, 2022). Techno-optimism related to AI, digitalisation services and automated decision-making is well acknowledged in research literature (e.g., Kvacik et al., 2023; De Togni et al., 2024; Ratner and Schrøder, 2024). New technologies become repairs to things that are considered broken, such as dysfunctional public services. The promises driving the recent influx of generative AI tools has only strengthened this trend, and it is unlikely that it will be reversed anytime soon. Our lives are likely to increasingly involve algorithmic systems and AI services, which are both repairing the public sector, and under constant repair themselves (see also, Galis and Vlassis, 2025).

With a focus on breakdown, repair, and public sector algorithmic systems, this Special Issue joins a stream of research marrying the notion of repair with algorithmic systems (e.g., Kaun and Liminga, 2023; Schwennesen, 2019; Velkova and Kaun, 2019). It also joins several recent thematic collections that have brought together algorithmic systems, public sector institutions, welfare states, automated decision-making, and artificial intelligence. These have focused on datafication (Dencik and Kaun, 2020), implementation challenges for artificial intelligence (Mergel et al., 2023), power relations and agency (van Toorn et al., 2024), digitalisation in the context of welfare states (Huby et al., 2024) and social and ecological sustainability (Saikkonen and Choroszewicz, 2025). How digital services, automated decision-making, and algorithmic systems change the work of civil servants has also been widely discussed elsewhere, for example through concepts such as street-level algorithms and system-level bureaucracy (Alkhatib and Bernstein, 2019; Bovens and Zouridis, 2002).

Besides the focus on breakdown and repair, what distinguishes this issue from previous thematic collections is attention to how public sector organisations themselves are implicated by algorithmic systems. Rather than examining citizen experiences or service provision, the contributions to this Special Issue focus on the ways in which public sector organisations, ranging from public service media to health and care organizations, deal with, or are expected to deal with, breakdowns and repair efforts. The contributions approach algorithmic systems, including AI tools and services, both as things needing repair, and as repairs to other forms of breakdown.

Collectively, the articles of this issue encourage us to ask: What do breakdowns related to algorithmic systems make visible? What is being maintained or transformed with acts to repair algorithmic systems, or to repair things with algorithmic systems? What gets pushed into the background with acts of repair? Where lies the power to define what is broken and how? On whose expense is repair done, and who bears the burden of it? Who, instead, benefits from it? What constitutes a desirable repair? To what extent can the availability of repairs determine brokenness? By attending to these questions, the articles allow thinking through the use and effects of algorithmic systems and AI in the public sector in a critical yet productive manner. While critical scholars have raised awareness of what can go wrong with datafication, algorithmic systems or AI, what might eventually work satisfactorily or even be desirable is often left for others, often technology developers, to experiment on (e.g., Susser, 2022). Examining the breakdown-repair process is productive in this sense: after all, if things consistently break down in a similar manner, there is something to be learned about their social and societal desirability.

Thinking in terms of breakdown and repair

Following Christopher Henke and Benjamin Sims (2020: 3), we consider repair to be the process of "restoring both social and material order". Understood in this sense, repairing can involve the hands-on work of returning material things to working order. Yet not only machines, structures, and other material things can be the object of repair, but also social formations: organisations, relationships, processes, health, or healthcare. Indeed, in scholarship employing the notion of repair, repair has targeted various systems and objects from bicycles (Dant, 2019) to digital data (Pink et al., 2019), from workplace social order (Henke, 1999) to biased search results (Velkova and Kaun, 2021), and from AI-powered sorting robots in a recycling facility (Montiel Valle and Shorey, 2024) to the digital infrastructure of welfare provision (Kaun and Liminga, 2023). Material and social aspects of repair often go hand in hand (Henke and Sims, 2020): repairing a material object, such as a bridge, might not involve just a feat of engineering, but also the restoration of diminished trust in public infrastructure. Similarly, repairing data in a cancer registry can involve not just technical fixes, such as imputing missing details, but also the upkeep of ad-hoc arrangements between actors involved in producing cancer data (Lambotte and Martin-Scholz, this issue). Repair is thus a socio-technical phenomenon, including interventions to material structures, meaning, organisation, or social interactions, all of which are parts of keeping socio-technical systems in working order (Henke and Sims, 2020).

Repair is, of course, the flipside of things breaking down, being damaged or worn out, or for any reason not working as expected. If repair takes both material and more abstract forms, so do breakdowns. Things might fall apart literally: an undersea cable might be damaged, a server rack might overheat, a database might fail to connect, or a recommender system might suddenly spout unintended output. Even such literal breakdowns might provoke varying diagnoses of what went wrong and how it should be fixed. But breakdowns are sometimes more intangible to begin with. Things might, for example, break down even as their own state remains stable. This might happen as the surrounding circumstances change in ways that make a system cease to fulfil its desired function. Such situations can give rise to various appraisals of reasons for breakdown and the need and form of consequent reparatory actions. Repairing a welfare service with AI is a good example (Neves et al., this issue): it gives rise to questions on what constitutes a breakdown or a repair, and who determines these. These questions direct attention to the social and discursive, rather than the material, aspects of both breakdown and repair.

Focusing on breakdown is a well-known STS strategy. Susan Leigh Star (1999) famously discusses its merits as a conceptual probe. Infrastructures and other obscure things, which normally remain hidden and are largely taken for granted, may gain unprecedented visibility when they stop working. Breakdown foregrounds things that otherwise escape attention and brings to light relations with and through technologies. Repair, in this sense, is called for when things cease being invisible and the objective is to merge them into the background once again.

In *Autonomous Technology*, Langdon Winner (1978) goes one step further and discusses refusal to repair. For Winner, refusal can be an epistemological strategy. Breakdown, and the visibility things gain as a result of it, enables a mode of inquiry into our relationship to a particular connection, device, or technique in a way that is not possible before breakdown. This offers a possibility to observe how a technology occupying the physical or social space affects our world, and to consider whether this is what we desire. Repairing something, for Winner, contains at least an implicit acknowledgement that it has a desirable place in our world, and thus should be restored to working order.

Another strength of repair and breakdown as conceptual tools is how they highlight that socio-technical artifacts and systems develop not only with initial innovations. There is also – and perhaps especially, at least in the case of digital systems – an opportunity for development when things require repair (Jackson, 2014). Breakdown and repair call attention to productive involvement: examining the breakdown–repair process can reveal, for example, how human and non-human actors make up sociotechnical systems in a process of creative problem solving (Tanweer et al., 2016; Pink et al., 2016), or how human experts step in to smoothen automation processes that do not quite collapse, yet are also not completely functioning (Alastalo and Lehto, this issue). All of this points to breakdown and repair as analytically productive concepts, as they focus attention on and foreground the elusive.

All acts of repair are not equal in terms of their relationship to social and material change. This Special Issue joins a stream of repair scholarship that has begun to attend to modalities of repair that help with making distinctions between repair acts. Henke and Sims (2020), for example, have presented two alternatives: repair as maintenance and repair as transformation, which have different implications in terms of social or material change. Maintenance is about attending to the status quo, keeping things running, or returning them to normal. Understood in the maintenance sense, acts of repair might involve either routine upkeep that ensures things are running, or reactions to potentially serious and large-scale falling-apart. The key here is how repair protects an existing social and material order. Acts of repair might even purposefully avoid transformative effects by ensuring that any adjustments do not compromise the object's relationship with its surroundings (Carillon, this issue). Repair, in the maintenance sense, is a conservative force, sometimes invisible, aimed at preserving the existing social and material order.

In transformative repair, in contrast, broken-down things are not restored back to their earlier state. Instead, existing structures or practices are purposefully and sometimes radically rearranged, putting forth a new social and material order. The key here is that repair is a force of change rather than preservation. Transformative acts of repair can present emancipatory opportunities for those not currently in power, or they can equally well serve the interests of the powerful; there is no guarantee that the transformation will be progressive in any positive sense of the word, or lead to growth or development (Ruckenstein, this issue). Nevertheless, repair in the transformative sense, as Steven Jackson (2014: 227) contends, can be "a site of some of the most interesting and consequential operations".

Another possibility to distinguish reparatory acts is to consider the mark they leave on the world, as Denis and Pontille (2025) suggest. Breakdown, in this sense, is an interruption, an event worthy of notice. Repair can cause something noticeable again: it is a means to resolve the interruption and to ensure that things start moving along again. Maintenance, in this way of thinking, is something that escapes notice: it aims to prevent problems from occurring, and to ensure that things are always kept in the background where they belong. When pre-emptive and continuous maintenance work is appropriately and successfully carried out, there is no breakdown to focus on: it appears as if nothing interesting has happened.

A third option is the viewpoint of broken world thinking (Jackson, 2014). Here, breakdown is considered to be the normal and continuous state of the world, in which things are always falling apart (Graham and Thrift, 2007; Jackson, 2014). This approach focuses attention on how the world moves forward not so much with initial innovations, but with constant productive acts of repair. In terms of the mark left in the world, breakdown ceases to be an event, as there is nothing unusual when things do not work as expected. Yet repair is not simply maintenance that keeps things in the background, it can be a transformative force. Broken world thinking thus collapses a clear distinction between maintenance and transformation, as constant and business-as-usual repair is taken to be exactly where the transformative potential lies.

As we will discuss below, the contributions to this Special Issue take different stances in terms of qualities and modalities of repair, based on the empirical aspects of the cases they examine.

The contributions to the Special Issue

This Special Issue presents five empirical studies examining brokenness, breakdown, and repair in the context of algorithmic systems for public sector organisations and processes. These contributions span different empirical contexts: AI development for long-term care (Neves et al.), an algorithmic recommender system in public service media (Carillon), a software robot automating data work in healthcare (Alastalo and Lehto), human repair efforts in cancer registries (Lambotte and Martin-Scholtz), and the aftermath of a healthcare data platform reform (Ruckenstein). Together, these contributions address both aspects of repair outlined above: repairing something broken in algorithmic systems, and repairing something in the public sector with algorithmic systems.

In the first article of the Special Issue, "Breaking or Repairing Long-Term Care for Older People? AI Delegation and the Carefication of Later Life", Barbara Barbosa Neves, Geoffrey Mead, Alexandra Sanders, Alex Broom, Naseem Ahmadpour and Kal Gulson examine socio-technical discourses of commercial developers of AI for long-term care in later life. The authors address the discursive aspects of breakdown and repair by examining how age- and care-related ideas are constructed by the AI industry. They do this with a visual, semiotic and textual analysis of AI companies' websites. As the authors discuss, the AI industry paints both caregivers and those in need of care not just as lacking, but lacking specifically in ways that AI solutions promise to fix. The authors thus connect breakdown and repair with techno-solutionism, and provide an in-depth analysis of how techno-solutionism in the care sector context turns particular ideas about technology into particular ideas of what is broken and how it can be restored. Those technologies that are in the industry discourses presented as possible and available at the same time affect which problems are constructed as worthy of repair: namely, the problems that prioritise efficiency and privilege technological fixes. This happens at the expense of other, already well-recognised systemic issues in public health and care.

In the second article, "Closing the Algorithmic Black Box: Breakdowns and Patching Strategies in a Public Service Media", Kevin Carillon examines breakdowns and repairs occurring in the implementation of an algorithmic recommender system in a public service media organisation. Carillon draws from participant observation in the organisation and focuses attention on episodes of breakdown and repair of the recommender system. Mobilising the notion of the (algorithmic) black box in the analysis, the article shows that while breakdowns make the recommender system visible and could thus 'open' the black box, repairs purposefully 'close' it again. Carillon proposes to call this process 'patching': a modality of repair that keeps the system running but preserves its opaque status, purposefully avoiding addressing the root issue that caused a breakdown in the first place. This opens up a way of conceiving algorithmic black boxes not as a stable state resulting from the properties of technologies, but as the outcome of black-boxing practices that emerge and re-emerge as the system breaks down and is consequently repaired.

The third article, "Frictions in Automating Routine Data Work – A Human-Assisted Robot in Datafied Healthcare in Finland" by Marja Alastalo and Iiris Lehto, examines breakdown and repair of robotic process automation of data validation in primary healthcare. The authors' analysis is based on ethnographic fieldwork with a data work team, where they focused attention on the constant not-quite-working but not-quite-broken state of the software robot. Motivated by this empirical observation, the authors examine how frictions, both technical and social in nature, complicate the software robot's smooth functioning. Due to friction, automation requires constant repair work, or what the authors call human assistance, to function properly, or at all. This constant need for human input contradicts the exaggerated expectations and promises associated with public sector automation. The authors maintain that the notion of friction, when employed side-by-side with breakdown and repair, redirects attention from episodes of repair to a more structural need for human aid and attention. This turns attention from autonomously functioning to human-assisted technologies, potentially a feature of automation projects more broadly.

In the fourth article, "Maintaining and Repairing the Cancer Registries' Regime of Knowing in the Turbulent Context of the French National AI Strategy", François Lambotte and Anja Martin-Scholz examine the work required to repair data in cancer registries. The need for this repair work, the authors show, is exacerbated by changes in health data governance resulting from a national AI strategy. Drawing from ethnographic fieldwork, the article contrasts the context-agnostic policy view on AI-driven transformation with the highly context-specific, manual, and labour-intensive repair practices carried out by human experts in the cancer registries. Theoretically, Lambotte and Martin-Scholz combine the notion of 'regime of knowing' with the notion of 'broken data', producing an in-depth analysis of intertwined elements of care, know-how and power relations that play out in repair work carried out to create data and maintain its quality. As the article shows, this repair work involves both manual technical fixes in the registers, as well as the maintenance of political, economic, social, or normative elements of cancer registries themselves, notably including the (often ad hoc) arrangements between different institutions. All these elements get increasingly disrupted by AI-related developments, leading to an increasing need for repair work.

In the fifth and final article of the Special Issue, "The Darker Qualities of Repair", Minna Ruckenstein examines the aftermath of the introduction of a healthcare data management platform. This algorithmic system was a repair attempt to begin with, aimed at improving healthcare by reorganising workflows and generating new data resources. Based on a series of workshops with physicians using the system, Ruckenstein examines the consequences this had on physicians and their work. The analysis reveals that repairing healthcare with an algorithmic system was a disruptive act that derailed physicians' existing workflows and led to repetitive downstream repair tasks. Ruckenstein characterises different aspects of this repair work as a 'darker' form of repair: it is a burden for physicians, who end up performing tasks that not only feel pointless and frustrating, but also distract them from the goal of helping patients. Further, the repetitive reparatory tasks fail to repair anything or lead to meaningful improvements. The article puts forth the darker qualities of repair as a lens to examine whose aims and interests are served by data-driven reforms, and to evaluate and anticipate breakdowns that accompany them.

Repairing (with) algorithmic systems

To round up this Special Issue's discussions on repairing (with) algorithmic systems, we highlight five fronts of repair debates that the contributions participate in.

Qualities and modalities of repair. The articles in this Special Issue address different stages of development related to algorithmic systems and AI in the public sector: the promissory stage prior to system implementation when algorithmic systems are proffered as solutions to broken aspects of services provided in the public sector (Neves et al.), the aftermath of an algorithmic system's introduction (Ruckenstein), different breakdowns that occur with an existing and operating system (Carillon; Alastalo and Lehto), and the data repair work that takes place at the backstage of health and care, but that is increasingly required by expected AI transformations (Lambotte and Martin-Scholtz). In these analyses of breakdown-repair processes, the authors encounter various forms of breakdown, and various modalities or qualities of repair.

Neves and colleagues analyse breakdown and repair as attempts to create agreement that the existing order in long-term care is compromised in a specific way, and that commercial AI developers provide the desirable means to re-establish order. This does not mean simply the return of the old order: the breakdown constructed here requires a transformation – one that advances the AI industry's interests. In both Carillon's and Ruckenstein's articles, identifying the modality or quality of repair is at the heart of the analysis. For Carillon, repair appears in the form of 'patching' that is not targeted at the root cause of the breakdown. Instead, repairs are carefully constructed so that the algorithmic system's legitimacy is not threatened or, in other words, unwanted transformations do not occur. Ruckenstein's analysis suggests that many qualitatively different repair processes can be simultaneously at play when algorithmic systems are brought in to rearrange organizational practices. These different qualities of repair may be far from productive and renewing: it can rather be a burden. Alastalo and Lehto deal with a constant cycle of breakdown and repair. In their case, the robot's breakdowns are its well-known feature, and what they discuss exhibits qualities of broken world thinking. Their analytical solution is to focus on the friction that creates the broken world. Lambotte and Martin-Scholtz analyse broken data and its repair, and discover laborious acts of data maintenance, but also maintenance of a more social kind, such as relations of power between institutions. Transformations, in their case, are not contained within repair work which remains a conservative force, but rather enter from the outside, as national AI strategies and policies bring with them new data-related requirements.

All of this points to the value and importance of breakdown and repair as analytical approaches, and different modalities and qualities of repair as an 'analytical toolkit' as Ruckenstein suggests. It also points to the need to carefully consider and distinguish what breaks down, the qualities of repair that enter as a response, and the limits of these concepts. What externally appears as repair, for example, may not inherently conform to positive or empowering qualities often suggested by the notion. The 'permanent beta' status of many algorithmic systems also poses a risk of flattening their falling-apartness. While these systems are always under repair, attention to various qualities of repair can do more than just describe that state and sustain and conform to it.

Repair vis-à-vis solutionism. The notion of technological solutionism is often invoked simply as the technological fix to a more complex problem. More potently, as Lotje Siffels and Tamar Sharon have recently discussed (2024), solutionism can be considered a mode of problem construction, where available technologies begin to constitute problems. As Neves and colleagues highlight in their contribution to this Special Issue, the notion of technological solutionism can be usefully paired with the conceptual tools of breakdown and repair. Armed with these concepts, we can begin to see how generally available forms of AI applications, and particularly rigid expectations for their value and performance (Lehtiniemi, 2024), come to define what is a problem, what is considered a breakdown, and what does not work according to expectations. Available means to solve problems therefore begin to define both what is considered to be broken and how to repair it. The relationship between solutionism and repair might be considered in terms of the 'slippage' that Henke and Sims (2020: 19) discuss: a contrast is drawn between a system now and its desired state and then repair with algorithmic systems is posed as a means to bridge between the two. To be clear, the issue here is not that the existing order begins to look undesirable when conditions change along with new technologies. Rather, the issue is that breakdowns thus constructed are not necessarily the ones that most pressingly call for repair. As Siffels and Sharon (2024: 125) point out, attention to solutionism "allows one to focus on how the problem definition for which a technosolution is proposed came to be and to question if this was done well". Breakdown and repair as a form of techno-solutionism remains a theme with broader applicability in the kinds of 'AI transformations' that emerge across fields of application. This approach takes some of the shine away from the largely positive and forward-looking associations with the notion or repair, a theme we will return to later.

Methodologies to study breakdown and repair. Three out of the five articles included in the Special Issue employ ethnographic methods, broadly understood. This, in our view, speaks of the contexts in which the processes of breakdown and repair can be observed. As Alastalo and Lehto describe in their contribution to this issue, their focus on the constantly-breaking-down robot was not initially planned. Rather, this breakdown, or 'friction' as they call it, caught their attention during observations. Breakdown and repair, in other words, left a mark (Denis and Pontille, 2025), and this served as an invitation to investigate the issue further. In their contributions, Carillon as well as Lambotte and Martin-Scholz similarly encountered breakdown and repair work during their empirical investigations. Even though breakdown makes things visible, smaller and constantly ongoing breakdown–repair processes are probably more likely to escape analytical attention unless they are observed in this way. More spectacular breakdowns can attract attention from afar – the potentially publicly highly visible breakdowns of the recommended system investigated by Carillon being an example – but details about them can also be most likely captured in the course of ongoing observation.

Repair and optimism. At its heart, repair appears as an optimistic and forward-looking concept: something noble or empowering is involved in attempts to return things to order, or to fix, renew, restore, or care for things. When something is framed to be *in need of repair,* the feeling of progress might be difficult to contest, and those involved in repair can experience involvement in making things better. Great expectations are placed, for example, on the opportunity to fix or improve public services as more data becomes available. This is clearly visible in healthcare, where data, and already existing data practices, are expected to feed innovation powered by AI. However, as Ruckenstein extensively discusses, attempts to repair things involve also darker aspects: repair might fail in its intentions and shape physician's daily work in ways that do not give them much reason for optimism. As also Lambotte and Martin-Scholz as well as Alastalo and Lehto show, repair related to algorithmic systems in practice means various forms of practical, grassroots-level human work and recontextualization. Often this might happen without the possibility to consider, let alone affect, how repair is done and what is its purpose.

The veneer of optimism might also hide other important questions, such as those of power and possibility: Who gets to maintain the existing order with repair, and what consequently gets hidden or contained (Carillon, this issue)? Hopes placed in repairs with algorithmic systems may postpone other urgently needed repairs if resources get diverted from other already well-known solutions (Neves, this issue), or because accumulation of 'more data' is argued to be needed before any action can be taken (Hoeyer, 2019). Thus, promissory repairs might distract from the kind of repair the world needs right now, and repairing with algorithmic systems can involve the avoidance of repairing by other means.

Repair and the human side of algorithmic systems. Finally, the contributions to this issue underline that repair related to algorithmic systems can implicate the humans and the human work involved in those systems in different ways. Attention to repair can make visible how the construction of breakdowns and their repair might cast humans as lacking as Neves and colleagues describe in their contribution, framing human deficiencies as the reason for repair. Alternatively, attention to breakdown and repair can help recognise necessary and unavoidable acts of care, maintenance, or assistance that keep algorithmic systems and processes up-and-running, as Alastalo and Lehto, as well as Lambotte and Martin-Scholtz, discuss in their contributions. Attention to breakdown and repair can show how repairing apparently technical breakdowns can also, or even primarily, target human and organisational relations, as Carillon's analysis shows. And more reflexive approaches to repair might help recognize how attempts to repair with algorithmic systems can derail humans from focusing on what matters to them, ethically and professionally, as Ruckenstein's contribution to this issue helps us see. Repair is a socio-technical phenomenon involving interventions in all the social and technical aspects of keeping systems in working order. But we would argue it can also be something more: in all of the above senses, repair can turn attention to how humans are affected, implicated, required by, or are constitutive parts of, algorithmic systems.

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References

Alastalo M and Lehto I (2025) Frictions in Automating Routine Data Work: A Human-Assisted Robot in Datafied Healthcare in Finland. *Science & Technology Studies* 38(4): 57-63.

Alkhatib A and Bernstein M (2019) Street-level algorithms: A theory at the gaps between policy and decisions. In: *Proceedings of the 2019 CHI conference on human factors in computing systems*. Association for Computing Machinery, pp. 1-13.

Allhutter D, Cech F, Fischer F, Grill G and Mager A (2020) Algorithmic profiling of job seekers in Austria: How austerity politics are made effective. *Frontiers in Big Data* 5.

Bareis J and Katzenbach C (2022) Talking AI into Being: The narratives and imaginaries of national AI strategies and their performative politics. *Science, Technology & Human Values*, 47(5): 855-881. https://doi.org/10.1177/01622439211030007.

Bovens M and Zouridis S (2002) From street-level to system-level bureaucracies: How information and communication technology is transforming administrative discretion and constitutional control. *Public Administration Review* 62(2): 174-184.

Broussard M (2023) *More than a Glitch: Confronting Race, Gender, and Ability Bias in Tech*. Cambridge: The MIT Press.

Carillon K (2025) Closing the Algorithmic Black Box: Breakdowns and Patching Strategies in a Public Service Media. *Science & Technology Studies* 38(4): 35-56.

Dant T (2019) Inside the bicycle: Repair knowledge for all. In: Strebel I, Bovet A and Sormani P (eds) *Repair Work Ethnographies: Revisiting Breakdown, Relocating Materiality*. Singapore: Springer Nature Singapore, pp. 283-312.

Dencik L and Kaun A (2020) Datafication and the welfare state. *Global Perspectives 1*(1): 12912.

Denis and Pontille (2025) *The Care of Things: Ethics and Politics of Maintenance*. Cambridge: Polity Press.

De Togni G, Erikainen S, Chan S and Cunningham-Burley S (2024) Beyond the hype: 'Acceptable futures' for AI and robotic technologies in healthcare. *AI & Society* 39: 2009-2018. https://doi.org/10.1007/s00146-023-01659-4.

Eubanks V (2018) *Automating inequality: How high-tech tools profile, police, and punish the poor.* New York: St. Martin's Press.

Galis V and Vlassis V S (eds) (2025) *Digitalization, Data and Welfare: Sociotechnical Approaches to Service Delivery*. Cheltenham: Edward Elgar Publishing.

Graham S and Thrift N (2007) Out of order: Understanding repair and maintenance. *Theory, Culture & Society* 24(3): 1-25.

Henke C R and Sims B (2020) *Repairing infrastructures: The maintenance of materiality and power*. Cambridge: Mit Press.

Hoeyer K (2019) Data as promise: Reconfiguring Danish public health through personalized medicine. *Social Studies of Science* 49(4): 531-555. https://doi.org/10.1177/0306312719858697.

Huby G, Røste R and Reutter L M (2024) Digitalization – Saving or Undermining the Nordic Welfare State? *Nordisk välfärdsforskning* (2): 120-126.

Jackson S J (2014) Rethinking Repair. In: Gillespie T, Boczkowski P J and Foot K A (eds) *Media Technologies: Essays on Communication, Materiality, and Society*. Cambridge: MIT Press, pp. 221-239.

Kaun A and Liminga A (2023) Welfare service centers: Maintenance, repair, and care at the analog interfaces of the digital welfare state. *New Media & Society* 27(5): 3039-3054. https://doi.org/10.1177/14614448231220362.

Kaun A and Männiste M (2025) Public sector chatbots: AI frictions and data infrastructures at the interface of the digital welfare state. *New Media & Society* 27(4): 1962-1985.

Kvakic M, Hansen H A and Fineide M J (2023) If digitalization is the answer – what is the problem? An analysis of policy documents related to the digitalization of Norwegian child welfare services. *Nordic Social Work Research* 15(3): 381-393. https://doi.org/10.1080/2156857X.2023.2277255.

Lambotte F and Martin-Scholz A-M (2025) Maintaining and Repairing the Cancer Registries' Regime of Knowing in the Turbulent Context of the French National AI Strategy. *Science & Technology Studies* 38(4): 64-96.

Lehtiniemi T (2024) Contextual social valences for artificial intelligence: Anticipation that matters in social work. *Information, Communication & Society* 27(6): 1110-1125. https://doi.org/10.1080/1369118x.2023.2234987.

Marjanovic O, Cecez-Kecmanovic D and Vidgen R (2021) Algorithmic pollution: Making the invisible visible. *Journal of Information Technology* 36(4): 391-408. https://doi.org/10.1177/02683962211010356.

Marres N and Stark D (2020) Put to the test: For a new sociology of testing. *British Journal of Sociology* 71(3): 423-443. https://doi.org/10.1111/1468-4446.12746.

Mergel I, Dickinson H, Stenvall J and Gasco M (2023) Implementing AI in the public sector. *Public Management Review*: 1–14. https://doi.org/10.1080/14719037.2023.2231950

Montiel Valle D A and Shorey S (2024) Dis//assemblages of AI: Repair labor and resistance in the automated workplace. *Information, Communication & Society* 27(10): 2022–2037. https://doi.org/10.1080/1369118x.2024.2371794.

Neff G and Stark D (2004) Permanently beta. *Society online: The Internet in context 173*: 188.

Neves B B, Mead G, Sanders A, Broom A, Ahmadpour N and Gulson K (2025) Breaking or Repairing Long-Term Care for Older People? AI Delegation and the Carefication of Later Life. *Science & Technology Studies* 38(4): 13-34.

Pink S, Ruckenstein M, Willim R and Duque M (2018) Broken data: Conceptualising data in an emerging world. *Big Data & Society* 5: 1-13. https://doi.org/10.1177/2053951717753228.

Rachovitsa A and Johann N (2022) The human rights implications of the use of AI in the digital welfare state: Lessons learned from the Dutch SyRI case. *Human Rights Law Review* 22(2).

Ratner H F and Schrøder I (2024) Ethical plateaus in Danish child protection services: The rise and demise of algorithmic models. *Science & Technology Studies* 37(3): 44-61. https://doi.org/10.23987/sts.126011.

Ruckenstein M (2025) The Darker Qualities of Repair. *Science & Technology Studies* 38(4): 97-113.

Saikkonen P and Choroszewicz M (2025) Fostering Socially and Ecologically Sustainable Digitalisation of Welfare States. *Social Inclusion 13*.

Schwennesen N (2019) Algorithmic assemblages of care: Imaginaries, epistemologies and repair work. *Sociology of Health & Illness* 41: 176–192. https://doi.org/10.1111/1467-9566.12900.

Seaver N (2019) Knowing Algorithms. In: Vertesi J and Ribes D (eds) *Digital STS. A Field Guide for Science & Technology Studies*. Princeton: Princeton University Press, pp. 412-422.

Siffels L E and Sharon T (2024) Where Technology Leads, the Problems Follow. Technosolutionism and the Dutch Contact Tracing App. *Philosophy & Technology* 37(125): 1-33. https://doi.org/10.1007/s13347-024-00807-y.

Star S L (1999) The ethnography of infrastructure. *American Behavioral Scientist* 43: 377-391.

Susser D (2022) Data and the Good. *Surveillance & Society* 20(3): 297-301. https://doi.org/10.24908/ss.v20i3.15764.

Tanweer A, Fiore-Gartland B and Aragon C (2016) Impediment to insight to innovation: Understanding data assemblages through the breakdown–repair process. *Information, Communication & Society* 19(6): 736-752. https://doi.org/10.1080/1369118x.2016.1153125.

van Toorn G, Henman P and Soldatić K (2024) Introduction to the digital welfare state: Contestations, considerations and entanglements. *Journal of Sociology 60*(3): 507-522. https://doi.org/10.1177/14407833241260890.

Velkova J and Kaun A (2021) Algorithmic resistance: Media practices and the politics of repair. *Information, Communication & Society* 24(4): 523-540. https://doi.org/10.1080/1369118X.2019.1657162 .

Winner L (1978) *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*. Cambridge: MIT Press.

Breaking or Repairing Long-Term Care for Older People? AI Delegation and the Carefication of Later Life

Barbara Barbosa Neves

Sydney Centre for Healthy Societies, School of Social and Political Sciences, The University of Sydney, Australia/barbara.barbosaneves@sydney.edu.au

Geoffrey Mead

Sydney Centre for Healthy Societies, School of Social and Political Sciences, The University of Sydney, Australia

Alexandra Sanders

Sydney Centre for Healthy Societies, School of Social and Political Sciences, The University of Sydney, Australia

Naseem Ahmadpour

Design Lab, School of Architecture, Design and Planning, The University of Sydney

Alex Broom

Sydney Centre for Healthy Societies, The University of Sydney, Australia

Kalervo Gulson

Centre for AI, Trust and Governance, Sydney Centre for Healthy Societies, Sydney School of Education and Social Work, The University of Sydney, Australia

Abstract

From robots to chatbots, AI technologies in care (nursing) homes have gained policymakers' attention amid critical issues like staffing shortages. Concurrently, the long-term care sector has become a prime target for technologists due to its global market potential given the growing ageing population. Drawing conceptually on ideas of breakdown and repair, we explore sociotechnical discourses of AI-based care for later life. We combine Bruno Latour's concept of delegation and Madeleine Akrich's notion of user representations to frame how these discourses can support *breaking* or *repairing* long-term care. Through this theoretical lens, we analysed 33 AI companies targeting the sector. Visual, textual, and semiotic analysis of their websites identified overarching discourses on ageing carefication, public inefficiencies, AI solutionism, and care datafication. Older people were depicted as passive data sources and staff as inefficient, positioning AI as the solution to all caregiving challenges. We consider implications for caregiving futures and for reimagining AI-human care.

Keywords: AI in Long-Term Care, Datafication, Carefication, User Representation, AI Solutionism, Aging

Introduction

Like other spheres of social life, ageing and related policies are being influenced by technological changes and Artificial Intelligence (AI) advancements. These changes shape perceptions and practices within care institutions, welfare systems, and caregiving relations (Gallistl and Von Laufenberg, 2023; Lehtiniemi, 2023; Tarkkala et al., 2019). The use of AI in care (nursing) homes – from companion robots to generative AI-powered chatbots like ChatGPT – has captured policymakers' attention, especially as the COVID-19 pandemic illuminated systemic failures like staffing shortages (Chen, 2020; Neves et al., 2023; Neves and Omori, 2023). A recent Australian Royal Commission (Pagone and Briggs, 2021) into the sector urged technological investment to address long-term care deficits, from clinical neglect to increasing loneliness, affecting older people (aged 65+) in care homes (institutionalised ageing) and community settings (ageing in place).

In Australia and many Western countries, long-term care – which includes care/nursing homes and formal assistance given to older people living in their homes – is government funded and regulated as part of public service delivery (Australian Institute of Health and Welfare, 2024). This sector has become a prime target for technologists and the AgeTech industry due to its 'market potential' of profitable expansion across public and private care, and the portrayal of an ageing population as a biomedical problem requiring urgent government intervention (Gallistl et al., 2024; Gomez-Hernandez, 2024; Neven and Peine, 2017). Yet research shows novel technologies developed for later life often perpetuate visions of care as a cost and older people as passive and digitally unskilled (Jaakola, 2020; Neves and Vetere, 2019; Peine et al., 2021). This ageist perspective persists despite a body of knowledge on ageing and technology demonstrating older people are not only resourceful and adaptable to emerging technologies, but also actively shape technological use to address their own care needs (Neves et al., 2018; Peine et al., 2021). Moreover, older people play a vital role in care economies, providing care for others and themselves, even when living with frailty or health issues that necessitate formal or institutional forms of support (Dalmer et al., 2022; Neves et al., 2018). Nonetheless, stereotypical ideas of older people – particularly those requiring long-term care – continue to animate imaginaries and narratives of policymakers, technologists, and broader society (Chu et al., 2022; Gallistl et al., 2024; Neves et al., 2023; Stypińska, 2023).

In this article, we focus on the emerging AI industry for later life – namely on the *sociotechnical discourses* of relevant commercial actors: i.e., the overarching, interlinked elements used on AgeTech websites to represent how ageing, care, and technology are understood (Hall, 2018; Neven and Peine, 2017). While these discourses have not yet been explored in the literature, we contend they are critical to study, as they not only influence and justify technological development but also potentially shape policy decisions and assumptions about how care should be designed and delivered. In fact, the 'techno-solutionism' permeating contemporary societies results from a commercial and market-driven framing of social needs and challenges as problems demanding emerging technological solutions (Morozov, 2013). Drawing conceptually on ideas of breakdown and repair (Jackson, 2014; Star, 1999), we aim to explore how ageing and human care are problematised, and, in turn, how AI solutions are constructed and communicated. In this context, expectations that AI mend what is perceived as broken in public health and care often overlook how AI solutions can result in negative unintended consequences and call for their own repair. We treat techno-solutionism as one particular form of repair – a way of addressing perceived breakdowns that privileges technological fixes.

To grasp the shifts between human and technology, we combine Bruno Latour's (1999, 2005) notion of delegation with Madeleine Akrich's (1992, 1995) concept of user representations. This novel combination offers a wide-ranging approach to understanding how AI-focused discourses about later life care can reflect and support *breakdown* and *repair* in its various forms (from inefficient service delivery to care monitoring). To explore such discourses, we visually, textually, and semiotically analysed the websites of 33 companies offering AI technologies for the long-term care sector. Marketed technologies included carebots, chatbots, sensor systems, and smart clinical apps for institutionalised and/or ageing-in-place settings. The websites offer these discourses in a distilled form, relaying what members of the AgeTech industry identify as breakdowns and potential solutions (repairs) in long-term care. From website data, we are thereby able to infer how anticipated users are represented and prefigured.

Our findings show ageing is approached as a state demanding little more than care. Additionally, the sector is depicted as plagued with inefficiencies and failures of public delivery that can only be solved by AI technologies. AI is presented as a revolutionary solution to alleviate (all) challenges, from diseases to workforce shortages, enabling unprecedented support to home and residential caregivers by optimising care management through automated monitoring and analytics. These ideas justify the need for AI delegation in later life care while advancing simplistic user representations of older people and care staff.

This paper contributes, therefore, to the growing scholarship on AI, ageing, and care by offering an empirically grounded analysis of underexplored commercial discourses. We advance a novel application of the concepts of breakdown and repair to the long-term care sector and combine the frameworks of delegation and user representation in innovative ways to map how solutionism takes shape within sensitive care contexts. In doing so, we show how commercial portrayals not only justify AI-driven interventions but also obscure the social and relational dimensions of care, with implications for how ageing, responsibility, and vulnerability are conceptualised in policy and practice.

AI and long-term care: Breaking and repairing

The long-term care sector offers a valuable context for examining age- and care-related ideas underpinning the design, marketisation, and commercialisation of AI for older people (Dalmer et al., 2022; Gallistl and Von Laufenberg, 2023). The few empirical studies in long-term care indicate that AI technologies reflect stereotypes of older people as disengaged (Neves et al., 2024; Gallistl and Von Laufenberg, 2023). Such perceptions extend beyond care recipients, echoing societal views and anxieties surrounding ageing (Neves et al., 2023). For instance, Ivan and Loos (2023) show technology marketing tends to depict both older women and older people living with cognitive impairments as technologically incompetent, disinterested, and passive subjects – not active users. This concords with popular portrayals, which often link technology to masculinity, youth, and whiteness (Loos et al., 2022). Researchers have highlighted concerns about power imbalances within the *datafication* of ageing and long-term care systems (Dalmer et al., 2022; Katz, 1996). This datafication entails measuring and quantifying care practices and older adults' behaviours (Dalmer et al., 2022). But instead of supporting recipients' capacity for self-directed care, datafication undermines their agency by placing them under the constant oversight of those monitoring them. Such a process exposes power dynamics in how older bodies are conceptualised, perceived, quantified, monitored, and controlled through technology and social perspectives (Dalmer et al., 2022; Katz and Marshall, 2018). Gallistl et al. (2024) observe that in the context of AI's political economy and market-oriented logic, ageing is frequently commodified – with older people becoming profit-making 'data suppliers' to extract from and feed into large language models (LLMs) and predictive systems.

This article explores whether and how industry-led narratives of AI might reinforce these views (e.g., age-related stereotypes, power dynamics, techno-solutionism) – thereby threatening and breaking public assurances of care and empowerment in old age, even as these discourses present AI as a solution to service delivery breakdown. We ground our investigation in the conceptual ideas of breakdown and repair (Jackson, 2014; Star, 1999). Star (1999: 380) notes breakdowns in infrastructure expose our dependence on this mostly invisible "system of substrates." Infrastructure and public service delivery are not the only fragile entities requiring repair, since the very means of repair (in this instance, AI) is itself liable to break down and require repair. This raises a crucial question: what counts as a breakdown, and who gets to decide?

Breakdowns have a tangible political dimension. Fragile entities are not automatically, transparently, and unproblematically perceived to be broken down, but *asserted* to be so and therefore open to contestation. For Morozov (2013: 6), the deficiency of 'techno-solutionism' lies not only in a tendency toward easy technical solutions for a problem (or breakdown), but in the "very definition of the problem itself." Problems are framed to fit 'solutions,' with AI presented as the unproblematic answer (Bareis and Katzenbach, 2021; Siffels and Sharon, 2024). Thus, we do not argue there is any single inherent problem AI is addressing; rather, the property these breakdowns share is that AI is seen as their solution. By focusing on representations of AI users in long-term care, we can observe how the assertion of purportedly 'human' breakdowns acts to justify the introduction of a particular kind of repair. These breakdowns – in public service delivery (e.g., over-spending), human-delivered care (e.g., inefficiency), and the ageing body (e.g., frailty) – come to be defined as human only in opposition to their proposed solution: nonhuman technology. In the case of long-term care, we witness a reversal of the traditional breakdown-repair relationship; here, breakdowns attributed to 'human' functions are *asserted* so technological repair can be introduced (as opposed to humans tending to broken-down infrastructure). Though typically framed as a categorical 'innovation' or solution, this kind of repair requires durable maintenance – its own "subtle arts of repair" (Jackson, 2014: 222) – and efforts to resist potential algorithmic biases and datafication harms.

We therefore conceive of breakdown and repair as involving repeated alternation between what is breaking down and repairing. We begin with a set of perceived breaks: a degraded care system, consisting of humans ostensibly working inefficiently to assist frail older people (themselves in a 'breaking' state). The repair appears in the proposed roll-out of AI technologies targeted at several points (e.g., bodily surveillance, datafication, and broad-based care 'solutions'). But, following the insights of infrastructure literature (Graham and Thrift, 2007; Jackson, 2014), such modes of repair also break down and consequently call for their own repairs and maintenance. This marks an important shift, with the reallocation or 'delegation' of tasks to and from human beings. In long-term care, as we will see, delegation is a pivotal mediator in relationships between humans and nonhumans in care delivery and uptake. It is to the concept of delegation that we now turn our attention.

Conceptualising delegation and user representations

To understand the alternating relationship between breakdown and repair in long-term care, we draw on concepts developed by Bruno Latour (1992, 2005) and Madeleine Akrich (1992, 1995) within the framework of actor-network theory. This theory mobilises a vision of society as something that "has to be built, repaired, fixed and, above all, *taken care* of" (Latour, 2005: 204, emphasis in original). Key to this 'caring' process is a delegation of tasks to technological objects, which enables social relations to be maintained (Graham and Thrift, 2007; Latour, 1992).

Latour borrows delegation from the semiotician A. J. Greimas (Greimas and Courtés, 1982: 72), for whom it refers to a "transfer of competence which…confers on the subject concerned a margin of autonomy for the performance" (see also Greimas, 1990). Latour (1992) transposes this notion from linguistics to the social sciences to help make sense of how the capacity for or 'competence' in performing acts gets distributed between humans and technical objects. In this article, we use delegation in two ways: firstly, to identify which competences are redistributed to which actants, how this occurs, and to what extent. That is, are humans depicted as merely *supplemented* by technical objects, or are they thoroughly *displaced*? Secondly, we seek to identify what effect this delegation is predicted to have on the performance of the described actions. Crucially, the 'margin of autonomy' that delegation permits means the delegate will perform the action in a different way than the initial actor performs it. A technical delegate, for example, will impose upon the performance modifications arising from its own structure and the unique relations it maintains with its surroundings.

In this approach, delegation means designers 'inscribe' their envisioned functions in the technical object itself. Knowingly or not, they mobilise a particular image of it in relation to other objects and end users (Savolainen and Hyysalo, 2021). Such a view of the object – as inscribed with meaning – is what Madeleine Akrich (1991: 85) describes as the 'semiotic hypothesis':

> it is possible to describe a technical object as a scenario, a script, defining a space, roles, and rules of interaction between the different (human and non-human) actors who will come to embody those roles: from this perspective, every decision taken in the process of conception undertakes a distribution of competences and attributions between the object, its user, and a collection of technical and social apparatuses that constitute their environment.

In the scripts Akrich describes, a certain 'user representation' is implied, with particular competences attributed to imagined users. But Akrich (1992) is adamant the uses depicted in these scripts do not translate simply into actual uses. Designers may formulate inaccurate user representations, users may reject designers' aims, or the object design may assume a set of relations that does not exist. This becomes clear in the example of the Zimbabwe bush pump, a device for drawing water from a well (de Laet and Mol, 2000). As de Laet and Mol (2000: 249) explain, the pump functions effectively not because its designer anticipates end users perfectly, but because he "seems to dissolve his own actorship," relinquishing ownership and allowing the technology to evolve through collective use and local adaptation. The designer himself emphasises the pump is not the product of a single creator, but the result of collaborative effort, high-quality materials, and gradual evolution within the public domain (de Laet and Mol, 2000).

Akrich's (1992) semiotic hypothesis is therefore useful to grasp not how technology is necessarily *used*, but how developers imagine and *intend* it to be used. In this article, we take Akrich's approach but expand our focus to encompass actors outside the designers themselves. Beyond being inscribed with developers' intentional and unintentional programs of action, various other 'scripts' exist that represent and mediate objects, informing their use. In these scripts – from instruction manuals to promotional materials – intended end users are prefigured, with their bodily competences, intellectual aptitudes, moral beliefs, and social relations cast before them. These forms of representation fill the function of what Akrich (1992: 211) calls 'mediators': "[i]f we are to describe technical objects, we need mediators to create the links between technical content and user." The links connecting these elements are also boundaries that distinguish them, apportioning certain tasks to the user and delegating others to the technology. By investigating the representations embedded in the media portraying objects, it is possible to ascertain this apportionment and trace the boundaries between human and nonhuman, permitting us to delineate what Akrich (1992: 206) calls the "geography of delegation."

This 'geography' does not consist of straightforward border lines. At times, the beings invoked as delegates to repair breakdowns are in need of repair themselves (Henke, 1999). Such an interchange provides part of our justification for linking delegation to the concepts of breakdown and repair present in studies of infrastructure. In this scholarship, the processual approach is cast as "an unfolding *when,*" echoing pre-modern views of infrastructure as ongoing 'public works' (Alff, 2021: 626, emphasis in original). Likewise, a processual approach is crucial to grasp delegation, seeing it not as accomplished upon 'appointment,' but something that must be durably maintained. When humans delegate tasks to technical objects, it is important to recognise the work that is required to ensure the delegates' own ability to carry out their roles (Fox et al., 2023; Gray and Suri, 2019). As discussions of breakdown and repair suggest (Denis and Pontille, 2023), this maintenance process is an ongoing one, often requiring – as in the case of long-term care – the continuing reparative efforts of the very humans whose roles were delegated to nonhuman technologies. In representations of users, this back-and-forth mutual repair is frequently ignored, with certain designs even prohibiting user alteration (Akrich, 1992; Graham and Thrift, 2007). It remains unclear whether AI companies' socio-technical discourses around later life care exhibit these same dynamics. Analysing both delegation and user representations thus helps identify how AgeTech companies conceptualise breakdown and repair. In particular, the notion of delegation permits us to trace how tasks deemed to be affected by breakdown will be undertaken differently as a consequence of their delegation.

Methods

This article analyses textual and visual data from the websites of 33 companies commercialising AI technologies for later life care. The websites were found through a Google search using the most common terms identified in an exploratory literature review on AI and later life care: "AI" and "product[s]"/"service[s]" and "aged care" or "home care" or "elder[ly] care" or "long-term care" or "AgeTech" or "senior[s] care" or "senior[s] living" or "nursing home[s]." We collected data from all companies listed in the top 100 'most relevant results' (as of 1 May 2024), prioritising links most likely to be encountered by audiences (see Vermeer et al. 2022 for a similar strategy). We excluded sites not marketing their own products, including news, academic, and blog articles. The 33 companies operated globally or in these countries/regions: Oceania (Australia, New Zealand), North America (Canada, US), Asia (Hong Kong, Malaysia, Singapore), and Europe (Finland, Germany, Greece, UK) (see appendix). They offered AI technology/services focused on client monitoring and safety (14 companies); healthcare management related to areas including nutrition, pain, and therapeutic care (7); staff and operational support (5); robotic companions (4); and analytical and decision-making support (3). Technologies marketed included carebots, chatbots, sensor systems, and smart clinical apps, though their specific AI capabilities were frequently unclear.

We analysed the websites via a multi-tiered approach integrating qualitative and quantitative techniques. Each tier was informed by our general theoretical approach, emphasising delegation, technical objects, and user representations (Akrich, 1991; Greimas, 1990; Latour, 1992). Building on this, in the first stage, we conducted content analysis using theory-driven categories that enabled us to code and organise data into 'technology type,' 'care type,' 'user needs,' and frequently used words, which provided a sense of the most common priorities and language used on the websites. In the second stage, we thematically analysed textual and visual elements to identify recurring themes on user representations and AI roles within and across websites (Clarke et al., 2014). This relied on both deductive (based on our pre-existing theoretical framework) and inductive (based on new insights observed in the data) coding. To grasp the broader, synthetic structure of meaning – and overarching discourses in which these visual and textual elements are located – we required a further stage. In this third stage, we adopted a semiotic framework informed by Vermeer et al. (2022: 405), developing "narrative summaries…to determine the dominant discourse." Vermeer et al. (2022) analysed semiotic signs in advertisements targeting people living with dementia. In Saussure's linguistic model, a sign combines a signifier (a mental representation of speech – for instance, 'grey hair') with a signified (the conceptual meaning it conveys within a linguistic system – for instance, in contrast to 'black hair') (Chandler, 2022). Importantly, these signs also carry connotations (for example, grey hair is to older as black hair is to younger). This method has been used to examine visual depictions of older people on public organisation websites (Loos et al., 2022) and in the marketing of technology for later life (Ivan and Loos, 2023). This three-stage approach allowed us to identify categories, themes, and user representations. Finally, we synthesised these results (Figure 1) to shed light on the companies' narratives, revealing their main discourses about AI's roles in long-term care. Analyses were conducted by the first and third authors, reviewed by the second for discrepancies, and validated by the remaining authors.

Due to ethical obligations – aligned with institutional and national guidelines on anonymity, confidentiality, and copyright – we are unable to use full quotations from the websites. Instead, we have incorporated short, non-identifiable excerpts and provided contextual narrations based on our thematic and semiotic analysis. The same restrictions apply to website images. To address this,

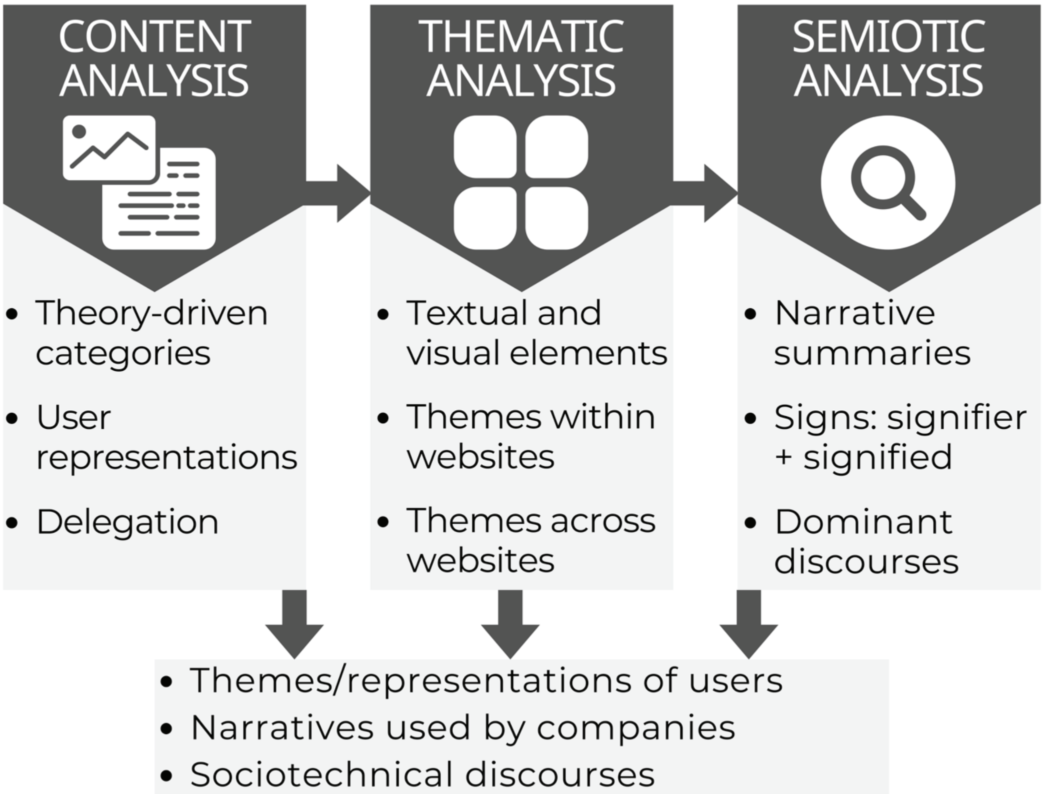

Figure 1. Data analysis approach.

we used Midjourney, an AI text-to-image tool, to generate mock-ups characteristic of those on the websites that visually represent main findings. We used a paid license, ensuring compliance with Midjourney's terms of use. This approach, which enables us to produce conceptual approximations rather than direct reproductions of copyrighted material, was previously employed by Ellison et al. (2022) and offers readers a representation of key visual themes by assembling the most illustrative elements from our dataset.

Findings

Our analysis identified narratives of breakdown and repair centred on datafication as a solution to perceived deficits in the sector, such as rising costs, unmanageable workloads, and substandard care. Website accounts positioned AI technologies as revolutionary solutions to systemic failures, while simultaneously reinforcing simplistic representations of older people and care work. Through exploring how care tasks are increasingly delegated from humans to AI technologies, we found commercial discourses utilised recurrent elements stipulating how AI should function in long-term care settings and how users – older people and care workers – should interact with these technologies. These sociotechnical discourses revealed how assumptions about ageing, later life, care work, and technological capability apportion care competences between human and nonhuman actors.

The AgeTech companies justified the need for AI delegation in later life care by employing four main discourses: i) *carefication* of ageing, ii) public inefficiencies of care, iii) AI solutionism, and iv) datafication of care. While analytically distinct, they closely interact. Together, they illustrate how technological framings both reflect and reinforce particular understandings of care relationships, while raising questions about what aspects of care become emphasised or diminished when delegated to AI systems.

Carefication of ageing

'Carefication' of ageing – in which ageing was framed as a state of old age requiring efficient care and surveillance – was found across all websites. Textual, visual, and semiotic representations positioned older people as inherently vulnerable and in need of technology-based interventions. For instance, websites repeatedly emphasised age-related "risks" and "problems" that could lead to "harm or hospitalization," promising "improved resident safety" and a capacity to identify issues before they escalate. These portrayals informed a discourse in which ageing is a fundamentally problematic and deteriorative later life process and stage requiring constant monitoring and management via AI systems.

Companies claimed their technologies could address these 'breakdowns' by providing "round-the-clock" care and surveillance of older people, who were textually and visually characterised as "vulnerable patients." This vulnerability was frequently quantified: websites stressed mortality rates from falls, high prevalence of malnutrition, and increased dementia risks associated with loneliness and social isolation. Statistics were used to justify interventions that could "automatically identify" when residents needed help and alert care staff to provide urgent assistance, suggesting AI was more reliable than older people or human workers in recognising care needs.

This framing naturalised the need for technological intervention while reinforcing stereotypes of old age as primarily defined by decline and dependency. Such a discourse positioned AI-based surveillance and care as inevitable, necessary responses to the "issues" and "challenges" of ageing and later life care, creating a self-reinforcing storyline in which the carefication of ageing justified increased technological delegation of care tasks.

Visual representations reinforced this carefication, with older people depicted as passive recipients of care rather than active participants in their own lives. Images typically showed them being assisted or monitored, while younger people were portrayed as active caregivers or technology operators. When older people were featured independently, they were frequently represented in

Figure 2. Mock-up image generated with Midjourney, characteristic of images on the analysed websites, illustrating the carefication of ageing.

contexts emphasising passivity, frailty, or risk – such as sitting, struggling to get up, using mobility aids, or being monitored by relevant technology. This visual scripting positioned older people as at-risk data sources to be monitored rather than autonomous individuals. Figure 2 reproduces an example of characteristic imagery from the analysed websites.

Public inefficiencies of care

By framing an ageing population and later life as defined by rising costs, accumulating risks, and constant care needs, websites justified claims that the long-term care sector cannot adequately manage such complex circumstances. The sector was consequently portrayed as substandard, characterised by systemic inefficiencies in the provision of quality service delivery.

Long-term care was depicted as facing significant challenges in the areas of staff engagement, communication, resident autonomy, and regulatory compliance, with these issues narrated as intrinsic to traditional care models. Human care labour – including constant "spot checks," "manual scanning," and extensive administrative requirements – took time away from "personalised care," "reduce[d] the quality of care," and led to "carer burnout" and "errors." Human care was therefore represented as inherently flawed and unreliable, requiring technological intervention to ensure quality care provision.

Within this discourse, care staff were painted as sources of inefficiency and risk. Companies highlighted how staff were overwhelmed by excessive workloads, suggesting this compromised their ability to provide quality care (see Figure 3). Staff were consequently portrayed as needing surveillance and control, with AI technologies offering to track regulatory and protocol compliance, thereby reducing errors. This depiction of care workers as potentially undependable was reaffirmed through promises AI could "predict and prevent unwanted occurrences" and offer more accurate, higher

Figure 3. Public inefficiencies of care workers (generated with Midjourney).

quality, and more efficient care than possible through human monitoring.

The solution was increased technological oversight, with systems that could "track," "monitor," and "alert" staff when action was needed – effectively positioning care workers as responders to AI-identified issues rather than skilled professionals exercising independent judgement. Picturing care workers as inefficient and unreliable validated the narrative that they required constant supervision. The technologies offered 'solutions' to these 'problems' in the form of comprehensive staff monitoring capabilities, including capacity to track care workers' movements, log their attendance, automatically report their delays to managers, and generate compliance reports.

These representations of public sector inefficiencies and staff inadequacies created a sense of urgency and crisis demanding urgent technological intervention. Traditional care practices were characterised as fundamentally flawed, with companies promising their AI could "empower staff" while concurrently ensuring they were "monitored" and "compliant."

AI solutionism

Having established long-term care as plagued by problems and human care provision as comparably inefficient, AI technologies were presented as "revolutionary" solutions capable of "transforming" the sector. Companies consistently presented their AI as a wide-ranging answer to the field's difficulties, promising to "revolutionize senior care" and resolve the industry's most critical issues. In light of the AI solution on offer, ineffective human care was reframed as a problem rooted not in underfunding or structural workforce challenges, but in *technical* inefficiencies. Thus, this AI solutionism operated not only by offering fixes, but by shaping the very nature of the problems to be fixed. This was reiterated through claims about technologies' "unprecedented" capabilities, from promises of "world-leading" and "game-changing" innovations to assertions that their products represented a "breakthrough" and "extraordinary" advancement in later life care provision.

This techno-solutionism rested on promises about AI's ability to address multiple care challenges simultaneously. Companies asserted their technologies could enhance staff efficiency, improve resident wellbeing, and boost operational performance – often via a single product. Complex organisational challenges, from workers' stress to regulatory liabilities, were reduced to coordination inefficiencies, only solvable through automated data flows and centralised AI platforms. These assertions were typically supported by metrics, with companies citing specific percentage improvements in worker efficiency, administrative tasks, and resident safety outcomes. Such quantification contributed a sense of scientific certainty to otherwise general claims about AI's transformative potential.

Central to this solutionist discourse was the casting of AI as inherently superior to 'fallible' human care provision. Technologies were described as offering more "accurate" and "efficient" care than possible through human monitoring, with companies emphasising how their systems could automatically identify when older adults required assistance and provide "actionable insights" that human caregivers might miss or be too 'unskilled' to identify. The problem of care was reimagined as a matter of gaps in data and detection – issues that AI, with its predictive analytics and surveillance capabilities, was uniquely suited to fix. The marketing consistently framed algorithmic monitoring as more reliable than human judgement, with companies stressing AI's precision in data collection and capacity for automated intervention.

The promised solutions extended beyond immediate care provision to encompass broader organisational challenges. Companies stated their products could elevate care standards, operational efficiency, and staff satisfaction by eliminating "mundane repetitive tasks." This all-encompassing problem-solving capability was frequently highlighted through declarations that AI could be used to replicate human judgement and analytical skills while concomitantly resolving human limitations. One company promised its AI would improve staff efficiency and resident safety as well as provide comprehensive reporting, ensure compliance, and foster better stakeholder collaboration, all

Figure 4. Representation of typical monitoring and analytics (generated with Midjourney).

through a single technological solution targeting critical organisational functions including clinical care, workforce management, quality assurance, and financial oversight.

Visual representations reinforced these solutionist accounts, with websites featuring sophisticated interfaces displaying real-time monitoring, predictive analytics, and automated alert systems (see Figure 4). Images typically showed AI systems actively monitoring and managing care situations, whereas human caregivers were depicted as responding to AI-generated alerts or following AI-directed protocols.

Notably, this solutionist framing positioned AI not merely as a tool to assist care provision, but as a holistic solution to systemic problems. Companies declared their technologies would "unlock" the "power" in data to deliver enhanced resident, staff, and business outcomes and foster continuous improvement. The underlying message was that AI could not only repair current care breakdowns but transform the entire care sector, addressing accommodation shortages, increasing profit margins, empowering staff, and improving service quality across care contexts. Through such expansive assertions, AI was again advanced as essential rather than optional, reconfiguring expectations about how later life care should be delivered and managed. Contextual, emotional, and relational aspects of care were often portrayed as burdens to be eliminated, legitimising the central role of the technology and the secondary role of human labour.

Datafication of care

To support and further improve that AI solutionism, care was depicted as needing to be 'datafied' to ensure effective monitoring, analysis, and regulation of older bodies and care practices. Websites channelled a discourse wherein data collection – often facilitated via AI-based surveillance – was naturalised as fundamental to quality care. Representations accentuated products' capacities to "continuously monitor" and "analyse" older people's activities, behaviours, and biological indicators to guarantee their safety and wellbeing, suggesting comprehensive data collection was synonymous with attentive care.

Visual representations underscored this datafication: images recurrently featured interfaces displaying metrics, charts, and real-time monitoring data. However, older people were often relegated to peripheral positions or represented via body parts or data points related to their actions, behaviours, biophysical pathologies, or bodily functions, symbolically reducing their presence to quantifiable parameters of fragility and vulnerability (see Figure 5). Textually, companies stressed their abilities to convert intimate daily activities into trackable metrics, from monitoring showering or sleep to detecting anomalies in eating patterns or vital signs.

These surveillance capabilities were presented as beneficial for both care recipients and providers, yet narratives generally prioritised institutional productivity over older people's autonomy, privacy, or dignity. The emphasis on data collection and analysis was accompanied by a lack of humanisation of older people, who were rarely represented as active managers of their own care; instead, older users were primarily depicted as data sources to be mined, monitored, and managed. "Efficiency" language dominated, with older people's experiences subordinated to service providers' data collection imperatives. Even claims of "personalized care" were articulated through data-based measures like "activity score[s]," "risk assessments," or "behavioural trends," with automated alerts for any "anomalies" requiring human intervention.

The underlying semiotic message conveyed that care could be reduced to measurable data points, with quality of care equated to both frequency and granularity of data collection. Textual and visual rhetoric also underlined technological mediation over human interaction, implying that understanding older people via their data was more efficient – and effective – than

Figure 5. Datafication (generated with Midjourney).

understanding them through human interpersonal engagement.

The 'datafication of care' discourse extended beyond individual monitoring to encompass entire care environments. Websites marketed "smart" platforms and systems that could analyse patterns, predict risks, and engender insights across residential facilities or home-based care organisations. This broad-scale, data-oriented surveillance was portrayed through signifiers suggesting technological omnipresence: interfaces showing multiple rooms simultaneously, bird's-eye views of facilities, and detailed activity logs. Such systems promised superiority in both oversight and risk management, thus feeding into efficiency logics and cost-minimisation desires that are particularly attractive to private – and, increasingly, public – providers.

Within this, care workers were similarly subject to datafication, with their tasks and locations monitored – and managers alerted if deviations, like lateness or a failure to attend to notifications, were recorded. This created a notion of care workers as points of risk requiring AI supervision for accountability. Websites, however, advertised such tracking of care delivery as a means of monitoring compliance and analysing staff productivity to improve service provision.

Companies' focus on optimising processes through data collection and analysis often overlooked the human dimensions of care work and its complex socioemotional and relational contexts. By prioritising the extractive logics of data accumulation and analysis, the datafication of older people, care workers, and care systems reduced the minutiae of human-to-human care to a set of computational metrics. This data-centric gaze depicted AI surveillance – and the subsequent conversion of all intimate daily activities into trackable datapoints – as inevitable and necessary for modern care provision, even if it diminished considerations of staff and older people's personhood.

Discussion

The four main sociotechnical discourses identified in our analysis help illuminate how assumptions of later life and care can shape both technological imaginaries and practices. These discourses show how AgeTech narratives of breakdown pervade representations of ageing and long-term care, echoing patterns observed in earlier technologies and prior research on technological interventions for older people (Gallistl and Von Laufenberg, 2023; Peine et al., 2021). In doing so, they create opportunities for the introduction of AI technology, framed as a 'solution.' These range from acute biophysical intervention to all-purpose structural remedy, with each introduction involving varying degrees of delegation from human action to non-human technology.

The dominant form in which websites represented older people was as sites of biophysical risk and deficit whose bodily fragility – stereotypically associated with ageing (Dalmer et al., 2022) – was evoked in images, quantified rates, and statistics. This purported breakdown of bodily and cognitive function rendered the older person passive: someone whose very existence expresses a need for tech-based, not touch-based, care and surveillance. This carefication of ageing – underpinned by organisational risk reduction and efficiency culture – implies a deficit approach to older people that is visible in existing research into how they are configured and portrayed in relation to other sociotechnical systems, like digital technologies (Ivan and Loos, 2023; Jaakola, 2020; Loos et al., 2022, 2023). Though such a breakdown could be conceivably 'repaired' in several ways (for example, increased employment of carers, greater medical supervision, etc.), the websites offered 'techno-solutions' as the automatic and most appropriate, effective, and efficient response. Likewise, the websites analysed purported to identify a breakdown in the service *infrastructure* that undergirds long-term care (Jackson, 2014). This breakdown was also linked to inefficiencies deriving from human functions: in this case, the character of care delivery, with the sector portrayed as facing critical challenges. Despite the distinct origins of this breakdown, websites again presented 'repair' as attainable solely through their technological solutions. Breakdown thereby becomes a strategic entry point – a market opportunity for advancing technological creep into the care economy – rather than an opportunity to either consider what led to the breakdown or reflect on the normative logics that underpin neglect in long-term care settings (Pagone and Briggs, 2021).

In the commercial AI narratives responding to these breakdowns, we observed a redrawing of the 'geography of delegation' (Akrich, 1992), with competences redistributed from humans to nonhumans (Latour, 1999). This delegation moves toward AI technology from two points of origin. First, it moves from older people themselves, whose competences for self-monitoring, expression, and even requesting help are delegated to objects in the form of AI systems. Second, carers' competences are delegated to these technical objects. As the delegation notion suggests, 'objects' enact competences in a distinct manner according to their own technical properties. Analysing the diverse ways competences are delegated permits us to pinpoint the importance of studying commercial entities: it is not a mere replacement of 'like for like,' but a transformation in how roles are enacted. In this case, this distinct manner is manifested, above all, in an increase in the *efficiency* of enactment. People's ability to identify their own ill health, for instance, becomes almost irrelevant as AI tools 'datafy' care, promising to reliably detect illnesses and diseases using objective markers. Thus, as older people's competences are delegated in the name of efficiency, they are positioned not as autonomous individuals but sites of risk whose health and conduct are best addressed in the form of datafied care (Dalmer et al., 2022; Gallistl and Von Laufenberg, 2023). At this point, the carefication of ageing and datafication of care intersect. Equally, the delegation of care workers' competences does not amount to a simple substitution of a nonhuman for a human (Latour, 1999). Again, the delegate accomplishes the task in a unique fashion: the AI does not merely grant users the ability to delegate care tasks to it, but also to exploit its affordances – e.g., its GPS tracker, calculating power, access to data – to supervise care workers. This provides a ready justification for its introduction: such workers are not dependable, but the technology is, and it can demonstrate the difference between the workers' and its dependability in a persuasive, quantitative manner.

Akrich (1995: 167) observes that novel technologies must make themselves functional to "dissimilar users possessing widely differing skills and aspirations." Despite the varying aims of different users, AI technologies were championed as beneficial to various individuals and groups: offering to lessen the burden for care workers, but also to render the latter more productive for their supervisors. By framing the breakdown as a case of inefficiency (especially of care workers) – and the solution as one of increased efficiency through data – the websites legitimised an interventionist approach while undermining confidence in human-centred care practices. This discourse created fertile ground for AI to be heralded as a new standard of care – and as the only solution to systemic problems in the long-term care sector. In addition to promissory accounts about AI technologies (Neves et al., 2023), this enthusiasm is guided by the idea that existing practices are insufficient to meet the demands of an ageing population and later-life care, specifically when ageing is framed as a biomedical burden (Berridge and Grigorovich, 2022; Gomez-Hernandez, 2024).

Although it is essential to critically evaluate the structural challenges in later-life care – including failures in the provision of adequate care and systemic inequities (Sturmberg et al., 2024) – we must also examine how AI solutionism shapes technological responses and efforts to prioritise efficiency over dignity, autonomy, and the complex needs of older people. Stereotypical beliefs were also used to frequently depict care staff in contradictory ways: as both highly caring and inefficient. As highlighted by Byrne and colleagues (2024), AI-generated images of nurses in long-term care often present them as calm, motherly, non-demanding figures. This depiction sharply contrasts with the realities of their demanding, fast-paced work environments, where nurses juggle multiple functions daily, including as managers, supervisors, counsellors, and liaisons (Byrne et al., 2024).

In addition to the specific tasks and roles delegated to nonhumans, the companies naturalised the AI technologies' wide-ranging, systematic roles – with relatively unlimited bounds. We can make sense of the ability for companies to imply comprehensive delegation and limitless roles for their products by returning to a central plank of techno-solutionism: the identification and depiction of problems in a manner that makes them amenable to technical responses (Morozov, 2013; Siffels and Sharon, 2024). This attention to the problem is especially pertinent when the technology's efficacy is not yet demonstrated. The promises present in the findings – in which AI remedies deficiencies in care delivery and increases profit, all while both empowering and controlling staff – are made more credible because of the dynamic and, at times, hypothetical form of the technology being marketed. Such fluidity permits AI to appear as a solution to problems that exist beyond its immediate application. In this way, this iteration of products finds its place in a history of AI mythmaking, which sees limits merely as temporary obstacles to be overcome in an undefined future (Brevini, 2021; Natale and Ballatore, 2020). The tendency to emphasise boundlessness, grounded in a capacity to re-cast complex breakdowns as technical problems with ready-made answers, enables AI products to be offered as general and systematic solutions, applicable almost irrespective of local context. As breakdown and repair researchers note, however, such systemic technologies must be adapted to these local contexts through maintenance practices like 'patchwork': the "labor that occurs in the space between what AI purports to do and what it actually accomplishes" (Fox et al., 2023: 2). Moreover, the abstract and general representation of AI should not distract from its concrete and local dependencies: "[a]rtificial intelligence is…a set of technological approaches that depend on industrial infrastructures, supply chains, and human labor that stretch around the globe but are kept opaque" (Crawford, 2021: 48).

AI solutionism requires forms of extraction and labour that are rarely accounted for, including increased data availability and computational power. It is therefore unsurprising that discourses highlighted a *datafication of care*, turning caregiving and receiving into data points (Dalmer et al., 2022; Gallistl et al., 2024). For instance, older people were rarely centralised or humanised, instead being depicted as data sources rather than active participants in their own lives or care. The emphasis was on collecting and analysing their information to generate actionable insights, with little or no focus on their subjective needs and preferences, even when personalisation was a core aspect of the narrative. While older people were positioned on the periphery – as vulnerable and risky due to frail health and a myriad of issues, from falls and malnutrition to incontinence and loneliness – they were also represented as central suppliers of data (Dalmer et al., 2022; Gallistl et al., 2024). Whilst even in this sense older people directly contribute to their care and the wider care economy (Neves et al., 2018; Peine et al., 2021), their role is overshadowed by the power dynamics inherent in the datafication of older bodies (Katz and Marshall, 2018) and the delegation of care competences to AI systems. Following Akrich (1992: 209), the dominant discourse permits us to see that older people are represented not as users, but elements in the broader care world into which the technology is inserted (see also Neven and Peine, 2017). As passive objects, they function in the discourse as a pre-existing problem to be solved – as well as a resource to be mined and exploited. Though such algorithmic harms are usually revealed as unanticipated, they are central to how such technologies are projected to be profitable and, by extension, built into their design (Broom et al., 2023).

Similarly, both care staff and the long-term care sector become additional labourers and data providers (Katz, 1996) in website representations – a role intensified within the AI ecosystem through heightened surveillance and datafication of care practices. Yet, these discourses often obscure the significant labour already required of staff to implement and maintain these technologies (Gallistl and Von Laufenberg, 2023). This challenge is further compounded by the lack of interoperability (systems' inability to effectively communicate or integrate with one another) among many proposed AI technologies, which adds to the encumbrance on already overworked staff tasked with adapting to and managing these tools (Neves et al., 2024). Limited digital literacy among staff can further exacerbate these challenges, amplifying the 'technostress' associated with introducing new systems – like the so-called 'welfare technology' used in public care services, as demonstrated by research on long-term care workers in Scandinavian contexts (Thunberg et al., 2024).

Our examination of company websites shows how inefficiencies in the care sector are framed as a breakdown whose reparative solution is found in AI systems. The promise of these systems is a delegation of competence from imperfect human care to efficient technical solutions. But as literature on repair has consistently shown, such a solution is itself liable to breakdown and the need for continuous repair (Denis and Pontille, 2015; Strebel, 2011). The delegation of competence implies a transformation in the delivery of care in two main ways: care is represented as driven by goals of efficiency and measurability according to objective indicators, and the new tools assume a redistribution of agency away from humans and toward nonhuman technical objects. This most immediately impacts care workers, who are represented in a diminished role alongside AI systems. It is most comprehensive for older people, who are represented as passive and not as users, but data sources and deficiencies to be managed. Such prevailing ideas of a later-life care economy reinforce the societal devaluation of recipients, perpetuating a deficit-based paradigm rather than one centred on proficiencies and capabilities.

Conclusion

This article explored the sociotechnical discourses underpinning the marketisation and commercialisation of AI for long-term care through an analysis of 33 websites of companies targeting the sector. Focusing on how AI companies market their technologies is crucial, as their narratives not only reflect broader conceptualisations of ageing, later life, and care, but can also shape societal ideas about – and systemic solutions to – these matters. By presenting older people as problems to be solved and care staff as labour to be optimised, marketing strategies reinforce stereotypical views that perpetuate inequalities in care practices. Understanding dominant discourses helps uncover the values and assumptions embedded in both technological design and discourse and their potential influence on policy and public perception.

Empirically, findings show that AI technologies are proposed as the only solutions to purported breakdowns in later-life care, from staff shortages to older people's loneliness. Older recipients were represented as uninterested, non-autonomous users and passive data sources. Staff were depicted as caring but ineffective, requiring surveillance and control. Such portrayals overlook diverse experiences of ageing and varying care needs, while promoting perceptions of an inefficient public sector unable to deliver care. These depictions often fail to recognise the sector's chronic under-resourcing or centre the dignity and autonomy of older people and workers. These companies' overarching message is that AI delegation will repair the long-term care sector by addressing inefficiencies in the public system and enhancing the capabilities of the private sector. They claim that by surveilling staff, automating routine tasks, and optimising workflows in a cost-efficient manner, AI will ensure optimal care and improve overall service delivery. The reliance on AI solutionism diverts attention from addressing systemic inequalities, instead prioritising efficiency via technological fixes.

Theoretically, these findings contribute several additions to the conceptual discussion of breakdown and repair. First, the notion of delegation allows us to track shifts between humans and nonhumans in a process of mutual breakdown and repair. Marketing materials identify a human breakdown to be repaired by nonhuman AI, which in turn requires human care in the form of maintenance and continuous repair. Second, focusing on how users are represented in marketing materials, we identified how this delegation is distributed, tracing who is considered a user, what competences they are allocated, and who is deprived of competence and rendered part of the environment. Finally, by supplementing breakdown and repair literature with a critical view of AI solutionism, we asked about the interests underlying the assertion of breakdowns. Our contribution here lies in repositioning techno-solutionism within the broader framework of repair – conceptualising it as one particular approach to addressing breakdowns rather than the comprehensive answer it claims to be. This repositioning allowed us to analyse the marketed technological fixes, without neglecting the ongoing maintenance and infrastructural labour that sustains these systems – forms of work that remain largely invisible when breakdowns are framed solely through a solutionist lens. As the websites leap from claims about bodily frailty, worker inefficiency, and sector underfunding to positing AI as a necessary solution, it is apparent that the assertion of breakdowns can be contentious and contested. Our contributions thereby enable us to both understand AI discourses in long-term care and use this empirical material to extract novel insights from the concepts of breakdown and repair.

At the same time, our application and expansion of the concepts of delegation and user representations are limited by our focus on promotional materials and the exclusive use of English-language sources. A component study, examining the development process and delegations inscribed in the technologies, would permit fuller use of these concepts. Yet such a study – employing a material-semiotic approach in contrast to our semiotic one (Law, 2008) – would require analysing the technologies themselves, many of which remain promissory, with the nature of their AI functions still unclear at this stage.

The introduction of AI into sensitive settings brings challenges, including heightened labour demands on care workers to implement and maintain technologies, increased surveillance, and the burden of managing often fragmented and non-interoperable systems. By framing care challenges as technical problems with ready-made solutions, the AI discourse risks undermining human-centred care practices and reinforcing a cycle of dependency on opaque systems of labour and infrastructure. It is therefore essential to continue critically evaluating the promises of AI in long-term care and advocating for practices that centre the dignity, agency, and wellbeing of both older people and care workers.

Furthermore, if AI will be providing the care, who will care for the AI? Repair and maintenance of technological infrastructure is itself a form of care (Jackson, 2014), yet the burden of sustaining these systems remains largely invisible in AI-driven solutions. Given the rapid advancement of AI and its expanding applications across the care spectrum, one could argue it has reached a stage requiring 'repair' much sooner than previous generations of technologies, such as mobile devices (Yampolskiy, 2019). Future research should explore these overlooked dependencies, examining how the upkeep of AI systems reshapes care-giving and receiving labour, governance, and socioethical responsibilities within long-term care settings.

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References

Australian Institute of Health and Welfare (2024) Older Australians and Aged Care. Available at: https://www.aihw.gov.au/reports/older-people/older-australians/contents/aged-care (accessed July 2024).

Akrich M (1991) De la sociologie des techniques à une sociologie des usages: L'impossible intégration du magnétoscope dans les réseaux câblés de première génération [From the sociology of techniques to a sociology of uses: The impossible integration of the video recorder in first-generation cable networks]. *Techniques & Culture* 16: 83–110. DOI: 10.4000/tc.725

Akrich M (1992) The de-scription of technical objects. In: Bijker WE and Law J (eds) *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, pp. 205–224.

Akrich M (1995) User representations: Practices, methods, and sociology. In: Rip A, Misa TJ and Schot J (eds) *Managing Technology in Society*. Michigan: Pinter Publishers, pp. 167–184.

Alff D (2021) Make way for infrastructure. *Critical Inquiry* 47: 625–643. DOI: 10.1086/714533

Bareis J and Katzenbach C (2021) Talking AI into being: The narratives and imaginaries of national AI strategies and their performative politics. *Science, Technology, & Human Values* 47(5): 855-881. DOI: 10.1177/01622439211030007

Berridge C and Grigorovich A (2022) Algorithmic harms and digital ageism in the use of surveillance technologies in nursing homes. *Frontiers in Sociology* 7: 957246. DOI: 10.3389/fsoc.2022.957246

Brevini B (2021) Creating the technological saviour: Discourses on AI in Europe and the legitimation of super capitalism. In: Verdegem P (ed) *AI for Everyone? Critical Perspectives*. London: University of Westminster Press, pp. 145–159. DOI: 10.16997/book55.i

Broom A, Peterie M, Kenny K, et al. (2023) The administration of harm: From unintended consequences to harm by design. *Critical Social Policy* 43(1): 51–75. DOI: 10.1177/02610183221087333

Byrne AL, Mulvogue J, Adhikari S, et al. (2024) Discriminative and exploitive stereotypes: Artificial intelligence generated images of aged care nurses and the impacts on recruitment and retention. *Nursing Inquiry* 31(3): e12651. DOI: 10.1111/nin.12651

Chandler D (2022) *Semiotics: The Basics*. Oxfordshire: Routledge. DOI: 10.4324/9781003155744

Chen L-K (2020) Gerontechnology and artificial intelligence: Better care for older people. *Archives of Gerontology and Geriatrics* 91: 104252. DOI: 10.1016/j.archger.2020.104252

Chu CH, Nyrup R, Leslie K, et al. (2022) Digital ageism: Challenges and opportunities in Artificial Intelligence for older adults. *The Gerontologist* gnab167. DOI: 10.1093/geront/gnab167

Clarke LH, Bennett EV and Liu C (2014) Aging and masculinity: Portrayals in men's magazines. *Journal of Aging Studies* 31: 26–33. DOI: 10.1016/j.jaging.2014.08.002

Crawford K (2021) *Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence*. New Haven, CT: Yale University Press. DOI: 10.12987/9780300252392

Dalmer N, Ellison K, Katz S, et al. (2022) Ageing, embodiment and datafication: Dynamics of power in digital health and care technologies. *International Journal of Ageing and Later Life* 15(2): 77–101. DOI: 10.3384/ijal.1652-8670.3499

de Laet M and Mol A (2000) The Zimbabwe bush pump: Mechanics of a fluid technology. *Social Studies of Science* 30(2): 225–263. DOI: 10.1177/030631200030002002

Denis J and Pontille D (2015) Material ordering and the care of things. *Science, Technology, & Human Values* 40(3): 338–367. DOI: 10.1177/0162243914553129

Denis J and Pontille D (2023) Before breakdown, after repair: The art of maintenance. In: Mica A, Pawlak M, Horolets A and Kubicki P (eds) *Routledge International Handbook of Failure*. Oxfordshire: Routledge, pp. 209–222. DOI: 10.4324/9780429355950-19

Ellison KL, Martin W, Pedersen I and Marshall BL (2022) Visualizing the datasphere: Representations of old bodies and their data in promotional images of smart sensor technologies for aging at home. *Frontiers in Sociology* 7: 1008510. DOI: 10.3389/fsoc.2022.1008510

Fox SE, Shorey S, Kang EY et al. (2023) Patchwork: The hidden, human labor of AI integration within essential work. *Proceedings of the ACM on Human-Computer Interaction* 7(CSCW1): 1–20. DOI: 10.1145/3579514

Gallistl V and Von Laufenberg R (2023) Caring for data in later life – the datafication of ageing as a matter of care. *Information, Communication & Society* 27(4): 774–789. DOI: 10.1080/1369118X.2023.2279554

Gallistl V, Banday MUL, Berridge C et al. (2024) Addressing the black box of AI–A model and research agenda on the co-constitution of aging and Artificial Intelligence. *The Gerontologist* 64(6): gnae039. DOI: 10.1093/geront/gnae039

Gomez-Hernandez M (2024) Industry visions of technology for older adults: A futures anthropology perspective. *Journal of Aging Studies* 70: 101248. DOI: 10.1016/j.jaging.2024.101248

Graham S and Thrift N (2007) Out of order: Understanding repair and maintenance. *Theory, Culture & Society* 24(3): 1–25. DOI: 10.1177/0263276407075954

Gray ML and Suri S (2019) *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass*. New York, NY: HarperCollins.

Greimas AJ (1990) *The Social Sciences: A Semiotic View*. Minneapolis, MN: University of Minnesota Press.

Greimas AJ and Courtés J (1982) *Semiotics and Language: An Analytical Dictionary*. Bloomington, IN: Indiana University Press.

Hall S (2018) The west and the rest: Discourse and power. In: Morley D (ed) *Essential Essays, Volume 2: Identity and Diaspora*. Durham, NC: Duke University Press, pp.141–184.

Henke CR (1999) The mechanics of workplace order: Toward a sociology of repair. *Berkeley Journal of Sociology* 44: 55–81.

Ivan L and Loos E (2023) The marketing of technology products for older people: Evidence of visual ageism. In: Rosales A, Svensson J and Fernández-Ardèvol M (eds) *Digital Ageism: How it Operates and Approaches to Tackling it*. Oxfordshire: Routledge, pp. 88–115. DOI: 10.4324/9781003323686-6

Jackson J (2014) Rethinking repair. In: Gillespie T, Boczkowski PJ and Foot KA (eds) *Media Technologies: Essays on Communication, Materiality, and Society*. Cambridge, MA: MIT Press, pp. 221–240. DOI: 10.7551/mitpress/9780262525374.003.0011

Jaakola J (2020) Ethics by other means? Care robot trials as ethics-in-practice. *Tecnoscienza: Italian Journal of Science & Technology Studies* 11(2): 53–71. DOI: 10.6092/issn.2038-3460/17477

Katz S (1996) *Disciplining Old Age: The Formation of Gerontological Knowledge*. Charlottesville, VA: University of Virginia Press.

Katz S and Marshall BL (2018) Tracked and fit: FitBits, brain games, and the quantified aging body. *Journal of Aging Studies* 45: 63–68. DOI: 10.1016/j.jaging.2018.01.009

Latour B (1992) Where are the missing masses? The sociology of a few mundane artifacts. In: Bijker WE and Law J (eds) *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, pp. 225–258.

Latour B (1999) *Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge, MA: Harvard University Press.

Latour B (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press. DOI: 10.1093/oso/9780199256044.001.0001

Law J (2008) Actor Network Theory and material semiotics. In: Turner BS (ed) *The New Blackwell Companion to Social Theory*, West Sussex, UK: Wiley Blackwell, pp. 141–158. DOI: 10.1002/9781444304992.ch7

Lehtiniemi T (2023) Contextual social valences for artificial intelligence: Anticipation that matters in social work. *Information, Communication & Society* 27(6): 1110–1125. DOI: 10.1080/1369118X.2023.2234987

Loos E, Ivan L, Sourbati M, et al. (2022) Visual ageism on public organisations' websites. In: Ylänne V (ed) *Ageing and the Media: International Perspectives*. Bristol: Policy Press, pp. 113–132. DOI: 10.51952/9781447362067.ch008

Morozov E (2013) *To Save Everything, Click Here: The Folly of Technological Solutionism*. New York, NY: PublicAffairs.

Natale S and Ballatore A (2020) Imagining the thinking machine: Technological myths and the rise of artificial intelligence. *Convergence* 26(1): 3–18. DOI: 10.1177/1354856517715164

Neven L and Peine A (2017) From triple win to triple sin: How a problematic future discourse is shaping the way people age with technology. *Societies* 7(3): 26. DOI: 10.3390/soc7030026

Neves BB and Omori M (2023) Artificial intelligence for long-term care in later life. In: Cockerham WC (ed) *Handbook on the Sociology of Health and Medicine*. Cheltenham: Edward Elgar, pp. 488–503.

Neves BB, Omori M, Petersen A, Vered M and Carter A (2024) Navigating artificial intelligence in care homes: Competing stakeholder views of trust and logics of care. *Social Science & Medicine* 358: 117187. DOI: 10.1016/j.socscimed.2024.117187

Neves BB, Petersen A, Vered M, Carter A and Omori M (2023) Artificial intelligence in long-term care: Technological promise, aging anxieties, and sociotechnical ageism. *Journal of Applied Gerontology* 42(6): 1274–1282. DOI: 10.1177/07334648231157370

Neves BB and Vetere F (2019) Ageing and emerging digital technologies. In: Neves BB and Vetere F (eds) *Ageing and Digital Technology: Designing and Evaluating Emerging Technologies for Older Adults*. Singapore: Springer, pp. 1–14.

Neves BB, Waycott J and Malta S (2018) Old and afraid of new communication technologies? Reconceptualising and contesting the 'age-based digital divide'. *Journal of Sociology* 54(2): 236–248.

Pagone T and Briggs L (2021) *Royal Commission into Aged Care Quality and Safety. Final report: Care, Dignity and Respect. Volume 1: Summary and Recommendations*. Commonwealth of Australia. Available at: https://www.royalcommission.gov.au/system/files/2024-03/aged-care-rc-final-report-volume-1.pdf (accessed 24 March 2024).

Peine A, Marshall BL, Martin W et al. (2021) *Socio-gerontechnology: Interdisciplinary Critical Studies of Ageing and Technology*. Oxfordshire: Routledge. DOI: 10.4324/9780429278266

Savolainen K and Hyysalo S (2021) User representations as a design resource: Achieving accountable design without access to users. *Science & Technology Studies* 34(2): 25–45. DOI: 10.23987/sts.84598

Siffels LE and Sharon T (2024) Where Technology Leads, the Problems Follow: Technosolutionism and the Dutch Contact Tracing App. *Philosophy & Technology* 37(4). DOI: 10.1007/s13347-024-00807-y

Star S (1999) The ethnography of infrastructure. *American Behavioral Scientist* 43(3): 377–391. DOI: 10.1177/00027649921955326

Strebel I (2011) The living building: towards a geography of maintenance work. *Social & Cultural Geography* 12(3): 243–262. DOI: 10.1080/14649365.2011.564732

Sturmberg JP, Gainsford L, Goodwin N et al. (2024) Systemic failures in nursing home care—A scoping study. *Journal of Evaluation in Clinical Practice* 30(3): 484–496. DOI: 10.1111/jep.13961

Stypinska J (2023) AI ageism: A critical roadmap for studying age discrimination and exclusion in digitalized societies. *AI & Society* 38(2): 665–677. DOI: 10.1007/s00146-022-01553-5

Tarkkala H, Helén I and Snell K (2019) From health to wealth: The future of personalized medicine in the making. *Futures* 109: 142–152. DOI: 10.1016/j.futures.2018.06.004

Thunberg S, Johnson E and Ziemke T (2024) Investigating healthcare workers' technostress when welfare technology is introduced in long-term care facilities. *Behaviour & Information Technology* 43(13): 3288–3300. DOI: 10.1080/0144929x.2023.2276802

Vermeer Y, Higgs P and Charlesworth G (2022) Selling surveillance technology: Semiotic themes in advertisements for ageing in place with dementia. *Social Semiotics* 32(3): 400–421. DOI: 10.1080/10350330.2020.1767399

Yampolskiy RV (2019) Predicting future AI failures from historic examples. *Foresight* 21(1): 138–152. DOI: 10.1108/fs-04-2018-0034

Appendix

Table 1. Description of companies.

#	Location	Technology Type	Technology Description	Market
1	Aus, Greece	Analysis and Decision Support	Improve operational efficiency/care quality through automated monitoring/reporting.	Residential Care
2	Aus	Analysis and Decision Support	Generate personalized health care plans and monitor regulatory compliance.	Residential Care
3	Global	Analysis and Decision Support	Provide resources and recommendations for dementia care and caregiver support.	Home Care
4	Aus	Client Monitoring and Safety	Monitor health risks and manage staff.	Residential & Home Care
5	Aus, Singapore, Malaysia	Client Monitoring and Safety	Track resident safety and activities, providing real-time alerts and analysis.	Residential Care
6	Aus	Client Monitoring and Safety	Monitor home environments through audio detection and virtual assistance.	Home Care
7	Aus, NZ	Client Monitoring and Safety	Monitor safety incidents and regulatory compliance through video surveillance.	Residential Care
8	Aus	Client Monitoring and Safety	Collect and analyse sensor data for health monitoring and emergency response.	Residential Care
9	Aus	Client Monitoring and Safety	Detect and prevent falls through radar-based monitoring.	Residential & Home Care
10	Aus, US, Global	Client Monitoring and Safety	Provide audio analytics and remote care support.	Residential & Home Care
11	Global	Client Monitoring and Safety	Track activities and provide automated health alerts.	Home Care
12	Aus	Healthcare	Track nutrition and eating patterns.	Residential Care
13	Aus, NZ, UK, Singapore, EU	Healthcare	Assess and monitor pain levels through facial recognition.	Residential & Home Care
14	Aus	Robotic Companions	Provide companionship and health monitoring.	Residential & Home Care
15	Aus, USA	Robotic Companions	Provide emotional support and entertainment.	Not specified
16	Global	Robotic Companions	Enable social connection and daily monitoring through TV interface.	Residential & Home Care
17	Global	Staff and Operational Support	Optimise operations and staff efficiency.	Residential Care
18	HK	Healthcare	Track health conditions and provide medication reminders.	Home Care
19	US	Client Monitoring and Safety	Support independent living through voice-activated monitoring.	Home Care
20	US, UK	Healthcare	Guide health monitoring for community care workers.	Residential & Home Care
21	UK	Staff and Operational Support	Schedule and manage care services.	Home Care
22	US	Healthcare	Enhance care delivery and monitoring.	Residential & Home Care
23	Canada	Healthcare	Provide therapeutic music for health outcomes.	Not specified
24	UK	Robotic Companions	Promote active aging through robotic companionship.	Home Care
25	US	Staff and Operational Support	Schedule and manage home care services.	Home Care
26	US	Client Monitoring and Safety	Detect early health risks through wearable monitoring.	Home Care
27	US	Client Monitoring and Safety	Detect and prevent falls.	Residential Care
28	Germany	Client Monitoring and Safety	Analyse fall risk and provide mobility recommendations.	Residential & Home Care
29	Finland	Staff and Operational Support	Organise and track home care visits.	Home Care
30	US	Client Monitoring and Safety	Monitor activities and provide automated assistance.	Home Care
31	US	Staff and Operational Support	Manage non-clinical operations.	Residential Care
32	US	Client Monitoring and Safety	Connect stakeholders and offer monitoring services.	Home Care
33	US	Healthcare	Monitor and manage incontinence.	Residential & Home Care

Closing the Algorithmic Black Box: Breakdowns and Patching Strategies in a Public Service Media

Kevin Carillon

UCLouvain, Belgium/ kevin.carillon@uclouvain.be

Abstract

This article examines the organizational trajectory of a news recommender system developed within RTBF, Belgium's public service media. Based on thirteen months of ethnographic fieldwork, it conceptualizes the algorithm as a black box in the making and investigates how breakdown–repair cycles shaped its embedding and eventual stabilization within the organization. The study identifies two major breakdowns and demonstrates that the subsequent repairs functioned less as transformative solutions than as *patching strategies*: targeted adjustments that resolved immediate issues while simultaneously reinforcing the system's legitimacy. By foregrounding these patching strategies, the article contributes to Science and Technology Studies (STS) by extending the literature on breakdowns and repair. It shows that such practices not only address technical vulnerabilities but also reconfigure organizational relations, contain dissent, and gradually contribute to the closure of the algorithmic black box.

Keywords: Algorithms, Black box, Breakdowns, Repairs, Patching strategies, Public service media

Introduction

The widespread adoption of algorithms has significantly transformed the public sector (Andrews, 2019; Levy et al., 2021; Meijer et al., 2021; Wenzelburger et al., 2024). Within public service media (PSM), these technologies are now extensively used to personalize content access, promising increased audience satisfaction and loyalty (Álvarez et al., 2020; Murschetz, 2021; Mitova et al., 2022). Research nevertheless shows that implementing such recommender systems poses major challenges. Confronted with critiques of these systems and their potential harms to users, PSM organizations, on the one hand, seek to distinguish themselves from major private platforms by incorporating public service values in the design of their algorithms (Schwarz, 2015; Sørensen, 2020; Hildén, 2022; Carillon, 2024). On the other hand, by disrupting traditional methods of content promotion and distribution, they can also generate tensions within the organizations that deploy them (Diakopoulos, 2019; Hansen and Hartley, 2021; Bastian et al., 2021; Blassnig et al., 2024).

Because most research focuses either on design or on use, few studies provide empirical evidence on how these 'intelligent technologies' (Bailey and Barley, 2020) evolve over time in relation to the organizational context in which they are embedded. Moreover, long-term ethnography is often presented as the best way to capture the algorithm–organization nexus holistically (Seaver, 2017; Lange et al., 2018; Christin, 2020). Nevertheless, it remains rare in PSM studies even though the literature highlights the value of longitudinal, context-sensitive approaches for penetrating algorithmic opacity (Ziewitz, 2016; Seaver, 2019; Christin, 2020). To address this gap, I conducted thirteen months of participant observation inside a Belgian PSM organization, examining the development, implementation, and internal use of a news-recommender system.

In this paper, I frame the algorithmic system as a *black box in the making*. The black box metaphor, widely employed in Science and Technology Studies (STS), describes here an artefact once the surrounding controversies have been resolved (Pinch and Bijker, 1984; Pinch, 1986; Latour, 1987). Traditionally, scholars have opened black boxes through socio-historical analyses that uncover the negotiations, debates, meanings, and power dynamics leading to its stabilisation (Hsu et al., 2008). Instead of opening a fully formed box, I invert the perspective to follow *in situ* the processes that close it. Specifically, I analyse the breakdowns and repair practices that shape the system's biography (Pollock and Williams, 2011; Glaser et al., 2021). These cycles serve as a lens through which to examine how such events reconfigure the relations constituting the system and redefine its organizational standing.

The analysis shows that breakdowns and repairs are not merely instances of material disorder, but moments when underlying organizational tensions and power struggles surrounding the system come to the surface. These incidents reveal not only the algorithm's technical limitations but also the dynamics that have shaped its development and implementation: internal conflicts, competing priorities, and power relations. Furthermore, the data indicate that repairs take the form of *ad hoc* fixes that do not aim to resolve these deeper organizational causes. On the contrary, they are strategically deployed to reinforce the system's legitimacy within the organization and sustain innovation in the face of resistance—a process I analyse as 'patching.' Then, rather than questioning the system's functionalities or authority, patching strategies tend to consolidate its legitimacy and entrench its role within the organization, thereby contributing to the gradual closure of the black box.

This article makes two contributions. First, by foregrounding patching, it enriches the breakdown-and-repair literature, showing that such events can also drive a broader closure process in which a technology's operational logic and authority are reaffirmed and reinforced. Second, the study provides insights into how public organizations manage and legitimize algorithmic systems, revealing that the black boxing of algorithms can stem from organizational strategies intended to institutionalize them as such.

Conceptual framework

Algorithmic system as black box in the making

The black box metaphor is commonly used in algorithm research to underscore the opacity of these systems (Pasquale, 2015), whether resulting from deliberate choices or technical design (Burrell, 2016). In this work, I draw more specifically on the work of Pinch and Bijker (1984) and Latour (1987), who interpreted the metaphor to account for the ways in which artefacts become stabilized and taken for granted over time.

The black box metaphor in STS, as discussed by Hsu et al. (2008), is closely linked to the development of the Social Construction of Technology (SCOT) framework by Pinch and Bijker (1984). Central to SCOT is the idea that technological artefacts and scientific facts are shaped by socio-technical processes. Pinch and Bijker expanded the black box metaphor into an analytical tool for understanding how (arte)facts achieve stability and appear unquestionable. For instance, their renowned study of the development of the bicycle illustrates how different social groups influenced its design and meaning over time.

For Pinch and Bijker, the black box metaphor is both programmatic and critical. Their primary aim is to "open the black box," uncovering the layers of negotiation, debate, meanings, and power dynamics that lead to the stabilization of artefacts. In this framework, black boxes are not natural endpoints but rather temporary resolutions of controversy. A controversy denotes a situation in which a dispute arises among multiple actors, each mobilizing specialized forms of knowledge, without any party being able to establish definitive truths (Latour, 2006; Callon, 2013). Such controversies are marked by a dense entanglement of heterogeneous stakes, empirical facts, and normative values. They are also distinguished by the simultaneous negotiation of both technical definitions and social meanings (Callon, 1994, 2013). As Pinch (1986) explains, a black box symbolizes the moment when controversies surrounding an artefact are settled.

Almost simultaneously, Latour, in *Science in Action* (1987), elaborated on a similar conception. According to Hsu et al. (2008), this convergence may have resulted from an exchange of ideas between the two authors during the drafting of their respective works. Latour integrated the black box metaphor into Actor-Network Theory (ANT), redefining it as a complex network of actants that temporarily operates as a cohesive and stable "whole." This reinterpretation reflects Latour's view of science and technology as shaped by interconnected actants, both human and more-than-human, rather than unique entities.

This conceptualization of the black box highlights an important aspect of power in Latour's framework. Indeed, as black boxes become increasingly closed (meaning their internal workings are accepted as reliable and no longer questioned), their authority becomes harder to challenge. Reopening a black box to scrutinize its internal processes or foundational assumptions thus requires significant effort and resources, making such attempts increasingly costly and improbable over time. In this context, the need for understanding the artefact fades into the background as it gains authority and the box becomes 'black.' As Akrich (2006: 173, my translation) notes, "it is precisely when [an artefact] nears stabilization that it becomes, through its disappearance, an instrument of knowledge." In the same vein, Beyes et al. (2022: 1007) argue that "the computer calculates and in doing so it makes itself absent from discussion, and if successful it becomes a black box, fundamentally invisible because inevitable and inscrutable." In other words, as the black boxing process unfolds, the artefact fades from view, and the authority of its outputs strengthens.

While the black box metaphor has been widely used to investigate the historical formation of black boxes, this paper proposes to reverse the perspective by considering the algorithmic system as a black box in the making, in order to examine, *in situ*, the processes that lead to its closure. This theoretical framework provides an effective way to examine how the system evolves over time in relation to the organizational context in which it is embedded. Building on Latour's call (1987: 21), the idea is then to shift our focus "from finished products to production" and therefore "from 'cold' stable objects to 'warmer' and unstable ones [...] before the box closes and becomes black."

On breakdowns and repairs

Breakdowns and repairs are central concepts in infrastructure studies (Star, 1999; Henke and Sims, 2020). In this paper, I use the breakdowns and repairs as an analytical lens. These moments help identify key turning points in the history and evolution of the recommender system at various stages of its lifecycle. By focusing on these events, we gain insight into the system's role and status within the organization, its materiality (Graham and Thrift, 2007; de la Bellacasa, 2011), its vulnerabilities (Denis and Pontille, 2023), and the transformations it undergoes.

Breakdowns refer to specific incidents that occur when a system encounters the limits of established protocols and practices (Jackson, 2013: 228). In doing so, they reveal the underlying structures and relationships that ensure the smooth functioning of infrastructures. This insight underscores their relational nature: infrastructures are shaped by a web of sociotechnical relationships that both sustain their operation and render them invisible. As Star (1999: 382) notes, "the normally invisible quality of working infrastructure becomes visible when it breaks." In other words, breakdowns serve as conceptual tools that allow us to explore the often-hidden aspects of infrastructures, such as the relationships they rely on, the invisible labour and practices that sustain them, and the meanings that have become embedded within them.

Repairs, by contrast, refer to the sociotechnical efforts undertaken in response to a breakdown, with the aim of resolving it. Far from being peripheral, these interventions are an essential component of the innovation process. As Henke and Sims note, innovation rarely follows a linear path of design and implementation. Instead, it emerges through "messy processes of implementation, breakdown, problem-solving, and repair" (Henke and Sims, 2020: 14). Within this framework, repairs do more than restore a previous state: they can serve as catalysts for creative recombination and the formation of new relationships, potentially leading to the emergence of new entities. (Jackson, 2013). As such, repair offers a valuable analytical lens for understanding how systems evolve over time and how these transformations reshape their roles within broader organizational structures.

In this context, an equally important aspect of the analysis is how actors collectively address a problem previously identified as such and work to resolve it, as well as how these cycles can become arenas for power struggles. As Henke and Sims (2020: 24) emphasize, repair entails restoring not only material components but also social relationships: "A successful repair is not only a material accomplishment; repair also creates a shared narrative of what went wrong and how it was fixed, persuading participants that local sociotechnical order has been restored." Beyond the material dimension, breakdown and repair cycles become pivotal moments where power dynamics are made visible and potentially reconfigured. During these episodes, the authority embedded within a system and the power relations surrounding it may be renegotiated, reaffirmed, or contested (Henke, 2019). Yet, as Henke and Sims (2020: 20) point out, "once people believe a breakdown has been resolved […] these aspects tend to recede into the background once again".

Similar to Seaver's (2017) proposal to use 'infrastructure ethnography' to study algorithms, a conceptual parallel can be drawn between black boxes and infrastructures. Indeed, beyond their shared relational nature, these two concepts exhibit several common characteristics. Firstly, both black boxes and infrastructures tend to obscure the underlying relationships that support their functioning and existence. As their operations become taken for granted, these relationships fade into the background. Secondly, both exert a form of authority by inscribing and solidifying certain meanings, values, or worldviews within their structures and operations. Finally, the existence of black boxes and infrastructures is generally only questioned when disruptions occur. These disruptions often serve as moments where power dynamics come to the forefront. This parallel underscores the idea that breakdowns and repairs offer a valuable lens for examining the formation of black boxes and the role these events play in shaping them. As Neyland and Möllers argue (2017), 'looking for trouble'—moments of breakdown—is productive for emphasizing the centrality of associations and decentring the question of the power of the algorithm itself.

Contextual background

Algorithmic systems in PSM

Since the end of public monopolies, PSM have encountered numerous challenges. The digital age has transformed the media landscape, intensifying competition from commercial outlets and social media platforms (Jakubowicz, 2007; Donders, 2012). This shift has forced PSM to rethink their strategies, adopting new technologies to better meet evolving consumer expectations and remain competitive (Bardoel and d'Haenens, 2008; Burri, 2015). One promising approach to tackling these challenges is the adoption of recommender systems, which are now widely implemented in PSM (Álvarez et al., 2020).

These algorithmic systems deliver relevant content to users based on predefined criteria, such as individual preferences or online behaviour. Various methods are employed, including content-based filtering, collaborative filtering, popularity-driven algorithms, and hybrid models that combine multiple techniques (Hildén, 2022; Møller, 2022). By personalizing content distribution, these systems not only enhance the user experience but also provide media organizations with valuable insights into audience behaviour (Murschetz, 2021), allowing them to promote their content more effectively and broaden their reach (Álvarez et al., 2020; Fieiras-Ceide et al., 2023; Møller, 2022; Hildén, 2022).

However, the use of such algorithms also raises ethical concerns. Their potential to shape how people access information and engage in public discourse is a growing issue (Sørensen, 2011; Joris et al., 2022). Risks like 'filter bubbles' (Pariser, 2011) are especially concerning, as they may limit the diversity of perspectives that users encounter. While these risks remain debated in the scientific literature (Flaxman et al., 2016; Haim et al., 2018; Ross Arguedas et al., 2022), studies on PSM show that they are aware of these challenges and are working to address them (Schwarz, 2015; Van den Bulck and Moe, 2018; Hildén, 2022). As a result, some PSM are differentiating themselves from private platforms by integrating public service values into their systems, with varying success (Schwarz, 2015; Sørensen, 2020; Hildén, 2022; Carillon, 2024).

The adoption of these systems can also create tensions within the organizations that implement them. Scientific literature, particularly through newsroom studies, has explored the conflicts arising from the changes these systems impose on the roles and practices of journalists (Bucher, 2017; Bastian et al., 2021; Diakopoulos, 2019). By reshaping how content is promoted and distributed, these algorithmic systems can be perceived as a threat to the journalistic profession. On a broader level, these systems also tend to crystallize tensions between two opposing visions of the role and place of PSM in society (Van den Bulck and Moe, 2018; Sørensen, 2019). On the one hand, a techno-optimistic perspective views algorithmic systems as an opportunity for PSM to expand their audience and foster greater audience loyalty. On the other hand, a more pessimistic perspective sees these systems as inherently incompatible with the ethics and values of public service.

Case study

RTBF is the public service broadcaster for Belgium's French-speaking community. Based at its Brussels headquarters known as "Reyers," the organization employs around 2,000 people. It manages nine radio stations (excluding web-only channels), three television channels, a dedicated news website (rtbf.be), and the digital platform Auvio, which offers catch-up TV and free video-on-demand (VoD) services. Governed by a board of directors reflecting the political composition of Belgium's French-speaking Community, RTBF is led by Jean-Paul Philippot. Its strategic direction and funding are redefined every five years through the negotiation of a 'management contract' with the government.

In 2016, RTBF launched its strategic plan titled "Vision 2022," aimed at modernizing its operations and adapting to the new habits of media consumers. At the core of this vision was the launch of the Auvio platform, which centralized all its content into a single digital platform. At the same time, RTBF focused its efforts on data-driven innovation to develop new approaches to content personalization and distribution.

In 2017, the organization began developing the first version of a recommendation algorithm specifically designed for the Auvio platform, in collaboration with external partners. In addition, RTBF also developed a centralized data management platform. This period marked RTBF's public commitment to the development of "public service algorithms."

Momentum continued into 2018, as RTBF implemented significant organizational changes. Shifting away from its traditional hierarchical structure, the organization adopted a circular organizational model, creating a data management department to oversee and coordinate its

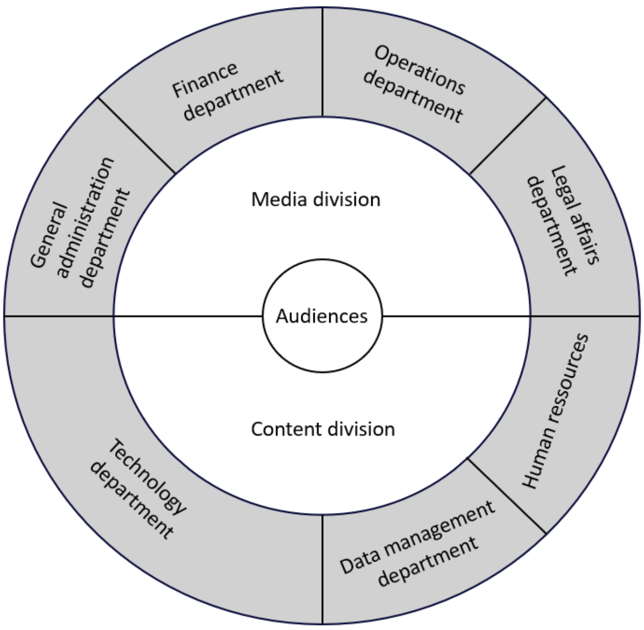

Figure 1. RTBF organizational structure adopted in 2018. (The diagram is based on information available at https://www.rtbf.be/entreprise/a-propos/detail_notre-modele-d-entreprise?id=10003887).

growing portfolio of data-driven projects. As illustrated in Figure 1, this new organization is centred around a core consisting of audience management, a media division responsible for content distribution, and a content division responsible for content production, which together encompass RTBF's editorial functions. This core is supported by a range of departments (shown in grey in the figure) that cover so-called "support" functions. These include the technology department, the largest of them, and the data management department.

After facing challenges with external partners in developing the recommender system for Auvio, the project was brought in-house and assigned to the data management department. Previously focused on overseeing projects and producing analyses, the department's role evolved into that of a producer of recommender systems. A few months later, the development and implementation of a new version of the Auvio recommender system coincided with the launch of a new data governance framework, led by the data management department. Several specialized committees were formed, including the data committee, algorithms committee, metadata committee, and GDPR committee. These groups fostered collaborative discussions, guided the design of data-driven projects and established key performance indicators (KPIs) to measure the success of ongoing initiatives.

Building on this success, RTBF then launched a new project to implement a recommender system for news articles on its rtbf.be website, with the development once again entrusted to the data management department. The goal was to provide a more personalized experience on the platform, increase user engagement, and strengthen their connection with the news produced by RTBF.

Methods

Data collection

Methodology plays a pivotal role in discussions about the contextualized study of algorithms. In recent years, ethnographic methods have gained significant traction for analysing algorithmic systems, as they provide a holistic approach to understanding their complexity. However, one significant issue, as Christin (2020: 904-905) notes, is the limited access ethnographers have, focusing only on observable practices and spaces. The seeming opacity of algorithms also further complicates efforts to centre the analysis on the algorithms themselves. Additionally, the relational nature of algorithmic systems poses another challenge, as their relational nature spreads analytical elements across various temporal and spatial dimensions (Seaver, 2019).

Despite these challenges, Christin emphasizes that ethnographic methods and detailed descriptions remain essential for studying 'associations,' particularly in the realm of technology (2020: 905). Ethnography offers a means to uncover the often-hidden relationships that characterize algorithmic systems, making it a valuable approach in organizational contexts. Building on this idea, Christin (2017, 2020), Seaver (2017), and Lange et al. (2018) propose a variety of data collection strategies designed to "make algorithms ethnographically tractable" (Seaver, 2017: 7). These strategies aim to address the opacity and relational complexity of algorithms by shifting the analytical focus to their broader sociotechnical environments.

One central recommendation from these scholars is to prioritize the interactions between the components of sociotechnical networks, paying close attention to the practices, relationships, and processes that surround algorithms. By examining how algorithms are embedded within and interact with diverse fields (often disconnected from one another), researchers can gain a more nuanced understanding of how these systems "come into being" (Neyland, 2015) and exert power. To complement this approach, Seaver (2017) advocates for the inclusion of diverse materials (the 'heteroglossia') in the ethnographic analysis, such as press releases, social media updates, organizational documents, and public communications.

Building on these insights, I conducted a 13-month participant observation at RTBF, spending one to two days per week embedded within the organization from May 2022 to June 2023. This long-term approach served three key objectives: to deeply immerse myself in the organization's daily activities, to closely observe participants' practices, and to collect a comprehensive and robust dataset. Acting as a "right-hand man" to the Data Management Director, I gained significant access to various aspects of RTBF's operations. However, a few limitations emerged. I was not permitted to attend Executive Committee meetings (one of RTBF's two governing bodies) and had access only to their meeting minutes. Similarly, I was excluded from private discussions between the Data Management Director and the CEO.

Despite these limitations, my position provided a unique vantage point. I was immersed in the internal dynamics of the data management department during the development and implementation of the news recommender system. More importantly, I also found myself at the centre of a network of activities where various departments and actors—the technology department, platform management team, website management team, journalists, legal services, the Data Protection Officer (responsible for GDPR compliance), and the customer relationship management team—converged around the recommender system project. This central role also allowed me to attend a wide range of meetings with key external stakeholders, including service providers (for software or data storage solutions), technical support teams, and even representatives from other public service media and regulatory bodies. In practice, I participated in every meeting, briefing, informal conversation, or presentation I could physically attend. While my observation was geographically anchored to a single location, it afforded me significant mobility within RTBF, enabling me to witness interactions not only among internal actors but also with external collaborators beyond the organization's formal boundaries.

The research generated a wealth of data, including observation notes, around 900 pages of internal documents (such as presentations, meeting minutes, and technical documents), 400 pages of external documents (annual reports, management contracts, social media updates, press releases, and charters), as well as numerous photographs, screenshots, and six hours of recorded interviews with the key stakeholders of the project.

Data analysis

The collected data were first analysed through a biographical lens. Drawing on the principle that "an algorithmic assemblage should be studied as it evolves across contexts and over time" (Glaser et al., 2021: 12), this approach invites researchers to identify and then analyse 'key biographical moments' in the system's evolution. Rather than attempting to account for every factor and actor involved—something that is not "feasible let alone desirable" (Hyysalo et al., 2019: 16)—the focus is placed on pivotal moments that unfold the system's multifaceted dimensions and its evolving relationship with its organizational environment. The biographical approach thus serves a dual purpose: it helps navigate the complexity generated by in-depth ethnographies of technology, and it avoids the pitfall of analysing the artefact as a static snapshot, instead following its trajectory through time and space (Pollock and Williams, 2011).

Given the developments outlined in the previous sections, breakdowns and repairs stand out as strong candidates for identifying these moments. To this end, the material was coded using a multi-thematic approach (Ayache and Dumez, 2011) to: (1) compile all the breakdowns and repairs encountered during the development and implementation of the recommender system, (2) link each repair to its corresponding breakdown, and (3) delineate the temporal boundaries of each resulting breakdown-repair cycle in the system's biography.

Once these cycles were established, I applied Nicolini's (2009) zooming-in/zooming-out strategy. *Zooming in* probes the fine-grained texture of practice, capturing both the situated activities of actors and the artefacts and material arrangements that support those activities. *Zooming out*, by contrast, broadens the frame to trace how these practices connect across moments, revealing the associations that link them over time.

Practically, I first zoomed in on each cycle individually. Cycles were analysed through open coding, generating first-order codes rooted in participant terminology. After several iterations, these codes were synthesized into broader second-order themes, highlighting the practices and dynamics within each cycle. By zooming out to compare the cycles and their respective themes, I was then able to identify patterns regarding the causes of the breakdowns, the objectives pursued during repairs, and their broader implications for the system and the organization.

Finally, these insights were triangulated with the 'parse corporate heteroglossia' identified by Seaver (2017) ensuring the robustness and coherence of the interpretation.

Findings

The analysis identified four major breakdown-repair cycles (Figure 2). The first concerned a technical malfunction triggered by a software update. The second involved issues related to the temporal relevance of the articles recommended by the system. The third stemmed from the accidental deletion of a critical segment of code essential to the functioning of an API. The fourth cycle revolved around the symbolic and editorial implications of the recommendations generated by the system.

As shown in the results presented in Figure 2, these breakdown-repair sequences do not all offer the same analytical depth. The first and third cycles were limited to ephemeral technical failures that were addressed through simple fixes aimed at restoring system functionality. By contrast, the second and fourth cycles gave rise to deeper forms of friction, involving repair processes that unfolded over an extended period and engaged both technical and organizational issues. Following Jackson's (2013) insight that breakdowns and repairs often exceed mere functional restoration and open spaces for reflection, redefinition, or reconfiguration, the discussion that follows focuses on these two cycles.

When the algorithmic system breaks: Uncovering organizational disorders

Two major breakdowns significantly impacted the biography of the recommender system. The first (second cycle) occurred after several months of development, when the initial version of the system was launched on the platform. It operated for a few weeks before complaints started pouring into the data management team. Both platform and editorial teams expressed frustration with the quality of recommendations, claiming the "algorithm was broken."

Interactions with various stakeholders quickly pinpointed the issue: the organization produces a significant volume of articles tied to fleeting events, such as sports results or daily weather forecasts. However, the recommender system,

	Description of the breakdown	**Description of the repairs**	**Timeline**
First cycle	The system crashed due to a missing software update	- Identified the software - Software update applied	2 days
Second cycle	The system generated outdated recommendations	- Manual annotation project to determine the temporal relevance of articles - Development and implementation of a "timeliness" algorithm for the recommender system - Establishment of the Editorial Algorithm Committee (EAC) to address issues related to the recommender system	3 months
Third cycle	The system crashed due to the loss of part of an API's code	- Reconstructed the missing code using available technical documentation	5 days
Fourth cycle	The system generated inappropriate recommendations	- Temporarily disabled the system - Developed business rules to exclude sensitive topics - Introduced a decision tree system for recommendation validation - Development of a "non-recommendable" flag in the content encoding tool (Cryo)	2 months

Figure 2. Summary of breakdown and repair cycles identified through multi-thematic analysis.

which relied on both content similarity and user data, failed to account for the temporal aspects of articles. Consequently, a significant portion of the recommendations were already "outdated." For instance, the system continued recommending the launch of the government's COVID-19 app, long after the pandemic had subsided.

A second major breakdown (fourth cycle) occurred a few months later when the organization published a series of articles about a journalist who had committed suicide at the Reyers headquarters, as I noted in my observation notes:

> The organization published a series of articles about a journalist who committed suicide at the Reyers headquarters. The day after the publication, a wave of panic swept through the teams. A team member, visibly distressed, explained the issue: the recommender system, in connection with the articles about the journalist's death, was only suggesting content related to employee well-being and workplace abuse. The symbolism of these recommendations was particularly concerning. It implied that RTBF was somehow responsible for the tragedy, creating a negative perception of the organization's work environment. To prevent further harm and potential reputational damage, the decision was made to temporarily disable the recommender system.

At first glance, these two breakdowns appear to be purely technical failures: in the first case, the system generates outdated recommendations because it does not account for temporal relevance, and in the second, it produces inappropriate recommendations due to a lack of contextual filtering. Both cases highlight limitations in the system's design, particularly its reliance on content similarity. However, a deeper analysis reveals that these breakdowns are not just technical disruptions but also manifestations of organizational tensions, particularly related to power dynamics surrounding the introduction of the algorithmic system.

> [Stakeholder]: From the very beginning, the project faced resistance…
>
> [Researcher]: How so?
>
> [Stakeholder]: When the [Committee] had to approve the project, it was clear that the editorial team representatives were sceptical… let's just say they weren't exactly enthusiastic. There were lengthy discussions about how the algorithm would function and where it would be placed on the website's homepage. Eventually, we reached a compromise: the widget would initially be positioned at the bottom of the page, and if it performed well, we could move it higher. It wasn't ideal… after all, no one really sees it unless they scroll all the way down… but it was better than nothing.

This excerpt from an interview illustrates how the project encountered resistance from the outset. The decision to position the recommendation banner at the bottom of the homepage was a strategic compromise, limiting its visibility while still integrating it. This move reflects a clear effort to maintain editorial control and reduce the algorithm's influence on the user experience.

This tension reappears multiple times throughout the algorithm's biography. Initially, the project to develop the algorithm was envisioned as a cross-functional initiative, bringing together the support teams—particularly the data management team—and the editorial teams. The support teams' role was to translate the editorial teams' needs and expertise into technical rules for the algorithm's operation. However, as the project progressed, editorial teams gradually distanced themselves, leaving the support teams to handle most of the development. This disengagement was not accidental. As one interviewee noted:

> We tried to invite them several times [to meetings], but it's complicated… They don't seem very interested, actually.

Another interviewee elaborated:

> I think the motivations were quite varied. For some, it's a clear opposition: they simply don't want to hear about it. For others, it's a matter of not having enough time to truly participate… And for some, I think it's a combination of poor communication and a feeling of not being legitimate.

From the beginning, the support teams anticipated the resistance the algorithm would encounter. As one representative noted during a meeting:

> The algorithm will inevitably cause some friction with the editorial teams, so it's crucial to bring them on board throughout the project. We are fully aware of this. The algorithm is not intended to replace their work but rather to assist them.

Thus, to a large extent, the disengagement of editorial teams can be seen as a response to the perceived threat of the system. As Hansen and Hartley (2021) argue, algorithmic systems introduce a particular vision of what constitutes news, disrupting established editorial processes. Traditionally, editors determined what content was highlighted through a complex interplay of expertise, working knowledge (Harper, 1987), and journalistic values. The introduction of a recommender system, which determines visibility based on algorithmic rules, shifts some of this "truth-telling" power away from human editors, leading to tensions. Glaser et al. (2021) describe this as a conflict between the performativity of algorithmic and non-algorithmic assemblages: the recommender system, with its data-driven logic, challenges the editorial process, rooted in human judgment and professional expertise.

This resistance was clearly expressed when, at the time of the launch of the recommendation algorithm (which also coincided with the renegotiation of the management contract with the government), one of the main trade unions posted a poster in every hallway of the Reyers building (Figure 3). The poster, a caricature, explicitly criticizes RTBF's digital strategy, particularly its focus on datafication and algorithmization processes. The picture of the robot, which symbolizes both the recommender system and, more broadly, the ongoing digital transformations, takes on a specific meaning here: it represents a sense of dispossession and loss of control experienced by the workers.

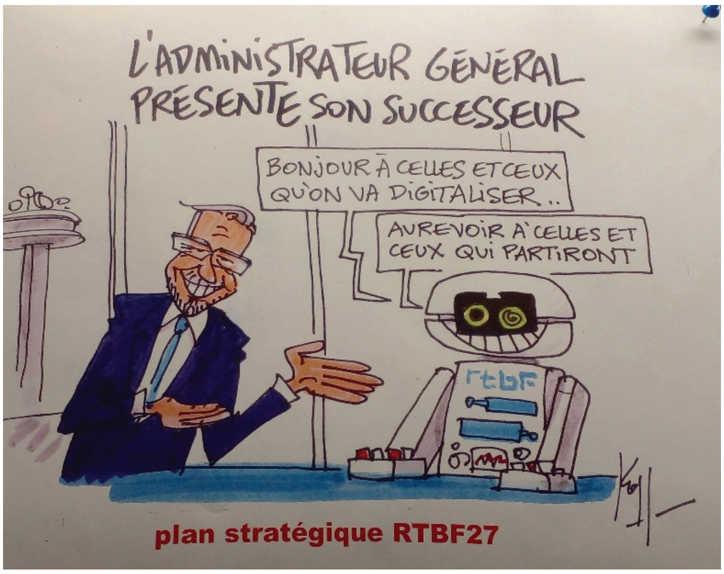

Figure 3. Caricature displayed in the hallways of RTBF during the launch of the recommender system and the renegotiation of the management contract with the government: "The CEO introduces his successor." The CEO presents a robot that says, "Hello to those who will be digitalized. Goodbye to those who will leave."

The introduction of the recommender system has thus crystallized an opposition between two contradictory narratives about innovation within the organization. On the one hand, the support teams, responsible for technical development and implementation, adopt a more techno-optimistic vision. These teams see the recommender system as a beneficial and desirable innovation for the organization, perceiving it in terms of human-machine collaboration. On the other hand, the editorial teams view the recommender system not as an asset, but rather as a threat to their expertise and role, challenging the editorial work that lies at the heart of RTBF's mission.

Another key illustration of these tensions lies in the issue of metadata. Recommender systems depend on structured and consistent metadata to function effectively. However, metadata tagging was perceived by editorial teams as a burdensome task. Editors prioritized immediate content considerations, while data teams emphasized metadata normalization as essential for system performance. This discrepancy in priorities became a long-standing issue at RTBF, repeatedly hindering personalization efforts. A stakeholder expressed frustration over the lack of metadata quality control:

> We keep telling them that the metadata is crucial, but they don't take it seriously. It's an insoluble problem.

This ongoing challenge further underscores the fundamental misalignment between editorial and support teams. For data teams, metadata is a structural necessity. For editorial teams, it is an additional task that diverts attention from their core responsibilities. This misalignment further deepened the divide, reinforcing the perception that the recommender system was fundamentally incompatible with editorial workflows.

From the perspective of the project managers, the withdrawal of the editorial teams had far-reaching consequences. For them, the system's breakdowns in the second and the fourth cycle were not just technical errors but stemmed largely from a lack of editorial involvement during development. As one stakeholder noted in an interview:

> They are far more knowledgeable than we are on these matters [...] Everything would have been so much easier, and we could have avoided so many problems if we had been able to anticipate…

This statement highlights a decisive point: had the editorial teams been actively involved, they could have offered valuable insights to help prevent and address these issues before they worsened. Their disengagement was not only a sign of organizational tensions but also a direct factor in the system's breakdowns. By stepping back early in the design phase, the editorial teams unintentionally created a void, forcing the support teams to take more control over how information was prioritized in the algorithm's design, despite lacking the necessary working knowledge. For the project managers, the absence of editorial teams ultimately sets the stage for breakdowns, leading to misaligned recommendations and, over time, growing scepticism toward the system itself.

Patching strategies for addressing opposition to innovation

I now take a closer look at the repairs that followed the breakdowns. I show that, beyond simply fixing the technical issues exposed by breakdowns, the repair efforts were primarily intended to reintegrate editorial teams into the project and reinforce the system's legitimacy. In doing so, I argue that these interventions constitute what I call 'patching strategies': rather than tackling the root causes of the breakdowns by questioning the foundations and the authority of the algorithm, they focus on adjustments that preserve the system while mitigating opposition to it.

> We need to be careful. People who don't understand the project can easily dismiss it with a simple counterargument. It's unfortunate, but it's true.

As illustrated by this quote from one of the project managers during a meeting, the support teams were particularly concerned about the occurrence of breakdowns and their potential to jeopardize the project by providing additional arguments to its opponents. Many discussions in repair-focused meetings within the support teams reflected a persistent desire to "bring everyone back into the project," "get people on board, even the most sceptical," or "gather everyone around the table." This recurring theme in the repair efforts highlights two key aspects: first, the breakdowns do not stem solely from the algorithmic technology itself; second, all corrective actions are directed toward a common goal that goes beyond the mere material repair of the algorithm. Indeed, as Henke and Sims (2020: 3) emphasize, material repair "almost always goes along with repairs to other forms of order."

In the second cycle, the solution took the form of a cross-functional project: the development of a "service algorithm" designed to assign a temporal validity to articles in the RTBF catalogue. Once integrated into the recommender system, this algorithm would help prevent outdated suggestions. More than just a technical fix, the project was designed as a catalyst for renewed collaboration between editorial and technical teams. This repair effort was carried out within the newly established "Editorial Algorithm Committee" (EAC), initiated by the Data Management Director. Officially tasked with "finding solutions to editorial challenges related to algorithms," the committee brought together support team managers, content managers, and media managers.

One of its first initiatives was the "news articles annotation" project, aimed at training the algorithm to recognize the temporality of content. Members from all teams were tasked with manually assigning a relevance lifespan to a representative sample of news articles, allowing the system to learn and generalize these classifications. A dedicated annotation tool was used, and the results were closely monitored. Participants could categorize articles using predefined time frames (24 hours, 48 hours, 15 days, 3 months, cyclical, or timeless).

However, despite the stated goal of editorial involvement, analysis of the project's dynamics revealed that support teams once again carried out most of the annotation work. It was observed during project monitoring that the most actively engaged participants all came from the support teams.

At the same time, the recommender system was also promoted internally through multiple messages on the organization's intranet, as well as to the public. All these promotional messages highlighted the "public service" aspect of the RTBF recommender systems—emphasizing their alignment with the public service mission of the PSM—and their role as a tool designed exclusively to assist or complement the work of editors.

In the fourth cycle, the breakdown exposed a structural weakness of the system through its inability to contextualize recommendations, particularly for sensitive topics. The tragic incident involving the journalist deeply shook all teams within the organization. From the project's perspective, it marked a turning point, prompting the editorial teams—who had previously been cautious—to openly raise their concerns before the EAC. As the discussion progressed, new potentially problematic situations emerged. An editor, for example, highlighted another significant risk of algorithmic bias during a meeting:

> Imagine a user who starts reading articles about the MR [a Belgian political party]. Because the algorithm relies primarily on content similarity, it might continue suggesting more MR-related articles. This could create the perception of editorial bias, especially during elections, potentially violating RTBF's obligation to remain neutral.

To address the issues raised by the breakdown and improve the recommender system, The team introduced a new approach to make the system's decision-making process more precise and better suited to the organization's needs. The main idea was to identify "real-world cases," meaning concrete situations, to refine the algorithm and make it more effective in managing recommendations. This approach allowed for better contextualization of articles and ensured that the recommendations would be more appropriate. In this context, the editorial teams played an increasingly active role. Until then, they had been somewhat detached from the algorithmic management, but this time they were directly involved in defining the new "business rules" for the system. This process required considering more nuanced criteria tailored to the specificities of RTBF's missions, considering the diversity of content and editorial challenges. For example, a rule was established to prevent articles on sensitive topics from triggering further recommendations.

On the technical side, an adjustment was made by introducing an additional filtering layer in the form of a decision tree. This system allowed for the establishment of a set of precise criteria that each article had to meet before being recommended. This new structure enabled better control over the types of content that were being distributed and allowed certain articles, deemed inappropriate, to be excluded from the recommendations. This helped align the recommended content with the organization's editorial values. Meanwhile, the development of a new feature for Cryo, the editorial management tool, was launched. This feature enabled editorial teams to tag certain articles as "non-recommendable" upon publication, giving them more control over the recommendation process. From that point on, the continued involvement of the editorial teams in managing the recommender system was regarded as a success by the project managers.

As a result, each cycle of breakdowns and repairs did not lead to a radical transformation: the repairs, even from a technical standpoint, merely added corrective elements to the existing structure—essentially, patching the system. I adopt the concept of *patching* from the field of software development, where it refers to the application of a corrective piece of code designed to fix a bug, address a vulnerability, or resolve performance issues (Dadzie, 2005). These patching strategies were primarily seen as opportunities to reintegrate reluctant stakeholders into the project. This process mirrors research using actor-network theory to examine innovation. Indeed, as Akrich (1989) points out, innovation is fundamentally about enrolling an increasing number of allies, whose involvement strengthens the innovation's position. Although these adjustments were intended to address the concerns of the editorial teams, they did not challenge the fundamental logic of the algorithmic system. Rather than creating a space for critical discussion that could have led to questioning the algorithm's existence or its influence on news distribution, these repairs mainly focused on fixing issues while reinforcing the system's legitimacy within the organization.

The main driver of this strategy was the concerted effort to reengage the editorial teams by presenting the repairs as collaborative and inclusive. The creation of the EAC, for instance, provided an institutional platform to incorporate their concerns. However, this consideration took place within predefined limits, ensuring that the system's structure would not be altered. This is explained by the fact that the development of the system required significant resources, and the managers involved in the project were committed to embedding the innovation within the organizational landscape. Thus, what I describe as patching involves targeted adjustments that preserve the existing structure, while addressing the issues that are immediately apparent. Each patch acted as a fix to resolve concrete issues without questioning the system's authority. Despite the improvements made, the underlying power dynamics remained unchanged: editorial teams were reintegrated, but they were not empowered to challenge the fundamental logic of the algorithm.

Closing the black box through breakdown and repair cycles

Having shown how patching strategies operate, I now take a broader perspective to examine how cycles of breakdown and repair have shaped the recommender system's role and standing within the organization. This perspective reveals a counterintuitive finding: by reinforcing a particular narrative of innovation and minimizing opposition, these cycles have contributed to the entrenchment of the system and the closing of the black box. As a result, the system has become both taken for granted and less visible within the organization. This phenomenon not only obscured the system's complexities but also changed the way it was perceived by stakeholders, shifting their focus from breakdowns and repairs to more mundane concerns related to its ongoing use and maintenance.

> [A manager during a meeting]: I'm really happy to see how things have changed. [...] It's great to see that all our efforts are making a difference. [...] I'm noticing a big improvement. Teams are increasingly requesting that we provide insights regarding content publication.

This quote illustrates how the relationship between actors and the system evolved during the repair phase of the second breakdown. In a meeting on platform metrics, a manager expressed satisfaction at the increasing reliance of editorial teams on the system's outputs for determining optimal publication times, signalling a transition from scepticism to greater trust in the system's utility. Despite the system's earlier failures, the ongoing cycles of breakdowns and repairs fostered a sense of improvement, and as each patch was implemented, resistance within the organization lessened. In time, the system moved from being a subject of contention to one that was normalized and integrated into the routine operations within the organization. This aligns with the findings of Cuevas-Garcia et al. (2023: 369), who, in their study of sewer inspection robots, argue that innovation success relies on continuous efforts of 'plausibilization'—the ability to persuade stakeholders of an innovation's value by constructing and maintaining its 'narrative plausibility' within broader imaginaries.

As the repair phases progressed, the editorial teams took on a more active role in shaping the system's functioning. They began to propose refinements to the algorithm's parameters, fine-tuning it to better meet their editorial goals. For instance, they advocated for the promotion of longer articles to enhance user engagement, the spotlighting of timeless content to evoke nostalgia, and recommending local content based on user location. The latter was particularly significant, as it fulfilled a legal requirement for information distribution mandated by the management contract. Furthermore, the data produced by the system—including user consumption patterns captured by the platform's trackers and new metrics specifically designed to assess the algorithm's performance—was disseminated within the organization. This data allowed various governing committees to make informed strategic decisions about the next steps in the algorithmic personalization of RTBF's interfaces. For instance, one such decision was the development of a new, fully personalized page titled "My Choice."

The focus on technical failures and their resolution thus gradually receded from the foreground of organizational discussions. As one interviewee noted:

> One of the biggest challenges is stability. Having functional systems is important but maintaining them is just as crucial. [...] Take, for instance, the constant updates to OS [operating systems] across the different devices people use to access the platform. These changes create all sorts of issues, from display problems to page latency. [...] It's a never-ending story.

This quote underscores the idea that system stability is not an absolute condition (MacKenzie, 1993; Orlikowski, 2000) but the result of an ongoing effort, where the management of everyday technical challenges eclipses the dramatic breakdowns that characterized earlier phases. In line with Russell and Vinsel's (2018) assertion, who titled their study "after innovation, turn to maintenance," stakeholders' tasks have shifted from addressing identified breakdowns and implementing repairs to a more routinized approach (D'Adderio, 2011; Murray et al., 2021) focused on sustaining and maintaining the system over time. In this context, editorial teams took on the responsibility of supplying relevant content and metadata, as well as identifying recommendation-related issues and escalating them to the EAC. Similarly, support teams take on the responsibility of ensuring the system's ongoing technical maintenance through regularly scheduled "phases of care."

As this transition unfolded, the system gradually faded from the forefront of discussions and interactions. Conversations about the recommender system, which had once been central to strategic meetings, became less frequent, replaced by other organizational concerns. New priorities, such as generative AI—the first version of ChatGPT being released at the end of my fieldwork—began to capture attention, pushing the algorithm to the background. Editorial teams now interacted with the system pragmatically, integrating it into their workflow. Support teams, which had previously focused on resolving breakdowns, gradually shifted their efforts toward other projects, such as the development of the *My Choice* page or the launch of an automated newsletter. This mirrors my own experience in the field. Toward the end of the fieldwork, the system itself was only briefly mentioned during data management briefings or weekly performance monitoring meetings. My own tasks and the data I collected seemed increasingly removed from the original focus of my research; even though this "absence" speaks volumes from an analytical perspective.

The gradual invisibility of the recommender system, as it became embedded into the fabric of the organization's routine processes, is a direct consequence of its black boxing through breakdowns and repairs cycles. Initially, the algorithm drew significant attention due to technical breakdowns and power struggles surrounding its adoption. However, as the system underwent patching, it stopped being seen as a disruptive innovation and instead began to operate as a black box.

As controversies faded, stakeholders no longer needed to justify or legitimize the algorithm, and the discourse around the system shifted accordingly. Meanwhile, its results were used without the need to understand or even reference the system or how it produced its outcomes. In other words, the recommender system became a 'fact,' as defined by Latour (1987). As Brisset points out,

> "accepted by all as a black box, a fact is only invoked instrumentally within other networked processes of creating [other facts]. To acquire the status of a fact, it must emerge victorious from controversies with competing facts. To do so, it must, on the one hand, prove its resilience [...] in order to establish and strengthen its legitimacy. (Brisset, 2014:222, my translation)"

Discussion & conclusion

The analysis of breakdowns and repairs in the biographical trajectory of the recommender system reveals that these events go beyond the mere identification and resolution of failures. They are embedded in a broader sociotechnical dynamic of closure, playing a role in legitimizing the innovation within the organization. These findings extend existing work on breakdowns and repair practices, particularly within infrastructure studies, where such moments are often seen as revealing tensions and offering opportunities to reconfigure power relations (Jackson, 2013; Henke and Sims, 2020).

To better grasp this process, I introduce the concept of 'patching' as a specific modality of repair. The term originates from software development, where it refers to the insertion of a corrective code snippet designed to fix a bug, address a security vulnerability, or enhance performance (Dissanayake et al., 2022; Islam et al., 2023). A patch is characterized by its targeted and additive nature (Dadzie, 2005): it modifies specific functionalities without overhauling the system's architecture or interrupting its operation. It allows the system to continue functioning while undergoing transformation.

This type of intervention has become central in the video game industry, where patching is now a routine and even structuring practice (Newman, 2012). It supports the post-launch lifecycle of games by adding features, correcting unexpected behaviours, or rebalancing gameplay mechanics (Truelove, 2021). Yet these fixes are far from neutral: they also serve as governance tools, redefining, for example, the relationships between developers and players (Švelch, 2019).

As the case study shows, patching refers to targeted interventions aimed at correcting immediately visible malfunctions without challenging the overall structure of the system. In the biographical trajectory of the recommender system, this included the addition of a service algorithm, the integration of a decision tree, the activation of a non-recommendation option, or the creation of ad hoc entities within the organizational chart. Each of these patches was incrementally incorporated as a new component of the system.

These interventions thus served a strategic purpose on multiple levels. On one hand, they allowed the organization to address concrete and localized issues (e.g., the temporality of recommended content) without questioning the foundations of the innovation. On the other, they helped sustain (if not reinforce) the power relations redefined by the system by diverting attention from more fundamental critiques of the algorithm's role in editorial processes. By reframing dissenting perspectives as mere technical or procedural matters, patches helped translate potentially disruptive forms of resistance into manageable adjustments.

In doing so, patches actively contributed to delineating the boundaries of controversy. They determined what could be problematized and debated, and conversely, what remained outside the scope of discussion. Rather than opening a space for deliberation about the system's legitimacy or relevance, these interventions worked to secure its position within the organization. In this sense, patching operates as a mechanism of containment and consolidation, reinforcing the legitimacy of innovation under the guise of pragmatic problem-solving. As shown in the study by Sims & Henke (2012) on repair strategies within the U.S. nuclear weapons complex, the purpose of repair lies less in restoring technical functionality than in preserving the legitimacy and credibility of a technology. Their analysis highlights that this credibility does not rely solely on material interventions but is also rooted in closely intertwined institutional and discursive dimensions.

Because of its simultaneously strategic and corrective nature, patching occupies a distinctive position in the broader landscape of repair practices. It contrasts, for example, with forms such as tinkering (Harper, 1987) or improvisation (Henke, 2000; Schubert, 2019), which are typically seen as informal, localized responses by frontline actors to contingent disruptions. Patching, as documented here, appears instead as a targeted and orchestrated practice, led by innovation managers who mobilize organizational resources and formal governance mechanisms to implement adjustments aimed at reducing internal friction.

Patching also differs from maintenance practices. Maintenance is typically defined as a discreet and continuous activity aimed at ensuring the long-term viability of already stabilized systems (Russell and Vinsel, 2018; Denis and Pontille, 2022). It operates within the invisible routines of infrastructural work, as illustrated by the first and the third cycles, which in our case can be understood as maintenance practices. Patching, by contrast, occurs sporadically and visibly at moments of fragility, when the system's stability is still uncertain. Its goal is to prevent the escalation of a breakdown by containing its effects through a visible correction that addresses symptoms without tackling root causes.

Patching thus allows decision-makers to choose which criticisms to address, while avoiding the disruptive consequences of a transformational repair: a comprehensive overhaul undertaken only as a last resort in the face of existential threats or by actors seeking to reorient the system according to different ideals (Sims and Henke, 2012: 327). In the case under study, such a transformational repair would have meant either abandoning the project or completely reconfiguring the architecture of the recommender system and its role in editorial workflows.

These strategies reflect a broader dynamic in which the very categories of 'breakdown' and 'repair' are strategically constructed. In this sense, the findings echo Sorokin's (2023: 100) observation that actors involved in repair not only define what needs fixing but also determine what is deemed "desirable and beneficial" for the organization. In the RTBF case, innovation is assumed to be beneficial by project teams and their internal allies. Consequently, repair is not only aimed at restoring technical functionality but also at protecting and consolidating the institutional position of the innovation, without ever opening a broader debate about the system's overall legitimacy.

In this way, patching strategies align closely with what Graziano and Trogal (2017) describe as a 'politics of repair,' where to repair is to govern: to decide who acts, on what issues, and according to which values. The patching strategies observed at RTBF should therefore not be seen as mere technical adjustments. Rather, they constitute acts of governance that contribute to the institutionalization of a specific sociotechnical order, which may be described as the algorithmization of editorial processes.

Although patching offers a fertile lens for exploring the intermediate zones between controversy and stabilization, the concept remains under construction. A first limitation of this study lies in its single-site design, which calls for comparative research to assess the transferability of the findings. A second limitation concerns the perspective adopted: most data were gathered from actors supportive of the project. As a result, the views of dissenting groups (such as journalists or unions) remain partially in the background, even though they were identified during fieldwork.

By linking patching strategies to the black box paradigm, this study refines our understanding of how organizations manage algorithmic systems through breakdowns and repairs. While Sachs (2019: 1698) notes that repairs are often "folded back into the black box of the algorithm, rendering them invisible and unacknowledged," this study reveals a different dynamic. Breakdowns and repairs are not simply absorbed by the black box: they actively contribute to its very constitution, becoming opportunities to close surrounding controversies.

Organizations often have a strategic interest in producing and maintaining such black boxes. However, the degree to which these systems become closed or remain open depends on evolving and context-specific dynamics, particularly within public administrations and service-oriented institutions, where administrative cultures and approaches to innovation vary significantly (Zhang and Feeney, 2020). As Meijer et al. (2021: 837) emphasize in their study on algorithmization in bureaucratic settings, "the outcome of the process of organizational rearrangement around the use of an algorithm is not determined by its technological features but influenced by social norms." The closure or persistence of black boxes is therefore not a purely technical outcome, but the result of negotiations, constraints, and strategic decisions embedded in broader sociopolitical logics.

This is especially significant in public service organizations, where the legitimacy of algorithmic systems is far from guaranteed (Reddy et al., 2019).

Unlike private companies, these organizations are generally bound by principles such as transparency, accountability, and fairness, and operate within established normative frameworks, which intensify debates surrounding the acceptability and oversight of such technologies.

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References

Akrich M (1989) La construction d'un système socio-technique. Esquisse pour une anthropologie des techniques. *Anthropologie et sociétés* 13(2): 31-54. https://doi.org/10.7202/015076ar

Akrich M (2006) La description des objets techniques. In: Akrich M, Callon M and Latour B (eds) *Sociologie de la traduction. Textes fondateurs*. Paris: Presse des Mines, pp. 159-178.

Álvarez M V, López J M T and Ruíz M J U (2020) What are you offering?: An overview of VODs and recommender systems in European public service media. In: Rocha Á, Ferrás C, Montenegro Marin C and Medina García V (eds) *Information technology and systems. ICTs 2020: Advances in intelligent systems and computing*, Vol. 1137. Cham: Springer, pp. 725-732.

Andrews L (2019) Public administration, public leadership and the construction of public value in the age of the algorithm and 'big data'. *Public administration 97*(2): 296-310. https://doi.org/10.1111/padm.12534

Ayache M and Dumez H (2011) Le codage dans la recherche qualitative une nouvelle perspective? *Le Libellio d'AEGIS* 7(2): 33–46. https://hal.science/hal-00657490.

Bailey D E and Barley S R (2020) Beyond design and use: How scholars should study intelligent technologies. *Information and Organization* 30(2). https://doi.org/10.1016/j.infoandorg.2019.100286

Bardoel J and d'Haenens L (2008) Reinventing public service broadcasting in Europe: Prospects, promises and problems. *Media Culture & Society* 30(3): 337-356. https://doi.org/10.1177/0163443708088791

Bastian M, Helberger N and Makhortykh M (2021) Safeguarding the journalistic DNA: Attitudes towards the role of professional values in algorithmic news recommender designs. *Digital Journalism* 9(6): 1–29. https://doi.org/10.1080/21670811.2021.1912622

Beyes T, Chun W H K, Clarke J, Flyverbom M and Holt R (2022) Ten Theses on Technology and Organization: Introduction to the Special Issue. *Organization Studies* 43(7): 1001-1018. https://doi.org/10.1177/01708406221100028

Blassnig S, Strikovic E, Mitova E, Urman A, Hannák A, de Vreese C and Esser F (2024) A balancing act: How media professionals perceive the implementation of news recommender systems. *Digital Journalism*: 1–23. https://doi.org/10.1080/21670811.2023.2293933

Brisset N (2014) Performer par le dispositif? Un retour critique sur la théorie de la performativité. *L'Année sociologique* 64(1): 217-246. https://shs.cairn.info/article/ANSO_141_0215

Bucher T (2017) 'Machines don't have instincts': Articulating the computational in journalism. *New Media & Society* 19(6): 918–933. https://doi.org/10.1177/1461444815624182

Burrell J (2016) How the machine 'thinks': Understanding opacity in machine learning algorithms. *Big Data & Society 3*(1). https://doi.org/10.1177/2053951715622512

Burri M (2015) *Public service broadcasting 3.0: Legal design for the digital present*. London: Routledge.

Callon M (1994) L'innovation technologique et ses mythes. In: Lefebvre P (eds) *Gérer et comprendre*. Paris: Annales des Mines, pp 5-17.

Callon M (2013) Pour une sociologie des controverses technologiques. In: Akrich M, Callon M and Latour B (eds) *Sociologie de la traduction. Textes fondateurs*. Paris: Presse des Mines, pp. 135-157.

Carillon K (2024) "An Algorithm for Public Service Media?" Embedding Public Service Values in the News Recommender System on RTBF's Platform. *Emerging Media 2*(3): 422-448. https://doi.org/10.1177/27523543241290976

Christin A (2020) The ethnographer and the algorithm: Beyond the black box. *Theory and Society* 49(5): 897–918. https://doi.org/10.1007/s11186-020-09411-3

Cuevas-Garcia C, Pepponi F and Pfotenhauer S M (2024) Maintaining innovation: How to make sewer robots and innovation policy work in Barcelona. *Social Studies of Science* 54(3): 352-376. https://doi.org/10.1177/03063127231207082

D'Adderio L (2011) Artefacts at the centre of routines: Performing the material turn in routines theory. *Journal of Institutional Economics* 7: 197-230. https://doi.org/10.1017/S174413741000024X

Dadzie J (2005) Understanding Software Patching: Developing and deploying patches is an increasingly important part of the software development process. *Queue* 3(2): 24-30.

De la Bellacasa M P (2011) Matters of care in technoscience: Assembling neglected things. *Social Studies of Science* 41(1): 85-106. https://doi.org/10.1177/0306312710380301

Denis J and Pontille D (2022) *Le soin des choses : Politiques de la maintenance*. Paris: La Découverte.

Denis J and Pontille D (2023) Material fragilities. *Revue d'anthropologie des connaissances* 17(4). https://doi.org/10.4000/rac.31276

Diakopoulos N (2019) *Automating the news*. Cambridge: Harvard University Press.

Dissanayake N, Jayatilaka A, Zahedi M and Babar M A (2022) Software security patch management-A systematic literature review of challenges, approaches, tools and practices. *Information and Software Technology* 144. https://doi.org/10.1016/j.infsof.2021.106771

Donders K (2012) *Public Service Media and Policy in Europe*. London: Palgrave Macmillan.

Fieiras-Ceide C, Vaz-Álvarez M and Túñez-López M (2023) Designing personalisation of European public service media (PSM): trends on algorithms and artificial intelligence for content distribution. *Profesional De La información Information Professional* 32(3). https://doi.org/10.3145/epi.2023.may.11

Flaxman S, Goel S and Rao J (2016) Filter bubbles, echo chambers, and online news consumption. *Public Opinion Quarterly* 80(S1): 298–320. https://doi.org/10.1093/poq/nfw006

Glaser V L, Pollock N and D'Adderio L (2021) The Biography of an Algorithm: Performing algorithmic technologies in organizations. *Organization Theory 2*(2). https://doi.org/10.1177/26317877211004609

Graham S and Thrift N (2007) Out of order: Understanding repair and maintenance. *Theory, Culture & Society* 24(3): 1–25. https://doi.org/10.1177/026327640707595

Graziano V and Trogal K (2017) The politics of collective repair: Examining object-relations in a postwork society. *Cultural Studies* 31(5): 634-658. https://doi.org/10.1080/09502386.2017.1298638

Haim M, Graefe A and Brosius H-B (2018) Burst of the filter bubble? Effects of personalization on the diversity of google news. *Digital Journalism* 6(3): 330–343. https://doi.org/10.1080/21670811.2017.1338145

Hansen A S and Hartley J M (2021) Designing what's news: An ethnography of a personalization algorithm and the data-driven (re)assembling of the news. *Digital Journalism* 11(6): 924–942. https://doi.org/10.1080/21670811.2021.1988861

Harper D A (1987) *Working knowledge: Skill and community in a small shop*. Chicago: University of Chicago Press.

Henke C R (1999) The Mechanics of Workplace Order: Toward a Sociology of Repair. *Berkeley Journal of Sociology* 44: 55–81. http://www.jstor.org/stable/41035546

Henke CR (2019) Negotiating Repair: The Infrastructural Contexts of Practice and Power. In: Strebel I, Bovet A and Sormani P (eds) *Repair Work Ethnographies*. Singapore:Palgrave Macmillan, pp. 255-282. https://doi.org/10.1007/978-981-13-2110-8_9

Henke C R and Sims B (2020) *Repairing infrastructures: the maintenance of materiality and power*. Cambridge: Mit Press.

Hildén J (2022) The public service approach to recommender systems: Filtering to cultivate. *Television & New Media* 23(7): 777–796. https://doi.org/10.1177/15274764211020106

Hsu H, Lynch P M and Pritchard S (2008) Opening the "black box" of the "black box": The metaphor of the "black box" and its use in STS. In: *Science & Technology Studies Northeast Graduate Student Conference,* Cornell University, Ithaca, NY, 10-12 April 2010.

Hyysalo S, Pollock N and Williams R A (2019) Method matters in the social study of technology: Investigating the biographies of artefacts and practices. *Science & Technology Studies* 32: 2–25. https://doi.org/10.23987/sts.65532

Islam C, Prokhorenko V and Babar M A (2023) Runtime software patching: Taxonomy, survey and future directions. *Journal of Systems and Software*, 200. https://doi.org/10.1016/j.jss.2023.111652

Jackson S J (2013) Rethinking repair. In: Gillespie T, Boczkowski P J and Foot K A (eds.) *Media technologies: Essays on communication, materiality, and* society. Cambridge, MA: MIT Press, pp. 221–239.

Jakubowicz K (2007) Public Service Broadcasting in the 21st Century. What Chance for a New Beginning? In: Ferrel Lowe G and Bardoel J (eds.) *From Public Service Broadcasting to Public Service Media*. Gothenburg: Nordicom , pp. 30-49.

Joris G, Vercoutere S, De Clercq O, Van Damme K, Mechant P and de Marez L (2022) Nudging towards exposure diversity: Examining the effects of news recommender design on audiences' news exposure behaviours and perceptions. *Digital Journalism*: 1-22. https://doi.org/10.1080/21670811.2022.2106445

Lange A-C, Lenglet M and Seyfert R (2018) On studying algorithms ethnographically: Making sense of objects of ignorance. *Organization* 26(4): 598–617. https://doi.org/10.1177/1350508418808230

Latour B (1987) *Science in Action: How to Follow Scientists and Engineers through Society.* Cambridge: Harvard University Press.

Latour B (2006) *Changer de société : refaire de la sociologie*. Paris: La Découverte.

Levy K, Chasalow K E and Riley S (2021) Algorithms and decision-making in the public sector. *Annual Review of Law and Social Science* 17(1): 309-334. https://doi.org/10.1146/annurev-lawsocsci-041221-023808

MacKenzie D (1993) *Inventing accuracy: A historical sociology of nuclear missile guidance*. Cambridge: MIT press.

Meijer A, Lorenz L and Wessels M (2021) Algorithmization of bureaucratic organizations: Using a practice lens to study how context shapes predictive policing systems. *Public Administration Review* 81(5): 837-846. https://doi.org/10.1111/puar.13391

Mitova E, Blassnig S, Strikovic E, Urman A, Hannak A, de Vreese C H and Esser F (2022) News recommender systems: A programmatic research review. *Annals of the International Communication Association* 47(1): 84–113. https://doi.org/10.1080/23808985.2022.2142149

Møller L A (2022) Recommended for You: How Newspapers Normalise Algorithmic News Recommendation to Fit Their Gatekeeping Role. *Journalism Studies* 23(7): 800-817. https://doi.org/10.1080/1461670X.2022.2034522

Murray A, Rhymer J E N and Sirmon D G (2021) Humans and technology: Forms of conjoined agency in organizations. *Academy of Management Review* 46(3): 552-571. https://doi.org/10.5465/amr.2019.0186

Murschetz P (2021) Datafication and public service media: A review of the literature and some first propositions on its effects on PSM values. *MedienJournal* 44(3): 69-86. https://doi.org/10.24989/medienjournal.v44i3.1808

Newman J (2012) Ports and patches: Digital games as unstable objects. *Convergence* 18(2): 135-142. https://doi.org/10.1177/1354856511433688

Neyland D and Möllers N (2017) Algorithmic IF … THEN rules and the conditions and consequences of power. *Information, Communication & Society* 20 (1): 45–62. https://doi.org/10.1080/1369118X.2016.1156141

Neyland D (2015) On Organizing Algorithms. *Theory, Culture & Society* 32(1): 119-132. https://doi.org/10.1177/0263276414530477

Nicolini D (2009) Zooming In and Out: Studying Practices by Switching Theoretical Lenses and Trailing Connections. *Organization Studies* 30(12): 1391-1418. https://doi.org/10.1177/0170840609349875

Orlikowski W (2000) Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science* 11(4): 404-428. https://doi.org/10.1287/orsc.11.4.404.14600

Pariser E (2011) *The filter bubble: What the internet is hiding from you*. London: Penguin Books.

Pasquale F (2015) *The black box society: The secret algorithms that control money and information*. Cambridge: Harvard University Press.

Pinch T J (1986) *Confronting Nature: The Sociology of Solar-Neutrino Detection.* Dordrecht, Boston: Kluwer Academic Publishers.

Pinch T J and Bijker W E (1984) The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Social studies of science* 14(3): 399-441. https://doi.org/10.1177/030631284014003004

Pollock N and Williams R (2011) Moving beyond the single site implementation study: how (and why) we should study the biography of packaged enterprise solutions. *Information Systems Research* 23(1): 1-22. https://doi.org/10.1287/isre.1110.0352

Reddy E, Cakici B and Ballestero A (2019) Beyond Mystery: Putting Algorithmic Accountability in Context. *Big Data & Society* 6(1): 1-7. https://doi.org/10.1177/2053951719826856

Ross Arguedas A, Robertson C T, Fletcher R and Nielsen R K (2022) Echo chambers, filter bubbles, and polarisation: A literature review. *Reuters Institute for the Study of Journalism*: 1-42. https://doi.org/10.60625/risj-etxj-7k60

Russell A L and Vinsel L (2018) After innovation, turn to maintenance. *Technology and Culture 59*(1): 1-25. https://www.jstor.org/stable/26803881

Sachs S E (2019) The algorithm at work? Explanation and repair in the enactment of similarity in art data. *Information, Communication & Society* 23(11): 1689-1705. https://doi.org/10.1080/1369118X.2019.1612933

Schubert C (2019) Repair work as inquiry and improvisation: the curious case of medical practice. In: Strebel I, Bovet A and Sormani P (eds) *Repair Work Ethnographies*. Singapore:Palgrave Macmillan, pp. 31-60.

Schwarz J A (2015) Public service broadcasting and data-driven personalization: A view from Sweden. *Television & New Media* 17(2): 124-141. https://doi.org/10.1177/1527476415616193

Seaver N (2017) Algorithms as culture: Some tactics for the ethnography of algorithmic systems. *Big Data & Society* 4(2). https://doi.org/10.1177/2053951717738104

Seaver N (2019) Knowing algorithms. In: Vertesi J and Ribes D (eds.) *Digital STS: A Field Guide for Science & Technology Studies*. Princeton, NJ: Princeton University Press, pp. 412-422.

Sims B and Henke C R (2012) Repairing credibility: Repositioning nuclear weapons knowledge after the Cold War. *Social Studies of Science* 42(3): 324-347. https://doi.org/10.1177/0306312712437778

Sørensen J (2011) *The paradox of personalisation.* PhD Thesis, University of Southern Denmark.

Sørensen J (2019) Public service media, diversity and algorithmic recommendation: Tensions between editorial principles and algorithms in European PSM Organizations. In: *RecSys 2019: 13th ACM Conference on recommender systems – 7th International Workshop on News Recommendation and Analytics*, Copenhagen, Denmark, 16-20 September 2019.

Sørensen J (2020) The datafication of public service media dreams, dilemmas and practical problems a case study of the implementation of personalized recommendations at the Danish public service media. *MedieKultur Journal of Media and Communication Research* 36(69): 90-115. https://doi.org/10.7146/mediekultur.v36i69.121180

Sorokin A R (2023) Stewards of the Organization: The Management of Repair and Maintenance Work in Large Organizations. *Engaging Science, Technology, and Society* 9(3): 100-120. https://doi.org/10.17351/ests2023.1347

Star S L (1999) The ethnography of infrastructure. *American Behavioral Scientist* 43(3): 377-391. https://doi.org/10.1177/00027649921955326

Švelch J (2019) Resisting the perpetual update: Struggles against protocological power in video games. *New Media & Society 21*(7): 1594-1612. https://doi.org/10.1177/1461444819828987

Truelove A, de Almeida E S and Ahmed I (2021) We'll fix it in post: What do bug fixes in video game update notes tell us? In: *2021 IEEE/ACM 43rd International Conference on Software Engineering* (ed IEEE), Madrid, Spain, pp. 736-747, New York: IEEE.

Van den Bulck H and Moe H (2018) Public service media, universality, and personalization through algorithms: Mapping strategies and exploring dilemmas. *Media, Culture & Society* 40(6): 875–892. https://doi.org/10.1177/0163443717734407

Wenzelburger G, König P D, Felfeli J and Achtziger A (2024) Algorithms in the public sector. Why context matters. *Public Administration* 102(1): 40-60. https://doi.org/10.1111/padm.12901

Zhang F and Feeney MK (2020) Engaging through Technology: The Role of Administrative Culture and Mandates. *Public Management Review* 22(10): 1423-1442. https://doi.org/10.1080/14719037.2019.1630475

Ziewitz M (2016) Governing Algorithms: Myth, Mess, and Methods. *Science, Technology, & Human Values* 41(1): 3-16. https://doi.org/10.1177/0162243915608948

Frictions in Automating Routine Data Work: A Human-Assisted Robot in Datafied Healthcare in Finland

Marja Alastalo
University of Eastern Finland, Finland/marja.alastalo@uef.fi

Iiris Lehto
University of Eastern Finland, Finland

Abstract

This article explores the implementation of an Robotic Process Automation (RPA) -based robot designed to automate one small phase of data validation in primary healthcare. Drawing on ethnographic fieldwork conducted in a Finnish wellbeing services county, we investigate the complexities involved in the implementation and use of RPA technology. Theoretically, the article uses and develops the concepts of breakdown and friction to examine how the robot performs its mundane data tasks. In this case, technical breakdowns and repair work were relatively minor compared to persistent frictions and the ongoing need for human assistance. We identified four sources of friction that hindered the robot's ability to complete the assigned task: technical failures, legislation and national guidelines, austerity and cost savings, and organisational complexity and hierarchies. The robot is described as a human-assisted technology to highlight the support it required to function. The findings suggest that alongside breakdowns, frictions deserve attention when examining digital technologies and their everyday use.

Keywords: Friction, Healthcare, Data Work, Robotic Process Automation, Ethnography

Introduction

In healthcare, data are increasingly used for the often-conflicting needs of care, administration, innovation, and research (Hoeyer, 2023). Making high-quality data available requires labour and has created new forms of so-called data work across the public sector. The concept of data work refers to "any human activity related to creating, collecting, managing, curating, analysing, interpreting, and communicating data" (Bossen et al., 2019a: 466). A combination of technology hype and pressure to achieve cost savings has driven public healthcare organisations to seek technical solutions—such as robotic process automation (RPA) and speech recognition—to reduce routine human office and data work. However, the automation of healthcare data work is not without challenges (Hoyer, 2023; Morrison et al., 2013).

In this article, we explore the complications and complexities involved in implementing RPA in a public healthcare organisation in Finland. RPA is one of the latest forms of (office) automation. RPA is an umbrella term covering several light-weight IT solutions. RPA robots are often called 'digital workers' or even 'colleagues' who can be assigned mundane routine work. Automation is supposed to free human workers to perform more important tasks and to reduce the risk of human error (Dhatterwal et al., 2023). Typical software robots mimic the actions previously performed by human workers, such as clicking, copying, pasting, navigating, and sending emails or text messages (Kedziora et al., 2024: 1630). RPA can only handle structured digitised data. Cognitive RPA can apply artificial intelligence (AI) and machine learning (ML) to enhance its ability to capture and process information. (Lahtinen et al., 2023: 250; Venigandla, 2022: 33). Even though increasingly intelligent automation has become available in healthcare and public sector more generally, where accountability and transparency are required, RPA retains its value through its ability to build rule-based software robots that interact with various information systems and applications (Hofman et al., 2020; Loi and Spielkamp, 2021).

Previous studies reveal that RPA typically addresses specific tasks rather than complete, end-to-end value chains (Kedziora and Smolander, 2022: 6208). While automation transforms work, it does not eliminate it. Paradoxically, automating a certain phase of work can increase work elsewhere in the organisation (Kedziora and Smolander, 2022: 6208; Hoyer, 2023: 50; Vikkelsø, 2005: 19). Nevertheless, public sector organisations often hold high expectations that robotisation will result in substantial efficiency improvements, making it a valuable tool for enhancing organisational processes. This assumes that organisations can always find ways to improve their operations by streamlining work processes (Kedziora et al., 2024; Stock and Nguyen, 2019). Prior research has shown that despite the high expectations up to 75 % of organisations do not reap "the full benefits of their automation" (Asatiani et al., 2023: 110), and 30–50% of all deployments fail due to misapplication stemming from inflated expectations that can lead to misunderstandings of RPA's potential and result in operational disruptions. (Kedrioza and Smolander, 2022: 6209). It has also been shown that automation can feel like an "additional burden" for healthcare staff, because automation solutions are not error-free, and the risk of additional work is high, especially during the initial implementation phase (Kaitosalmi and Ratia, 2024: 251).

In what follows, we focus on an RPA robot implemented to automate a tiny task of data validation in one of the 21 wellbeing services counties in Finland. Wellbeing services counties were established at the beginning of 2023 as an outcome of a major administrative reform in which the responsibility for organising health-care, social services, and rescue services was transferred from municipalities to these counties.[1] The studied RPA did not use AI or ML because the organisation was very cautious about the legality and data protection implications of the data-driven solutions as we will explain later in detail. Because the RPA deployments have a high failure rate (Asatiani et al., 2023; Kedziora and Smolander, 2022), we analyse in detail how the robot coped with its tasks in practice and whether, and what kind of human assistance it needed. Our analysis is based on two-and-a-half--year ethnographic fieldwork conducted in a wellbeing services county. Theoretically we use the concepts of breakdown (Graham and Thrift, 2007) and friction (Edwards et al., 2011; Bates, 2018) to examine the robot, because from the start it was obvious that the robot did not fully suit performing the task assigned nor achieve the set goals. Because prior research has shown that automation and RPAs can lead to an increased amount of work, we call the robot a *human-assisted* technology to make visible the work that it required to operate.

We contribute to the body of research on automation in public sector healthcare by addressing a noted gap especially in the literature concerning the use of RPA in healthcare contexts (Ratia et al., 2018; Patrício et al., 2024). First, we provide novel empirical insights into an RPA robot in action and the sources of friction encountered during its use. Our results help to critically evaluate the exaggerated expectations and promises associated with public sector automation. Second, we contribute theoretically by demonstrating that the concept of friction is fruitful for providing a nuanced understanding of why technologies do not necessarily meet expectations. Third, we introduce the concept of human-assisted technology, which could be useful for highlighting the human work that RPA and automation more broadly can require.

Theoretical framework

In science and technology studies it is often assumed that breakdowns will reveal the infrastructures and networks that compose technologies (Latour 1987; Star, 1999). However, opening this 'black box' is a complex matter (Pinch, 1992). In the literature, breakdown is described as a typical feature of the world in general and of technological infrastructures in particular (Graham and Thrift, 2007; Jackson, 2014; Mol et al., 2010; Tanweer et al., 2016). Graham and Thrift (2007: 4) state in line with Lotringer and Virilio (2005) that to invent the plane is to invent the plane crash. In other words, the potential for various breakdowns, failures, and malfunctions is inherent to technology. As Jackson (2014: 230) notes, "breakdown disturbs and sets in motion worlds of possibility that disappear under the stable or accomplished form of the artifact". The concept of breakdown refers to prosaic moments when a technology is broken and fails to work. In a world of constant breakdowns, continuous maintenance and repair are required. Breakdowns can also lead to new innovations (Graham and Thrift, 2007; Jackson, 2014).

Informed by the concept of breakdown, we initially paid attention to moments when the robot under study was broken. However, we soon noticed that, in addition to breakdowns, there was something more at play that the concepts of breakdown or failure did not capture. Even when the robot worked as intended, it did not fully automate the small task of data validation which prevented data workers from concentrating on their other tasks. Therefore, the robot did not bring the expected relief to these workers. We use and develop the concept of friction to understand the robot in action. In science and technology studies, the concept of friction has been used to describe interruptions, deferments, and forces that oppose and resist data flow (Edwards et al., 2011). The concept of 'data friction', a special form of friction, was developed in the context of science studies to capture what happens when data move between people, disciplines, organisations, and machines. Data friction refers to the costs in energy, time, and human attention required to collect, store, move, receive, and access data, hampering the movement of data from one system to another. (Edwards, 2010: 84.) Each interaction between groups, organisations, or machines serves as a potential point of resistance where data might become distorted, misinterpreted, or lost. Data friction produces heat, that is, conflicts and unruly processes. (Edwards et al., 2011.)

Prefixes other than 'data' have been added to the term 'friction'. For instance, as a continuation of data friction, Edwards et al. (2011) developed science friction and metadata friction. The first concept is a consequence of data friction and refers to difficulties in interdisciplinary research, and the second refers to situations where "as with data themselves, creating, handling, and managing metadata products always exacts a cost in time, energy, and attention" (Edwards et al., 2011: 673). Furthermore, Bonde et al. (2019: 559) use computational friction to denote "the work of combining and turning data into useful information", and Tomalin (2023) speaks about online or e-friction. When friction resists and impedes, Tomalin (2023) argues, in the context of the ICT industry, that some forms of friction can also be beneficial. For example, in online stores, e-friction is beneficial if the payment system requires strong authentication or prompts the user to confirm the transaction. If there is a risk of disclosing sensitive information, implementing verification steps and prompts can help mitigate this risk. Therefore, a 'frictionless' technology would pose a privacy threat, and friction acts as a gatekeeper (Tomalin, 2023: 2).

Data frictions, following Bates (2018), can be understood as sites of negotiation rather than merely obstacles to overcome. Building on this, we conceive frictions not as discrete events, but as persistent rubbing that cannot be easily resolved or repaired. Just as the concepts of data-related friction emphasise that data does not move without friction, we use the concept of friction to analyse and identify factors that contributed to the robot's difficulties in automating the work task and freeing data workers to perform other tasks. As prior research has shown that frictions can be generative, causing 'frictional costs', that is extra work (Edwards et al. 2011: 673; see also, Bonde et al. 2019), we highlight this labour-consuming feature of friction by calling the robot a human-assisted technology. Furthermore, we use three categories of factors that Bates (2018) identifies as constitutive forces of data frictions when analysing the factors that caused them. Bates' analytical categories are based on Kitchin's (2014) theorising about complex data assemblages. The first category comprises data-sharing infrastructures and management (e.g., technical infrastructures, data management practices, organisations, and materialities). The second consists of sociocultural factors (e.g., systems of thought, forms of knowledge, subjectivities, communities, and institutions), and the third includes regulatory frameworks (e.g., legalities, policies, and standards).

Bates' three analytical categories sensitised us to different constitutive forces of frictions and enabled us to identify the dynamics of friction when the robot did (or did not do) the simple data work task assigned to it. At this point, we refine our research questions as follows: Which forces, and sociotechnical dynamics form and shape friction around the robot? What kinds of human work or assistance were needed because of the frictions? Because we investigate an RPA robot, we use the concept of friction. However, we also use the concept of 'data friction' to explain the organisation's choice regarding where to implement RPA, as we will show.

Data and methods

We draw on ethnographic fieldwork conducted in Finland in one of the 21 wellbeing services counties. Our research design was inspired by institutional ethnography (Smith, 1987; Devault, 2006), a method that enables researchers to use the everyday experiences of the research participants as entry points to explore power dynamics. Guided by institutional ethnography, we explored how the robot settled into its tasks starting from below in the complex hierarchical organisation. We shadowed an all-female data team (DT) from early 2022 for two and half years, although the first author has been in the field since early 2019. The DT worked on the entire process of producing standardised data to ensure data quality for secondary purposes, such as knowledge-based management at the organisational and national levels, the production of statistics and health research. The DT has been reorganised several times since it was founded less than ten years ago. To protect the team's anonymity, we do not provide the exact years and other figures in our case description. Further, the DT's foreperson has changed a few times, as has its composition. The DT has varyingly consisted of about 10 members, including the foreperson, half of whom had training and work experience in healthcare (e.g., as enrolled nurses, practical nurses, midwives, or specialised nurses), while roughly half had vocational business and administration training and work experience for instance as ward secretaries. Some had acquired further qualifications by completing a vocational degree in data processing. Half of them had worked—often in addition to their own duties—as the main users of client and patient information systems in different units and organisations[2]. Most team members were aged between 50 and plus 60 years.

Our data consist of 15 interviews with 13 interviewees and fieldnotes taken at the DT's weekly meetings. The interviews conducted via a videoconference tool lasted from one to one and a half hours. All interviews were recorded and transcribed verbatim. Between January 2022 and December 2024, we observed more than 70 weekly meetings. These meetings were held on a videoconference platform because the team had primarily worked remotely since the pandemic. The weekly team meetings lasted from one hour to ninety minutes, during which the DT discussed ongoing issues and went through the week's programme and upcoming events, such as training sessions. They also discussed issues and problems encountered with client and patient information systems and other information systems, external system suppliers, the in-house company and the robot. As our research permit did not allow audio recording of the team meetings and collaborative meetings, we took detailed written fieldnotes (for a more detailed description of the fieldwork, see Alastalo and Lehto, forthcoming). Since both of us participated in most of the meetings, we compared our fieldnotes to gain a comprehensive understanding of working with the robot, as we had focused on and wrote down slightly different things at times in very fast-paced meetings.

As is typical of ethnographic practice, our fieldwork, the making of analytical observations and systematic analysis of the produced data were intertwined. Our research and analytical process proceeded as follows. The robot caught our attention during the DT's weekly meetings, where the team frequently discussed the robot's failures and other issues they encountered with it. These moments served as an invitation for us to investigate it further. As the first phase of the analysis, we read through the fieldnotes and interview transcripts from the first round of interviews (five of which dealt with the robot) and collected all the episodes and interview sections where the DT members discussed the robot and the implementation of AI solutions more generally. Since failures do not reveal all the associations and relationships in the assemblage (Tanweer et al., 2016: 4), we decided to interview again those who worked with the robot to get a more comprehensive understanding of it. Before new interviews, we collected all the questions regarding the robot, for which we could not find answers in the existing materials. After that, we conducted four interviews: two with three team members who worked directly with the robot (in one of the interviews, two of the team members participated together) and two with senior managers who were directly involved in acquiring the robot and had decision-making authority regarding it.

In the second phase of the analysis, we focused on breakdowns and frictions as well as the human labour and attention required to repair, assist, support, and substitute for the robot. This phase led us to conduct six more interviews with the main users of the patient information system, whose workload was expected to be alleviated by the robot. They worked as nurses, practical nurses, and secretaries; one of them even held a full-time position as a main user. In the third phase, after the supplementary interview materials were analysed, we categorised all excerpts concerning breakdowns and frictions into four categories, namely, technical breakdown, legislation and national guidelines, austerity and cost savings, and organisational complexity and hierarchies.

Case: The robot and its milieu

Promoting a culture of experimentation in the public sector in Finland was one of the government's key goals in the late 2010s; it aimed to enhance public sector efficiency (Leino and Åkerman, 2021). Additionally, in public healthcare and social welfare a strategic goal was set to enhance digital and data-driven technologies to boost the effectiveness of healthcare and social welfare services (Sosiaali- ja terveysministeriö, 2018). More recently the wellbeing services counties have been encouraged to introduce advanced digital technology with a strong expectation that the workload of the staff will be reduced, and health and social services will be organised based on effectiveness data (Ministry of Social Affairs and Health, 2024: 21).

When we look at the studied organisation and its RPA robot, we can identify three drivers behind the decision to acquire the robot. Firstly, the organisation had adopted a national culture of experimentation, secondly, it aimed to improve its data quality, and thirdly, it sought to enhance its operations. According to one DT worker, 'a desire to get it (a robot) into something' was the starting point for acquiring the robot. This desire materialised in the senior management's assignment to 'consider the automation of some process in some manner'. As a result of this request, the organisation implemented two RPAs—one for primary healthcare data validation and another for recruitment services. According to the DT's foreperson, one small part of the healthcare data validation process was assigned to the robot also because the organisation wanted to 'leave no stone unturned' to improve the quality of its primary healthcare data.

High-quality healthcare and social welfare data are crucial to the organisation and used at both the local and national levels. For example, data collected from different information systems are needed to support knowledge-based—or, rather, data-driven—management. According to the national legislation (Laki Terveyden ja hyvinvoinnin laitoksesta, 2008), the organisation is also obliged to deliver these data to the national register maintained by the Finnish Institute for Health and Welfare. The register is used to guide and monitor healthcare provision, and, most importantly, to allocate state funding to the wellbeing services counties. Moreover, it is used in national statistics production and research.

Healthcare staff are required to record specific types of data in a specific standardised way in the patient information system. However, incorrect data entries that is friction in the data (Bates, 2018; Edwards, 2011), were frequently identified when the DT validated the data by checking for inconsistencies and missing entries, for instance, by comparing different reports. The struggle to reduce incorrect and missing data entries had continued for decades even though the DT workers and main users had trained, guided, and advised healthcare staff on structured recording. Additionally, the main users had the rather unrewarding task of reminding staff about missing or incorrect data entries. The management believed that having a robot would reduce the workload of both the main users and the DT, as no one would need to manually inform healthcare professionals about their incorrect data entries. In this case data friction (Edwards, 2010; Bates, 2018) together with an attempt to reduce the number of erroneous data entries, served as a generative force that partly influenced the implementation of the RPA.

The robot and its development were purchased from a large international company in 2023, but responsibility for the robot and its maintenance were later transferred to a company owned by various public sector organisations. The robot worked in conjunction with a checklist that scanned the patient information system's database and checked the data entries daily. Members of the DT and the IT team within the organisation had built the checklist to identify errors, such as missing information about the reason for seeking care. The checklist listed all incorrect entries and was updated daily. Every Sunday the robot sent an email notification to staff members who had made incorrect data entries or had not completed the necessary entries. The notification contained a request to make corrections and a tally of the incorrect entries.

The team discussed the number of errors several times during the weekly meetings, as they had observed that, despite the implementation of the robot, the number of errors had not significantly decreased. The team wondered whether the robot's message was difficult to understand or misleading, so the staff did not react to its request for that reason. The team decided to slightly modify the message content. This modification required human assistance from both the DT and the company responsible for the robot's maintenance. The DT rephrased the message and then sent it to what one interviewee termed the 'robot gurus' of the IT company, as the DT could not technically change it. After the message was recoded, the robot was put to work again. Rephrasing the message did not have a significant effect on reducing the number of errors.

Findings

In the following section, we address each of the four sources of friction and the related human assistance. First, we look at technical failures; second, we focus on legislation and national guidelines; third, on austerity and cost savings; and fourth, on organisational complexity and hierarchies as sources of friction.

Technical failures

Especially during the first months of its existence, the robot occasionally stopped doing its work, namely, sending email notifications to healthcare professionals who had made erroneous or incomplete entries in the patient information system. There were various reasons for the robot's 'vacations', as the DT called its technical failures. For instance, the robot did not send notification emails because of problems in the mail server's certificates, or the outgoing messages were stuck in the email outbox and had to be released manually, or the robot was unable to read the checklist correctly. According to prior research, most technologies go through a period during which their components are unreliable and fail to integrate smoothly (Graham and Thrift, 2007: 10). Similarly, most of the robot's technical failures likewise occurred soon after it was deployed, but the organisation had to be prepared for the possibility that failures could occur at any time. When failures occurred, the DT's foreperson had to ask the IT company to resolve the problems, as shown in the extract from the fieldnotes below:

> DT foreperson says "[T]he checklist robot is on the mend. [….] [Robo] will start soon". She explains that the robot had just had three weeks of vacation and is about to function again and send error . Two DT workers ask if their foreperson has two minutes after the meeting to chat about the robot, "what to do with the robot, now that he was on holiday". The data workers list the number of errors and unfinished data entries in the patient information system. They emphasise the magnitude of the number by saying "that's a lot". One team member defends the robot: "it's not the Robo's fault people need to be more careful." (DT meeting Oct 2023)

The robot's technical failures or breakdowns were not fatal for the organisation, even if they lasted for weeks, because they did not affect the provision of primary healthcare, as would have happened in the case of—for example—a breakdown of the patient information system. The DT's foreperson had to manually check whether the robot was working because there were no direct notifications of its malfunction. Since the robot's functionality was not a primary factor to be monitored, on one occasion when the DT foreperson was on holiday, a breakdown went unnoticed for weeks.

The technical breakdowns affected the main users and DT workers who oversaw the data quality and provided help in using the patient information system. While the robot was out of order, humans substituted for it and sent emails on its behalf. Therefore, the robot's reliability and efficiency as a co-worker and its role in reducing human labour were questionable. The team's foreperson expressed her frustration with the robot as follows: "I think I'm going to fire the robot, it plays up, lies with its legs stretched out" (DT meeting March 2024). The 'firing' was tinged with humour. Although it has been argued that technology is always breaking and that breaking can generate productive cracks in the system (Jackson, 2014), at the grassroots level and in the robot's case, frustration indicates friction as there was no room for continuous breakdowns in the daily data work routines carried out with limited resources. The robot's vacations also confused healthcare staff, who sent enquiries to the main users and the DT, wondering why there were no emails from the robot. Responding to these enquiries—that is, assisting the robot—increased the main users' and the DT's workload by generating extra email correspondence. Therefore, the robot itself caused friction when it disrupted their workflow (cf. Tomalin, 2023). The data workers whose tasks the robot was supposed to lessen gave it the name *Ruttunen*, which resembles a human surname and means 'dented' in English. They also added the suffix 'small', commonly used in surnames.

Repair illustrates the importance of human labour, even though it is not necessarily the case that breakdowns, malfunctions or failures can be easily fixed and repaired (Graham and Thrift, 2007: 4). Identifying and repairing the robot's technical breakdowns was not complicated, but the repairs only enabled the robot to return to work without bringing the expected relief to data workers. In other words, from the perspective of the DT and main users, the robot did not correct or repair the main problem, which was the ever-growing number of errors in the data. Although some main users found the robot to be somewhat beneficial, the DT and healthcare professionals were dissatisfied with the robot even when it worked.

Legislation and national guidelines

The national and EU-level legislation, as well as national guidelines, caused friction and consequently led to extra work. We consider first the national and EU-level legislation, and second, national guidelines for making data entries. To have worked properly from the DT's, main users' and healthcare staff's perspective, the robot's email notification should have included a link to an incorrect entry made by a healthcare professional. However, this was not possible. The EU and national data protection legislation, and the organisation's interpretation of it, did not allow 'Robo' to process personal data, because it was produced and maintained by an external supplier. In the following excerpt, the DT members discuss the robot's limitations:

> R2: But the problem is that the robot is only a messenger at such a low level, so the problem is that you cannot, those patient numbers cannot be given to the robot. Because they are personal data.
> R: Identification data, so.
> R2: Yes, identification data. But why the link cannot [be given], I'm not quite sure what the reason for it is. That the link cannot…

> I2: Have you passed on the request to get the link?
> R2: Yes, and the users have requested it.

The interview excerpt shows that the DT workers were uncertain and spoke inconsistently about data protection issues related to the robot. On the one hand, they knew that personal data could not be given to the robot. On the other hand, it seems that, if it had been up to them—the main users or the organisation's healthcare professionals—they would have included the longed-for link to the incorrect entries in the robot's messages. Therefore, legislation produced a beneficial friction because it helped to protect primary-care patients' personal data from potentially falling into the wrong hands. Regulatory frameworks are created because infrastructure and business models have evolved, and an appropriate amount of legislative friction is necessary (Bates, 2018: 422). The DT foreperson also highlighted data protection issues and referred to the external vendor, explicitly stating that the link could not be inserted 'under any circumstances':

> R: We cannot build a robot that could directly identify that you have [an error] here and there. [...] That's what the end users want, to put a link [to an error in the patient information system] in it, but the answer is unequivocal, we won't, because [...] there might be some data protection risk. And then [...] the robot is not our own product, but it is [company name]'s product, so it cannot be done under any circumstances. (DT foreperson)

Although legislation effectively protects patient data, it also required healthcare staff to navigate between different information systems. After receiving a notification email from the robot, healthcare staff were expected to consult the checklist to identify their errors and then access the patient information system to correct them. This process increased both the DTs and main users' workload, as healthcare staff often contacted them for assistance when they were unsure about which errors they had or how to correct them.

> The robot should produce more specific information. It should identify either the date when the error has occurred or the reason for the error. Because sometimes we are contacted by the staff "Hey, what is here, I got this message, and I cannot find [the error]". (Main user)

Consequently, the main users had to act as the 'robot's robot', as one main user described. The amount of 'connective infrastructural labour' caused friction and frustration.

Secondly, in addition to the EU and national data protection legislation, national guidelines given by the Finnish Institute for Health and Welfare for making health register entries further complicated the robot's ability to achieve its goal (i.e., to reduce the number of incorrect and missing data entries) and automate data validation. According to the guidelines, the guiding principle in record-keeping is that register entries, and their corrections cannot be made on behalf of healthcare professionals. For example, a doctor must determine the diagnosis and the reason for the visit, among other details. A nurse can only record a diagnosis if a doctor has made it. (Sosiaali- ja terveysministeriö, 2012: 45, 67.) Due to the high turnover of doctors, there were situations where it was not possible to correct all the entries. It was difficult, and sometimes impossible, to track down short-term temporary doctors and request them to correct their errors. If the doctor had moved on to another organisation before the errors were identified, they no longer had access to the patient information system. Therefore, it was not a matter of the team or main users ceasing their efforts to locate the responsible doctor. Consequently, the robot was inevitably deficient, and the data remained incomplete.

At times, DT meetings discussed both the potential uses of more advanced AI alongside robotics and, in particular, the ethics of AI technologies. During these discussions, the robot was described as the 'dumber cousin of AI' since it did not have any intelligent features. The foreperson wondered whether they should ask for ethical guidelines 'so that we don't head toward the edge of a ravine with a bag over our heads'. She promised to take the initiative to draw up ethical guidelines, as well as guidelines for data protection. The issue had been taken forward because, according to the senior-level manager, the organisation aimed to have key AI policy guidelines by the turn of the year (2025):

> In other words, this AI relates to such big, one might say, unresolved issues, even at the national level. In other words, data protection and security legislation come strongly into play. We have perhaps made a bit of a policy that we are now waiting to see what happens at national level and what kind of guidelines and instructions will be issued in relation to this. (A senior-level manager)

Legislative friction related to robotics and AI is by no means limited to the studied organisation, but is an EU-wide regulatory issue. For example, the lack of algorithmic transparency must be solved before AI is implemented in healthcare (Kiseleva et al., 2022). It is also one of the key reasons why healthcare organisations considering automation have implemented robotics instead of AI. With the ongoing procurement process for the new patient and client information system, issues related to automation and wider AI-based solutions have featured prominently in the organisation.

Austerity and cost savings

The tight financial situation of the organisation was reflected in all aspects of technology implementation and development. Budgetary constraints affected how new technologies were supplied and existing systems were upgraded. Investments in new technologies were piecemeal, because the top management had granted permission only for developments that were necessary to comply with legislation. Consequently, the robot was not developed further after its message was updated.

Financial constraints were discussed a great deal in relation to the robot. Two of our interviewees discussed the robot and the financial situation of the organisation in the following terms:

> R2: And now that there have been no such development ideas for it. And [it has] also been thought about whether it makes sense to keep it [the robot], so it has been said that let's leave it as it is for now. But it has not been further developed. And [it] will probably not be [upgraded], *given this economic situation, so that's perhaps the main reason*.
> R: And we already suggested to [mentions R2's name] that let's save on the robot, so let's put this one away. It hasn't brought us any help. But now that it's been paid for, it's going to be crawling around here.
> […]
> R: [...] But undeniably it felt like when you look at how much of a deficit we have, and how attempts are being made to cover it, you're never going to get it [covered] by not ordering pencils for us. We have been given those savings goals; we have nothing to save on. I did say in one of the meetings don't order anymore, when [mentions a colleague's name]—our warehouse manager—has been ordering us booklets, so now is not the time to order, let's save on booklets. But we are really short of what we can save on.

The financial situation of the entire public sector also affects the wellbeing services counties. The government has urged the counties to streamline operations and adapt to tighter budget constraints. The DT workers described the difficulties of finding more targets for savings. Since they were not very positive about the robot and thought that it did not help them, the DT workers were willing to give it up due to financial constraints, but it was not abandoned because it had already been paid for. The organisation would have had the expertise to build RPAs in-house; however, it did not have the required resources because a new information system was in the process of being acquired:

> We are no longer paying the [the robot supplier's name]. We can make robots here ourselves if we want to, but our human resources are in this sense scarce. (…) When the new client and patient information system starts, so then the structured recording and everything will probably start to roll in other ways, so it [the robot] will be unemployed, and then we will end the contract. It's not at all expensive, that robot. (DT foreperson)

> We could find more of these items, but we just don't have the capacity to invest at the moment. For example, if you think about the processing of invoices, which run into hundreds of thousands, if not millions, we would have cases, but we don't have the money at the moment. (A senior-level manager)

Friction arises from competing priorities. While the robot was able to maintain its position because it did not *directly* consume financial resources, it faced challenges as scarce resources were allocated to the procurement of a new patient and client information system. The development of this new system diverted attention and funding away from improving the functionality of the robot and other IT systems. As a result of the robot's underdevelopment, friction persisted, and the robot continued to need assistance. This dynamic illustrates how resource allocation decisions can affect the functionality and integration of technologies within an organisation.

Organisational complexity and hierarchies

Healthcare organisations are complex and highly hierarchical (e.g., Essex et al., 2023), and these characteristics also caused frictions and had consequences for the implementation of technology. We recognised three sources of friction in relation to organisational complexity and professional hierarchies. First, the complexity of the organisation contributed to the fragmentation of technology development and complicated technology procurement, development, and implementation. Second, because of organisational complexity and hierarchies, the robot's in/capabilities looked different and were not similarly visible or present for everyone. Third, because of professional hierarchies, the robot and its assistants were at a low level of the hierarchy.

First, the organisation's complexity, as well as its financial constraints, affected the fragmentation of technology implementation and development. For instance, the decision not to develop the robot was also influenced by the decision to acquire a new patient information system. The DT foreperson said in a weekly meeting that "the robot is running and working until [the name of the patient information system] is in use" (March 2024). Although the development of the robot was stopped and the DT questioned its benefits, the organisation was not giving up on it.

Second, the DT workers, the main users, and senior-level management had different understandings and views of the robot's capabilities. A DT worker described to us how the senior management did not know the reality or details of daily practices:

> DW: The higher up in the hierarchy we go, the more they miss how the robot works in practice. The practical competence [...], how it appears in their [main users'] life, what needs to be done. We may see from the eyes of [mentions a name], who introduced Robo, what it looks like. It looks very different and much better [to the management] than it appears to us. The practice is very different to how it is on paper. We didn't have any clue either where this would lead. We are not sure how much Robo has helped our users. From our point of view, well, Robo is up and running.

The DT workers assumed that the top management expected the robot to perform better and had higher expectations than those the robot could ultimately deliver. Our observations confirmed this view, because one of the managers explained how the robot sent customised email notifications to healthcare staff. In the following excerpt, the foreperson discusses the (changed) expectations placed on it:

> I think it met [the expectations] quite nicely. Although I currently think that the use of the robot would have stabilised, we drew a lot of attention to statistical recording, so the media value within our organisation was good. We were able to open up discussions in the domain very well, and having the robot meant we also had some good topics to discuss on the main user days. He was like a Trojan horse. Our goal was to get a qualitatively better end result of structured recording, and yes, it served quite well. Perhaps it was understood from the very beginning that the robot does not automatically solve anything in that way, but it is a way for us to constantly remind people that "Hey, the structured recording is important, the funding depends on it". Then we also had a lot of intranet news about the robot on several occasions, so yes, that's it. As I said, a Trojan horse, if a metaphor could somehow illustrate this.

For the organisation, the robot's value was also seen in its ability to direct attention to recording errors. Like a Trojan horse, it subtly highlighted the importance of structured recording and its significance to the organisation's funding. A senior-level manager noted that better results could not be achieved with the robot. Thus, it appears that the management did not even expect the robot to completely eliminate errors. For the management, the assistance required by the robot went (partly) unnoticed. The DT and main users still had to remind professionals that errors needed to be corrected. One of the main users described his frustration:

> The foreperson of the doctors has stated that he will not correct the errors, as he does not know how to correct them, does not want to learn, and does not have the time to do so. Someone else will do it on his behalf, or the errors will remain uncorrected. If the foreperson sets this example, his subordinates cannot be obligated to act. (Main user)

Higher-ranking professions are able to delegate routine or unpleasant tasks, such as documentation, to other occupations (Bossen et al., 2019b: 877). Some of the main users also understood the doctors' reluctance to correct their errors, because it took time away from patient care. Additionally, some main users were prepared for the possibility that the robot might lack sufficient authority to enforce corrections.

> And then the robot came. We had a feeling from the beginning that the staff might not go to check and correct [the errors] based on an email [from the robot]. We decided that in our area of responsibility, we will continue to send [error]lists once a month. […] We take care that they will be corrected. (Main user)

Third, as we have already shown, the healthcare staff had to make the required data entries in the patient information system, and the main users or DT workers could not correct erroneous entries or add missing ones for them. Hence, doctors, who were higher in the hierarchy than the main users, the DT, or the robot, should have corrected their errors after getting the robot's email. However, this did not happen because the robot did not have the necessary authority over the healthcare staff, and so human actors started to take the robot's message forward:

> The DT foreperson explains in a weekly meeting that "I crafted a letter for Robot that went out today. I've never written such a furious text in a friendly tone". She explains that she had asked two top managers' blessing for the letter. "You will see a copy of it then." The letter asks (the recipient) in no uncertain terms to correct the errors in the checklist by the deadline. (DT meeting Oct 2023.)

She called the letter she wrote on behalf of the robot using a Finnish word *myllykirje* which refers to letters sent by the long-serving former President of Finland on occasions when, for one reason or another, he was unhappy with someone's actions. The fact that she asked for the top manager's blessing for the letter, despite her position as a foreperson, can be interpreted as a sign that the team was in a rather weak position in relation to the healthcare professionals.

After this attempt, it became apparent to the team foreperson, as well as the senior-level manager, that the robot, even with assistance, was incapable of helping the organisation improve the quality of its data as expected. As a result, the management started to frame error correction as a supervisory issue and transfer the responsibility for requiring healthcare staff to correct errors in health records to managers. In other words, they undertook the repair work. Consequently, the foreperson thanked the DT for a job well done and simultaneously responsibilised it with the correction of errors because the robot was incapable of doing so:

> DT foreperson: You know how to handle domain managers, the supervisory [side], in a smart way. We produce information on how many errors there are and where they are.
> DW: [We] have guided, advised, trained.
> DT foreperson: You've done a tremendously good job, you've done everything you can to send out quality instructions, to respond to service requests. We have done everything we can to address this issue. The robot was the last resort, [but] it's no use, I think it's a burden (laughs). We have genuinely contributed to the issue, this is a supervisory issue, yes.
> (DT meeting June 2024)

Later, in the interview, she noted that, in practice, proper record-keeping is the responsibility of the main users, because the superiors of healthcare staff do not have the time to keep an eye on them. Additionally, she noted that supervisors have official responsibility for their units. Lower-level staff do not have this formal responsibility, although they are asked to carry out 'monitoring work'. Typically, employees can be reluctant to change their work habits or even afraid of learning new technologies (Hindel et al., 2020; Fernandez and Aman, 2019). In this case, the healthcare staff were not expected to adopt new work habits but only to accept the robot as a co-worker whose email notifications should be taken seriously.

Discussion and concluding remarks

We have explored the implementation of a human-assisted robot designed to automate a tiny task of primary healthcare data validation at a wellbeing services county in Finland. The robot was implemented both to improve data quality and reduce the workload of data workers objectives that are typical of RPAs (Berg, 2022: 159). By using breakdown and friction as analytical lenses we studied sociotechnical dynamics that formed and shaped friction around the robot and the human assistance it required. We identified four sources of friction that disturbed the robot's ability to carry out the assigned tasks: 1) technical failures, 2) legislation and national guidelines, 3) austerity and cost-savings and 4) organisational complexity and hierarchies. This is an analytical distinction, as the sources of friction are also interconnected.

1) In our case, technical failures and repair work played only a minor role compared to the constant frictions and the need for assistance. The robot was out of service due to technical breakdowns that required intervention and repair work by the external IT company. In addition to this, technical failures produced frictional costs (Edwards et al., 2011: 673), because human labour was needed to substitute for the robot when it was not performing its tasks. Technical repair work was therefore only one of the activities generated by technical breakdown.
2) Data protection legislation and national guidelines for health record entries were sources of both beneficial and adverse friction. According to the legislation, data protection and privacy must be particularly robust when handling sensitive data, such as patients' health records. The robot was implemented by an external vendor who, due to legislation and the organisation's interpretation of it, was not granted access to the patient information system. While this restriction served as a form of beneficial friction—safeguarding sensitive health data—it also limited the robot's functionality, as its messages did not contain direct links to erroneous data entries, even though such links would have improved usability. In this sense, the robot was designed to fail, since the absence of links was an anticipated limitation. As a result of these frictions, data workers and main users had to assist the robot by answering questions and advising healthcare professionals on their erroneous data entries.
3) Austerity and financial constraints were sources of friction for the robot and the implementation of automation technology more widely. While automation can indeed enhance efficiency, it does not come without cost. In this case, the robot itself was an inexpensive technology, but because of its deficiency, it required human assistance and caused frustration. The organisation could have built the robot in-house, which would have allowed it to add the desired links to erroneous entries. However, due to cost-saving measures and the procurement process for a new client and patient information system, this investment was not made. The robot's development was an obvious target for savings, as it was built on the old patient information system and was likely to become redundant ('unemployed') along with the new system. However, it was paradoxical that the wellbeing services county did not invest in the robot's development given that the data which were crucial for the funding allocated to the organisation were constantly incomplete in part. The data should have accurately reflected real occurrences, such as the number of patient visits and the specific reasons for those visits. Accurate data were also essential for invoicing: if the data were incorrect or incomplete, the organisation could lose revenue.
4) The final source of friction were organisational complexity and hierarchies. The complexity of the organisation and the large number of IT systems made the coordination of their procurement difficult. For instance, when the

robot was bought, the fact that the patient information system would soon be renewed was not taken into consideration. Moreover, employees at different levels of the hierarchy had different expectations and perceptions of the robot's capabilities. Additionally, they were not equally aware of the frictions and extra work caused by it. Data workers whose work was not made easier by the robot felt frustrated and were ready to abandon the non-functional robot. Some main users considered the robot a beneficial addition, although it did not significantly reduce their workload. The management believed the robot was successful in focusing attention on record-keeping, but they overlooked the additional workload it created.

Despite financial incentives to improve data quality, positions of the robot and its human assistants' in the organisational hierarchy remained weak in a hierarchical healthcare organisation. Therefore, the robot lacked authority in many areas and needed human assistance. Had it been a technology more critical to patient safety, its hierarchical position would likely have been higher or, at least, its breakdowns and frictions would have been taken more seriously. Prior studies have shown that the use of RPA may merely address symptoms without resolving the underlying issues, or it may bring about partial improvements (Kirchmer et al., 2019: 12). In this case, the robot did not solve the actual problem, which was that not all healthcare professionals, for various reasons, corrected errors or completed missing information.

Although we have analytically distinguished the different sources of friction above, they are also intertwined. The robot's design remained deficient due to the organisation's interpretation of legislation and cost-saving measures which hindered its further development. During the procurement phase, the upper-level management's enthusiasm for automation overrode the practical concerns raised by data workers regarding the robot's functionality. This, in turn, generated friction: a resource-consuming robot that remained a human-assisted technology, failing to deliver the expected human labour savings or to free up humans for more important tasks. Our findings also indicate that perceptions of the robot's usefulness varied between units. In some units, the robot was considered a helpful addition for sending reminder messages. However, in others, it was perceived as ineffective, as the number of errors had not, according to interviewees, decreased. Instead, due to friction new work practices emerged around the robot. This additional work frequently went unnoticed and unacknowledged by management.

Theoretically, based on these findings, we argue that, in addition to the concept of breakdown, friction is also a fruitful concept in the study of digital automation technologies. Focusing solely on (technical) breakdowns and repair work can obscure the human labour and assistance needed by digital automation technologies, such as RPA, which are expected to free workers' time for more meaningful tasks. The concept of friction (Edwards 2010; Edwards et al. 2011) and Bates' (2018) idea of examining different sources of friction proved helpful in analysing the (mis)alignment between automation technology and its intended task. Furthermore, we suggest that friction can be used to reveal conflicts and controversies (Pelizza, 2016) in the implementation and use of technology. In our case, however, the heat generated by the frictions did not lead to open conflicts or controversies but burst out as frustration. The team, for example, expressed their frustration through humour, joking about 'firing' the robot and giving it nicknames. Frictions—such as those in our case related to legislation, organisational complexity and hierarchies, or cost saving measures—can stem from political or organisational decision-making, or culturally shaped understandings of (professional) hierarchies. These sources of friction are therefore persistent and not easily reduced or removed, for instance at the level of an individual worker, a team, or even an entire organisation. As a result, technical failures may, at times, be more easily repaired than frictions (cf. Edwards, et al., 2011: 684-685 on metadata friction). It is also important to acknowledge that technologies as socio-technical are always accompanied by frictions. Rather than aiming to eliminate them entirely, it is necessary to consider how much friction can be tolerated for the technology to remain viable.

Moreover, the concept of friction offers a lens for considering automation technology critically. It helps to reveal the additional work related to technology even when it functions as intended (see also Bonde et al., 2019). Making extra work visible can also help explain why efficiency expectations are not met. In the context of public healthcare, which operates under tight budget constraints, it is particularly important to strive to assess all costs and resource demands related to the use of automation technology. By examining various frictions in detail, it is possible to assess whether the technology is suitable for the task at all. For example, in our case study, the senior management responsible for implementing the robot may not have fully understood the complexity of the work task to be automated. As a result, instead of being freed for more meaningful tasks, data workers ended up assisting the robot, which was frustrating for them. As Wacjman (2017: 124) notes, "technologies are facilitating not less work but worse jobs".

In sum, we suggest that frictions, as well as breakdowns, should be investigated when digital automation technologies and their usage are examined. Although technical failure or breakdown may explain certain malfunctions, these often fail to capture the full complexity of why a system—or in this case, a software robot—does not perform as expected. Actors must commit time, energy, attention, and resources to overcome many resistive frictions (Edwards, 2010). These cannot be overlooked, since the question of who fixes the devices and systems we use (Jackson, 2014) is not the only one worth asking; consideration must also be given to who provides assistance when frictions occur and who maintains the infrastructure. Our results contribute to science and technology studies by providing empirical evidence of the various sources of friction encountered when implementing technology in complex public healthcare organisations and automating routine data work. Furthermore, we suggest that, in addition to costs—time, energy, human attention, and controversies—also affects, such as frustration, require further attention when frictions are analysed.

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References

Alastalo M and Lehto I (forthcoming) Gendered data work practices and the struggle for recognition in a public healthcare and social service organisation. *Scandinavian Journal of Information Systems Preprints*: 18. https://aisel.aisnet.org/sjis_preprints/18/

Asatiani A, Copeland, O and Penttinen E (2023) Deciding on the robotic process automation operating model: A checklist for RPA managers. *Business Horizons* 66(1): 109–121.

Bates J (2018) The politics of data friction. *Journal of Documentation* 74(2): 412–429.

Berg M (2022) Hate it? Automate it!: Thinking and Doing Robotic Process Automation and Beyond. In: Pink S, Berg M, Lupton D and Ruckenstein M (eds) *Everyday Automation: Experiencing and Anticipating Emerging Technologies.* Abington: Routledge, pp.157–170.

Bonde M, Bossen C and Danholt P (2019) Data-work and friction: Investigating the practices of repurposing healthcare data. *Health informatics journal* 25(3): 558–566.

Bossen C, Pine KH, Cabitza F, Ellingsen G and Piras EM (2019a) Data work in healthcare: An Introduction. *Health Informatics Journal* 25(3): 465–474.

Bossen C, Chen Y, and Pine KH (2019b) Information infrastructures in healthcare and emergent data work occupations: The case of medical scribes and CDIS. *InfraHealth 2019: 7th International Conference on Infrastructures in Healthcare*, Vienna, Austria, 30-31 May 2019: 1–10. European Society for Socially Embedded Technologies (EUSSET).

Devault ML (2006) Introduction: What is Institutional Ethnography? *Social Problems* 53(3): 294-298.

Dhatterwal JS, Kaswan KS and Kumar N (2023) Robotic process automation in healthcare. In: Bhattacharyya S, Banerjee JS and De D (eds) *Confluence of Artificial Intelligence and Robotic Process Automation*. Singapore: Springer Nature Singapore, pp. 157–175.

Edwards PN (2010) *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge: MIT Press.

Edwards P, Mayernik M, Batcheller A, Bowker G and Borgman C (2011) Science friction: data, metadata, and collaboration. *Social Studies of Science* 41(5): 667–690.

Essex R, Kennedy J, Miller D and Jameson J (2023) A scoping review exploring the impact and negotiation of hierarchy in healthcare organisations. *Nursing Inquiry* 30: e12571.

Fernandez D and Aman A (2018) Impacts of Robotic Process Automation on Global Accounting Services. *Asian Journal of Accounting and Governance* 9:123–132.

Graham S and Thrift N (2007) Out of order: Understanding repair and maintenance. *Theory, culture & society 24*(3): 1–25.

Hindel J, Cabrera LM and Stierle M (2020) Robotic process automation: Hype or hope? *15th International Conference on Wirtschaftsinformatik*, 8-11 March 2020: 1750–1762. Potsdam, Germany.

Hofmann P, Samp C and Urbach N (2020) Robotic Process Automation. *Electronic Markets* 30(1): 99–106.

Hoeyer K (2023) *Data Paradoxes: The Politics of Intensified Data Sourcing in Contemporary Healthcare*. Cambridge: The MIT Press.

Jackson SJ (2014) Rethinking Repair. In: Gillespie T, Boczkowski P and Foot K (eds) *Media Technologies: Essays on Communication, Materiality and Society*. Cambridge: MIT Press, pp. 221–240.

Kaitosalmi J and Ratia M (2024) Evaluating Healthcare Automation: A Multi-Case Study on the Utilization of Automation Initiatives in Healthcare Operations. In: *International Conference on Knowledge Management and Information Systems*, Porto, Portugal, 17-19 November 2024: 246–255. Sétubal: SciTePress .

Kedziora D and Smolander K (2022) Responding to Healthcare Emergency Outbreak of COVID-19 Pandemic with Robotic Process Automation (RPA). In: *Proceedings of the 55th Hawaii International Conference on System Sciences*, 2022: 6207–6216. University of Hawaii at Mānoa: ScholarSpace.

Kedziora D, Siemon D and Sharda R (2024) 'Leanbotics' Case – Exploring Inclusive Synergies Between Robotic Process Automation (RPA) and Process Improvement. In: *Proceedings of the 57th Hawaii International Conference on System,* 2024: 1628–1637. University of Hawaii at Mānoa: ScholarSpace.

Kirchmer M, Franz P and Bathmaker D (2019) Value-Driven Robotic Process Automation - Enabling Effective Digital Transformation. A process-led approach to fast results at minimal risk. In: *Business Modelling and Software Design Proceedings,* July 2019: 2–28. BPM-Discipline Assets, London, Philadelphia.

Kiseleva A, Kotzinos D and De Hert P (2022) Transparency of AI in Healthcare as Multilayered System of Accountabilities: Between Legal Requirements and Technical Limitations. *Frontiers in Artificial Intelligence* 5:879603: 1–21.

Kitchin R (2014) *The Data Revolution: big data, open data, data infrastructures and their consequences*. London: Sage.

Lahtinen L, Mahlamäki T and Myllärniemi J (2023) Benefits and Challenges of Robotic Process Automation. In: *Proceedings of the 15th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management,* 2023: 249–255. Setúbal: Science and Technology Publications, Lda.

Laki Terveyden ja hyvinvoinnin laitoksesta 668/2008.

Latour B (1987) *Science in action: How to follow scientists and engineers through society.* Cambridge: Harvard University Press.

Leino H and Åkerman M (2021) The politics of making Finland an experimenting nation. *Critical Policy Studies* 16(4): 441–459.

Loi M and Spielkamp M (2021) Towards accountability in the use of artificial intelligence for public administrations. In *Proceedings of the 2021 AAAI/ACM Conference on AI, Ethics, and Society* (AIES '21), 19–21 May, 2021: 757–762. Association for Computing Machinery, New York, NY, USA.

Lotringer, S. and P. Virilio (2005) *The Accident of Art*. New York: Semiotext(e).

Ministry of Social Affairs and Health (2024) Strategy for digitalisation and information management in healthcare and social welfare. *Publications of the Ministry of Social Affairs and Health* 2024:1. Available at: http://urn.fi/URN:ISBN:978-952-00-5404-5 (accessed 23.10.2024).

Mol A, Moser I and Pols J (2010) Care: putting practice into theory. In: Mol A, Moser I and Pols J (eds) *Care in Practice: On Tinkering in Clinics, Homes and Farms. Care in Practice*. Bielefeld: transcript Verlag, pp.7–27.

Morrison C, Jones M, Jones R and Vuylsteke A (2013) 'You can't just hit a button': an ethnographic study of strategies to repurpose data from advanced clinical information systems for clinical process improvement. *BMC Medicine* 11:103.

Patrício L, de Sousa Costa CR, Varela L and Cruz-Cunha MM (2024) Literature review on the sustainable implementation of Robotic Process Automation (RPA) in medical and healthcare administrative services. *Procedia Computer Science* 239: 166-176.

Pelizza A (2016) Disciplining change, displacing frictions. Two structural dimensions of digital circulation across land registry database integration. *Tecnoscienza* 7(2): 35–60.

Pinch TJ (1992) Opening Black Boxes: Science, Technology and Society. *Social Studies of Science* 22(3): 487–510.

Ratia M, Myllärniemi J and Helander N (2018) Robotic Process Automation - Creating Value by Digitalizing Work in the Private Healthcare? In*: Proceedings of the 22nd International Academic Mindtrek Conference,* 10-11 October 2018: 222–227. Association for Computing Machinery, New York, NY, USA.

Smith D E (1987) *The Everyday World as Problematic: A Feminist Sociology*. Maidenhead: Open University Press.

Sosiaali- ja terveysministeriö (2012) *Potilasasiakirjojen laatiminen ja käsittely. Opas terveydenhuollolle*. Sosiaali- ja terveysministeriön julkaisuja. Tampere: Tampereen yliopistopaino.

Sosiaali- ja terveysministeriö (2018) *Kokeilukulttuurin kehittyminen on hyvässä vauhdissa*. Valtioneuvoston selvitys- ja tutkimustoiminta. Available at: https://stm.fi/-/10616/kokeilukulttuurin-kehittyminen-on-hyvassa-vauhdissa (accessed 23.10. 2024.)

Star SL (1999) The ethnography of infrastructure. *American Behavioral Scientist* 43(3): 377–391.

Stock R M and Nguyen MA (2019) Robotic Psychology. What Do We Know about Human-Robot Interaction and What Do We Still Need to Learn? *Proceedings of the 52nd Hawaii International Conference on System Sciences,* 2019: 1936–1945. University of Hawaii at Mānoa: ScholarSpace.

Tanweer A, Fiore-Gartland B and Aragon C (2016) Impediment to insight to innovation: understanding data assemblages through the breakdown–repair process. *Information, Communication & Society* 19(6):1–17.

Tomalin M (2023) Rethinking online friction in the information society. *Journal of Information Technology* 38(1): 2–15.

Venigandla K (2022) Integrating RPA with AI and ML for Enhanced Diagnostic Accuracy in Healthcare. *Power System Technology* 46(4): 33–42.

Vikkelsø S (2005) Subtle redistribution of work, attention and risks: Electronic patient records and organisational consequences. *Scandinavian Journal of Information Systems 17*(1): 3–30.

Wajcman J (2017) Automation: is it really different this time? *The British journal of sociology 68*(1): 119–127.

Notes

1 Hereafter, the wellbeing services county is referred to as the organisation, in order to avoid repeating a complex name and to refrain from using an abbreviation.

2 Main users of information systems typically perform their administrative tasks related to system use alongside their primary duties as nurses, ward secretaries or, in some cases doctors. These tasks may include managing access rights within their unit and providing user support and guidance on system use.

Maintaining and Repairing the Cancer Registries' Regime of Knowing in the Turbulent Context of the French National AI Strategy

François Lambotte
LASCO, UCLouvain, Belgium/francois.lambotte@uclouvain.be

Anja Martin-Scholz
CERTOP, Université de Toulouse, France

Abstract

This ethnographic study investigates maintenance and repair practices that underpin the data work of French cancer registries (CR) amid transformations in healthcare data governance driven by France's national AI strategy. CRs' mission is to provide high-quality data to assess public health policies. Through three cases of breakdown, we analyse repair practices in relation to the regime of knowing encompassing practices, value schemes, and authority arrangements. Drawing on this lens, our empirical study extends repair studies by showing how care, expertise and power relations are intertwined within CRs' repair work. When faced with governance transformations, our findings show how CRs resist these shifts and seek to maintain the regime of knowing to sustain their legitimacy within the healthcare data infrastructure. The study highlights how CRs' restoration efforts seem to fail and points to the need for CRs to move beyond repair to preserve domain-specific knowledge and public health values.

Keywords: Data Journey, Data Repair and Maintenance, Public Healthcare, French National AI Strategy, Cancer Registries, Regime of Knowing

Introduction

In 2018, France launched its national AI strategy (NAS) underpinned by three principles: data as a common good, data sharing, and the humanist ethos (Bareis and Katzenbach, 2022; Paltieli, 2022). Firstly, data should be a common good, a resource whose use and governance is defined by the community (Villani, 2018). Secondly, data sharing is conceptualised as a political virtue (Paltieli, 2022), with citizens consciously choosing to share their data for the benefit of the broader community. Thirdly, the NAS is rooted in the humanist ethos according to which AI innovations should be pushed into sectors that enable human flourishing (Bareis and Katzenbach, 2022). The strategy should therefore focus on sectors that serve the general interest, among which healthcare is central. Taken together, these three principles establish data governance, particularly in healthcare, as a central mechanism of the NAS. A concrete consequence of this was the creation of the Health Data Hub (HDH) "charged by law in 2019 with 'gathering, organising and making available the data of the national health data system mentioned in article L. 1461-1 of the public health code'" (Combes and Maquart, 2021: 4). From a strategic point of view, the HDH aims "to foster the development of AI projects and help improve quality of care" (Hogenhout, 2020: 39).

To understand the specific issues of this transformed healthcare data governance, we followed Hoeyer's (2016: 77-78) recommendation to focus on "everyday practices and to scrutinise the infrastructures facilitating data production and flow". Hence, in 2019 we initiated an ethnographic study with the objective of investigating the data work of two organisations responsible for cancer registries (CRs) in France. These organisations are tasked with the collection of nominative data concerning specific diseases (in this case, cancer) within a geographically defined population for research and public health purposes. The objective of the data work is to provide a comprehensive narrative of the care trajectory of individuals diagnosed with cancer. CRs play a pivotal role in the research activities of social epidemiologists who study the social distribution and determinants of health (Fianu et al., 2022), and data quality is a major concern for social epidemiologists. However, health data are rarely constructed for research purposes in the first place (Balka and Star, 2016; Pine and Bossen, 2020); in most cases, they are collected for purposes of diagnosis, treatment, and billing for treatment. CRs are in charge of the whole process (Leonelli, 2016) whereby data initially produced for treatment or economic reasons is recontextualised for scientific and public health purposes. To paraphrase Leonelli (2020: 9), this work occurs during the data journey, defined as "the movement of data from their initial sites of production [to the CR] in which they are processed, mobilised and re-purposed".

During our ethnographic work, we noticed that the data journey implies significant maintenance and repair work that is not only technical or material (Pink et al., 2018; Tanweer et al., 2016) but relates to political, economic, social, or normative elements constitutive of the socio-materiality (Bates et al., 2016) of the CRs. Hence, the journey highlights not only the specificity and complexity of the data work of CRs but also the rather unstable conditions in which the work is done. Taking these circumstances into account, our work seeks to understand the concerns of CRs about the creation of the HDH:; a direct consequence of the French NAS. CRs perceive this transformation of data governance as content-agnostic, treating data as a commodity (Ribes and Jackson, 2013) and wholly disregarding the specific domains of knowledge production (Alaimo and Kallinikos, 2022). Our ethnographic work shows how this transformation of health data governance has exacerbated the work of maintenance and repair. Consequently, we regard the transformation as having further weakened CRs in their ability to fulfil their public health mission.

To explain our empirical findings, we posit that the data work of CRs is specific to a domain of knowledge and thus draws heavily on a specific *regime of knowing* that encompasses "knowing practices through which actors develop and use knowledge; the valuation schemes through which actions, people, and things are evaluated; and the authority arrangements that determine which actors have control over how the work is performed in certain tasks" (Pachidi et al., 2021: 19). Moreover, we emphasise that repair and maintenance practices in healthcare data work extend beyond addressing technical issues to the ongoing preservation and restoration of the regime of knowing that supports the scientific and public health work of CRs at a time when that work is being shaken by the transformation of health data governance. From a theoretical perspective, we intend to show that combining the concepts of repair and maintenance with the regime of knowing helps deepen our understanding of how AI-driven transformation affects domain-specific knowledge practices.

In what follows, we first revisit the literature on data work in healthcare and present our theoretical framework, which combines the concept of regime of knowing with the concepts of repair and maintenance. In the empirical section, we draw on three cases of data maintenance and repair to describe the regime of knowing that sustains the data work of CRs. We then analyse how the transformation of health data governance (the creation of the HDH) has exacerbated the work of maintenance and repair.

Data work in healthcare

Bossen and colleagues define data work as any human activity related to creating, collecting, managing, curating, analysing, interpreting, and communicating data (Bossen et al., 2019: 466). Data work in healthcare has long been among the practices of diverse occupational groups in organisations working with information systems, including physicians, nurses, and administrative workers. The primary focus of these occupational groups is not data work. Scholars have questioned how healthcare practitioners have juggled data work in tension with their care practices (e.g., Mayère, 1990; Mathieu-Fritz and Esterle, 2013). Self-tracking devices have enabled patients, as well as healthcare professionals, to generate data (Kallinikos and Tempini, 2014; Ruckenstein and Schüll, 2017) and thus to participate actively in data work in healthcare. Studies have considered, for example, issues of power and control over patients through the data produced by wearable devices (Ruckenstein and Schüll, 2017), ambiguities in the meaning of the data produced by patients (Lomborg et al., 2020; Marent and Henwood, 2021), and the increasing work that contextualisation of those data implies for practitioners (Haase et al. 2023; Torenholt and Tjørnhøj-Thomsen 2022). Choroszewicz (2022) studied the place of emotional labour in the journey of data from their production to their repurposing for data analytics, highlighting the role played in data repair by care, frustration, and enthusiasm.

With the rise of big data, other data-focused occupations have grown in importance in healthcare organisations. These occupations are centred on data collection, structuration, curation, and validation. For example, Pine and Bossen conducted studies on the work of clinical documentation integrity (CDI) specialists, who monitor clinicians' data work to improve documentation. Their studies highlighted how CDI specialists translate clinicians' work to maintain the quality of coded data (Pine and Bossen, 2020); how CDI programmes coordinate the efforts of health organisations to maintain the quality of coded data for comparison, benchmarking, and quality reports (Pine et al., 2023); and the use of human–AI collaboration to facilitate coding (Bossen and Pine, 2023).

Data work draws on an increasingly complex network of distributed actors, both human and non-human. To map the actors of the data journey, Bossen et al. (2019) considered the different 'orders' present in reused data. For example, data that were produced initially to monitor patient treatment protocols and the healing process can have a second-order purpose in the billing process and then be reused to populate a database on cancer. All these data usages create interdependencies among the actors, entities, and artefacts that progressively create a data infrastructure with a variety of socio-technical issues. To our knowledge, few studies have focused on the maintenance work carried out on the ground (Bossen et al., 2019) by data workers in second- or third-order organisations.

Data work as a practice sustained by a specific regime of knowing

The data of CRs are set in the domain of social epidemiology. This domain of knowledge refers to "specific categories and rules, validation procedures, checks, methods, etc., as well as work profiles and experts" (Alaimo and Kallinikos, 2022: 25). These different elements compose what Pachidi and colleagues (2021) call a regime of knowing, which includes specific knowing practices of data workers, schemes of values, and authority arrangements.

First, *knowing practices* are the actions and methodologies employed by actors to develop and utilise knowledge within a specific domain (Alaimo and Kallinikos, 2022). For data workers, these are the activities through which they acquire the competencies and knowledge essential for performing their tasks. The knowing practices of data workers are constituted through training, interactions with peers, and accumulated experience, but also by the tools and methods that actors use to work on data. Second, these practices draw on certain *schemes of values* that determine which information matters and through which methods it should be acquired. Data processing and movement are value-laden (Fiore-Gartland and Neff, 2015; Leonelli and Tempini, 2020). In a hospital, for example, data workers draw on values such as the financial sustainability of the hospital to justify or legitimise their actions in improving clinical documentation or maximising reimbursements (Pine and Bossen, 2020). As we show in our empirical data, CR data workers draw on specific values such as the representativity of the database, especially in relation to minority groups that are often overlooked in the system. Third, *authority arrangements* are "the sanctioned ways to organise, affording power to actors whose expertise is highly valued, to impact how they and others engage in their work" (Bourgoin et al., 2020, cited by Pachidi et al., 2021: 21). Analysis of authority arrangements facilitates understanding of the distribution of power and resources among the constituents of the data ecosystem, including the question of who has access to data and who has the authority to determine how data should be transferred, decontextualised, and/or recontextualised. For Pachidi and colleagues (2021), authority arrangements are intimately associated with the value scheme employed to evaluate who has the requisite skills and expertise to undertake a task. The *regime of knowing* thus offers a means of valuation to highlight "the deeper challenges arising from the emergence of algorithmic technologies, related not only with how we know, but also with which ways of knowing are more valuable and who determines that" (Pachidi et al., 2021: 39). Moreover, a regime of knowing becomes particularly visible during major transformations, such as technological innovations, that give rise to power struggles among actors seeking to protect or transform elements of the regime of knowing.

As our ethnographic work will demonstrate in the case of CRs, the regime of knowing sustains the data journey from hospitals, laboratories, and insurance systems to the registries, enabling the production of meaningful social-epidemiological knowledge. Moreover, we show that it is not only the data that require repair and maintenance; when disrupted by the creation of the HDH, the regime of knowing itself is the primary object of these efforts. By disregarding domain-specific logics, the new governance model exacerbates the challenges that CRs face in fulfilling their social-epidemiological mission.

Data work as a practice of repair and maintenance

We adopt the standpoint of authors such as Denis and Pontille (2015: 8), who see "maintenance and repair as deeply inscribed in a logic of care that starts from decay and vulnerability instead of denying them (Tronto, 1993)". In studies of maintenance and repair, it is a matter of considering the order of things, part of the social order, as the ever-vulnerable result of an endless process of correction and repair (Denis et al., 2015; Hoeppe, 2020). Jackson (2014: 221) presents this as "an exercise in broken world thinking" that takes for granted the normality of erosion, breakdown, and decay, rather than of novelty, growth, and progress. Jackson (2014: 221) advocates "an appreciation of the real limits and fragility of the worlds we inhabit—natural, social, and technological". This approach shifts the focus from innovation, often described as a heroic moment that leads to success (Denis and Pontille, 2022), to how innovation is often conceived during repair and maintenance and cannot be consolidated or sustained without them.

In light of these considerations, it is appropriate to consider repair as a process "of accompanying things over time and ensuring that they persist beyond, below, the ruptures" (Denis and Pontille, 2020: 3, our translation). In this respect, things are 'not put back in order' but rather undergo a transformation to a state of 'working order' (Henke and Sims, 2020). As Jackson (2014: 223) states, "the world is always breaking; it's in its nature to break. That breaking is generative and productive […] always being recuperated and reconstituted through repair". Henke and Sims (2020: 4) elucidate the point: "Repair work is not always about directly fixing. [It is also] associated with broader discussions and arguments about what needs to be repaired, how it should be repaired, and even whether it is actually broken in the first place". The concept of repair extends beyond mere technical fixes to encompass the intricate dynamics of infrastructures, organisational systems, and interpersonal relationships, as articulated by Henke (2019).

Repair concerns the "subtle acts of care by which order and meaning in complex socio-technical systems are maintained and transformed, human value is preserved and extended, and the complicated work of fitting to the varied circumstances of organisations, systems, and lives is accomplished" (Jackson, 2014: 222). According to Denis and Pontille (2022), this notion returns to the foreground matters that seemed to be taken for granted, as well as the fragility of the basis on which they rest. Nevertheless, the notion of repair tends to assume that it is only a question of putting things back in order, sometimes neglecting how things are transformed through repair. Denis and Pontille regard repair as reducible to a single moment, namely the saving act. However, maintenance activities tend to focus not on an event but rather on small gestures that are fully part of existence and even vital to the stability of the relationships that humans have with most objects (Denis and Pontille, 2022: 48). Accordingly, these authors propose a distinction between repair and maintenance on the grounds that "they do not refer to exactly the same problems" (Denis and Pontille, 2022: 37, our translation). They thus argue for taking repair into account only as one of the many elements that punctuate maintenance, in that it makes things last. Similarly, Henke and Sims (2020) present a perspective on maintenance work as one end of the continuum of repair work.

In this debate, we take a position that distinguishes between repair and maintenance, although we perceive these activities to be situated on a continuum (Reiss-Sorokin, 2023). Repair is associated with breakdowns and accidents (Denis and Pontille, 2022). It signifies a unity of action and time, often involving "heroic efforts" (Henke and Sims, 2020) and a change of state (Denis and Pontille, 2022), and it is a reaction to an external event (Reiss-Sorokin, 2023). Conversely, maintenance entails prevention, anticipation, planning, and scheduling of actions (Reiss-Sorokin, 2023), regarded as business as usual (Denis and Pontille, 2022), hidden and mundane (Henke and Sims, 2020). This distinction emphasises that data work occasionally entails repair or maintenance: repair when data are absent or when a disruption in the infrastructure necessitates workarounds or improvisation (Schubert, 2019); and maintenance to prevent breakdowns, ensure data quality, and so on.

As we will demonstrate in the following case studies, the identification and prevention of such breakdowns are of equal importance to the repair of data itself. The integration of these two activities into a unified framework facilitates the demonstration of their interconnection and interaction in, for instance, the way maintenance activities can facilitate the identification of failures that require repair, or the manner in which repairs can be executed to enable access to data required for maintenance purposes.

Few studies have investigated data work as maintenance and repair of data. Through their research, Tanweer and colleagues (2016) developed a framework for understanding the breakdown/repair process of broken data. They argued that breakdowns and repairs can be understood as part of a larger process of data assemblage. Data assemblages are collections of data, tools, and practices that are used to produce knowledge. The authors contended that breakdowns and repairs are essential parts of the data assemblage process, as they allow the identification and correction of errors, the improvement of data quality, and the generation of new knowledge. Pink and colleagues (2018) presented the concept of broken data, arguing that data are not always clean and orderly collections of facts, but can be messy, incomplete, or broken.

In studies relating to healthcare data work, Schwennesen (2019) investigated patients' and professionals' efforts to repair broken data in order to make algorithms work. Bossen and Bertelsen (2023) reported that maintenance, cooperation, data quality assurance, and analysis are the most prevalent tasks of data workers. In their inquiry on the repair and correction of data relating to Covid-19, Boisson and Denis (2024) highlighted the work carried out by the 'lower-up' services that is often invisible and far from the heroic figures portrayed in the media.

To sum up, we consider that focusing on the repair and maintenance of the regime of knowing that sustains data work is particularly useful for understanding what people who take care of data through repair and maintenance are attached to and try to sustain in their everyday practices when confronted with major transformations. This approach gives a socio-technical thickness to data and data work by moving away from a standpoint where data are essentialised and their fabrication unquestionable, as if merely assembling and utilising them were enough (Marent and Henwood, 2021). It emphasises the vulnerability and fragility of data, the contingencies that condition their existence, and any factor that can affect their assemblage and processing into meaningful information. Thus, it provides a framework that deepens our understanding of the concrete consequences of national AI strategies on public health systems.

An ethnography of the data work of two French cancer registries

This research draws on ethnographic work carried out in organisations responsible for producing registers in two of the 101 departments (administrative divisions) of France, referred to here as H and T. CRs are typically non-profit organisations headed by a social epidemiologist who oversees the work of investigators responsible for collecting data from various sources and coders who code it in the registry databases. The registries fulfil a dual mission: monitoring cancer incidence and mortality rates within specific geographical areas, and conducting studies and research based on their data to evaluate care trajectories, prevention campaigns, and the influence of social inequalities on incidence and survival rates. In France, registries usually assess cancer incidence at the department level, and the departmental registries are either specialised for a type of organ (e.g., digestive system, thyroid) or general (i.e., like registre-cancers-44-85.fr, they record all cases of cancer in individuals residing in a department, irrespective of age or organ affected). Both the registries we investigated are general registries. The present research focuses on the data journey where data originating from several sources are repurposed in order to achieve the registries' double mission. Hence, we do not cover the processes of interpretation and knowledge creation that follow the creation of a registry.

Our ethnographic work started with researchers specialised in the use of epidemiological data. We conducted three interviews of 3 hours each to better understand the role of data in the domain of public health expertise. The interviews also contributed to our understanding of the current assemblage of organisations producing data in the French public health ecosystem. The epidemiologists who participated had been the first to raise concerns about the creation of the HDH. This exploratory work led us to focus on CRs. Within the two registries investigated, we conducted semi-structured interviews with epidemiological physicians (four interviews of around 2–3 hours each) and supervisors of the regional network of oncology (three interviews of 2–3 hours each). We shadowed investigators and coders in charge of data production and processing in the two registries (11 hours in total) and observed two meetings where the maintenance of the registry was debated (3.5 hours in total). We also collected a set of documents including the manuals used to support coding work and the record sheets used to encode patient data. This fieldwork took place over a period of 3 years from 2019 to 2021.

We analysed the data iteratively, drawing on an inductive approach in a double movement of zooming in and zooming out (Nicolini, 2009). Zooming out shed light on the complex ecosystem in which CRs are inscribed and the political, economic, and social elements at stake in the health data fabric (Martin-Scholz et al. , 2021): What are the interdependencies and power struggles among organisations in the data journey? What are the potential sources of breakdown? Zooming in, we paid particular attention to the activities (Delcambre, 2009) of investigators at the core of the registries and their data work: What are the different tasks needed to find, gather, and assemble the data? What are the breakdowns and in what circumstances do they occur? What are the maintenance and repair activities that follow and how do they relate to tensions and power struggles in the ecosystem?

This analytical approach helped us to reconstitute the data journey from the sites of production to the CR. As Bates and colleagues emphasised, the notion of journey symbolises "the disjointed breaks, pauses, start points, end points and frictions" that the process introduces (Bates et al., 2016: 4). Following Edwards (2013, cited by Bonde et. al 2019: 559), we paid particular attention to data frictions denoting "the costs in time, energy, and attention required simply to collect, check, store, move, receive, and access data".

Through our analysis, four cases of breakdown/repair/maintenance emerged, of which we chose to explore three. (The fourth case, around a treatment protocol, was set aside because of a lack of empirical data.) The case studies highlight that sources of breakdown are not limited to technicalities and that breakdowns occur not only at the level of data but also in the 'pipes' between the registries and the diverse organisations that the data originate from. Presenting our emerging results at conferences and seminars led us to enrich our theoretical framework, reiterate our analysis, and deepen our understanding and interpretation with the concept of the regime of knowing.

The results are presented in two sections. First, we describe the data work undertaken by CRs and unpack the knowing practices, values, and political arrangements that sustain the data journey. Second, we analyse how various events associated with the transformation of health data governance have shaken this regime of knowing and necessitated additional repair work for CRs.

The regime of knowing of French CRs

Figure 1 shows how the data journey is presented in official documents. The process consists of four

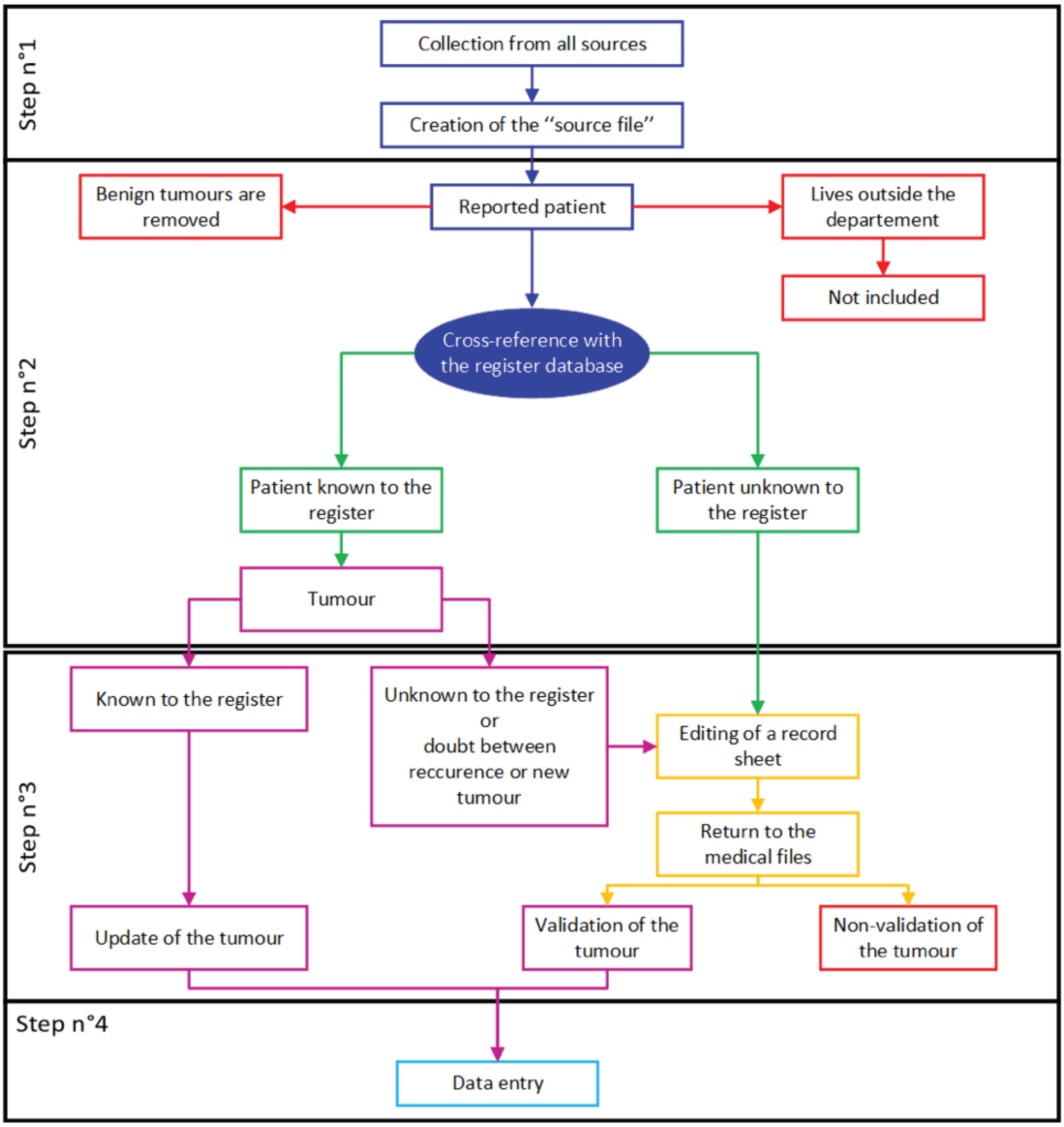


Figure 1. Case validation process (source: file for the evaluation of the H registry).

steps. In Step 1, the CR receives batches of files from source organisations (mostly hospitals and labs). In Step 2, they check the reported patient file. If the tumour is benign or if the person is from another geographical department, the file is removed. In Step 3, the remaining files are cross-checked with the CR database. If the patient is known, the CR has to verify whether the tumour is new or has already been encoded. If the patient is unknown or the tumour is new, they create a record sheet. Finally, in Step 4, data are encoded or updated.

The representation of the data journey in Figure 1 gives a false impression of linearity and automation in the CRs. In fact, our ethnographic work showed that this scheme encapsulated a much more complex mapping of the actors and data that participate in the CR data journey (see Figure 2). We will use this figure in the analysis of the three cases of maintenance and repair work within CRs.

The definition of data quality in the CRs is based on the accuracy of the data collected, their completeness for a sample of recorded cases, and the exhaustiveness of cases recorded for a given geographical area. Although the CRs attempt to register all cases of cancer for a given department, insufficient resources mean they are not able to record all the information about each patient. Hence, they focus their efforts on entering complete information on the stage of cancer development and the treatment protocols for a sample of 10 per cent of cases per year. A central value in public health studies, namely that in incidence analyses for a given type of cancer the sample should be representative of the broader population, implies making considerable efforts to reach marginalised populations for whom data are difficult to access. Consequently, the CRs prioritise not only the completeness of the data but also the completeness and uniqueness of the cases registered. This is achieved by dedicating ample work and attention to repair and maintenance of data.

Case 1: Repairing identity and location data

To ensure quality and consistency, for each new case encoders pay particular attention to the person's identity to avoid duplicate or erroneous encoding in the registry's database. Many countries rely on social security numbers to link health data across systems and to centralise health data (e.g., Denmark; Hoeyer, 2016). However, in France social security numbers cannot be used as identification keys to connect different databases (Lang, 2018). The different traces left by individuals in their various interactions with state-controlled structures or public services are split among databases with different identifiers and no reliable common denominator. Investigators use the patient's given name, surname at birth, date of birth, and address for identification purposes, but any of these elements can be broken: the date of birth may have been incorrectly recorded; the Insee (Institut national de la statistique et des études économiques) code identifying a city can be wrongly encoded (e.g., when two villages merge, the resulting municipality has a new Insee code); the patient may legally change their name (e.g., after marriage or naturalisation).

Investigators are allowed to cross-check identification data with Insee files and electoral lists (see Figure 2) that contain administrative details such as birth name, birth date, and current address. In some cases, the patient records are incomplete, with the postcode missing or not recorded by the CR investigator, but this information is required for purposes of deduplication and specific matching, such as associating cancer cases with a geolocalised socio-economic index. A breakdown due to the absence of this data affects the value of the CR data, as the cancer cases are then incomplete. The coders repair this by consulting other databases to find the missing information; they undertake the repair work knowing which data may be missing and where and how to find them.

For the CRs, exhaustiveness is different from completeness. Whether a registry is general or specialised, one of the main concerns of its researchers is to ensure the exhaustiveness of the cases recorded for a given area, in this case at the department level. The definition of the geographical area where cancers are registered is very important, both for ensuring that the area remains constant over time and for comparison with the population of that area. CR investigators pay particular attention to the address associated with the tumour at the time of diagnosis because

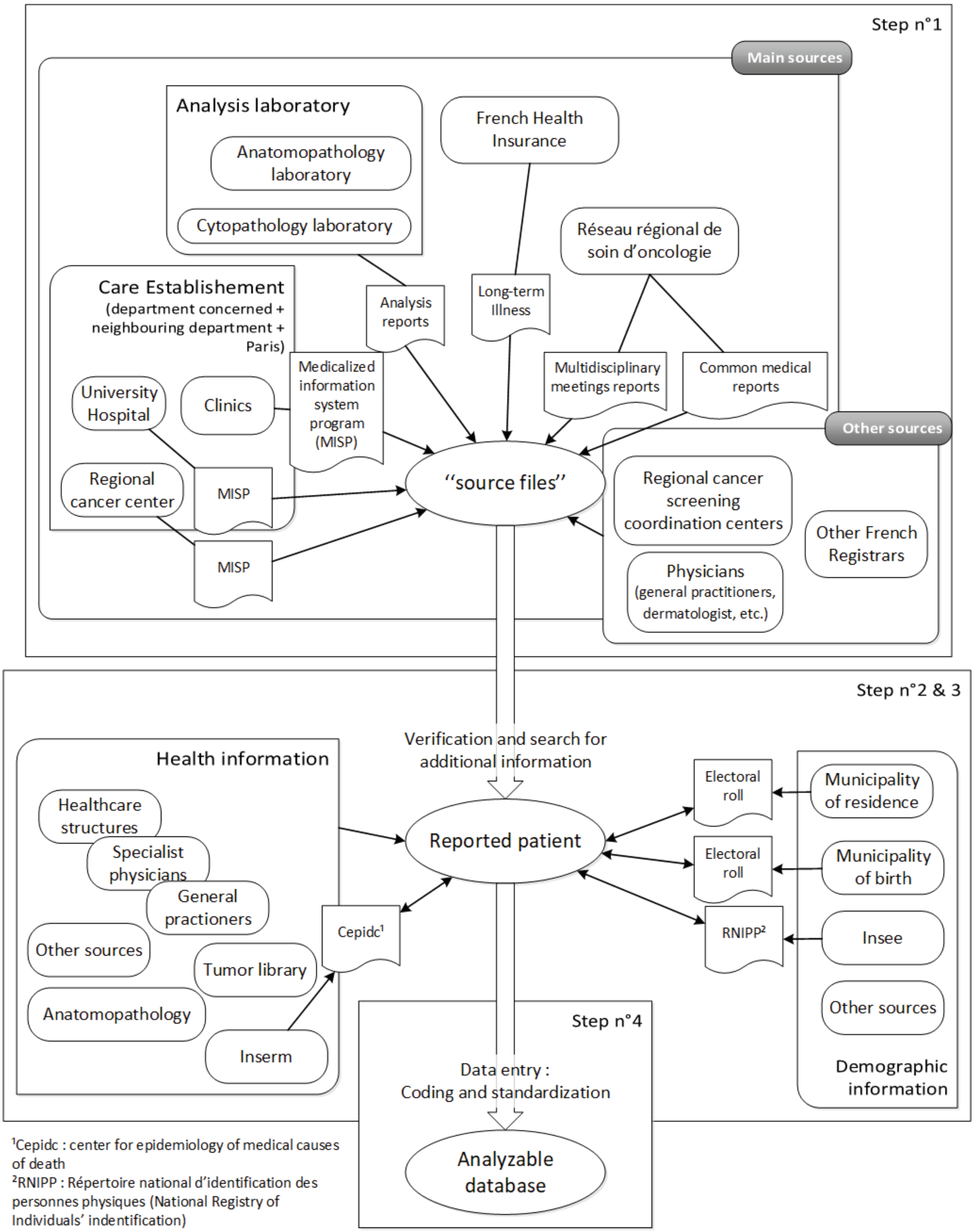


Figure 2. The complex ecosystem constituting the data journey of French CRs.

it enables socio-environmental impact studies to be carried out: Are patients in the area being exposed to a particular industrial pollutant? Does geographical remoteness influence compliance with a care protocol?

Mobility can also be a source of breakdown. For incidence studies, the CRs always encode the address linked to the diagnosis, and this address is linked to the cancer. Because CRs try to follow the evolution of the disease for each patient, they also need to keep a record of the patient's address. However, if a patient moves to another address, it becomes very difficult to follow them, and CR agents are aware of the biases and imperfections of the data they register.

> [Medical epidemiologist]: But knowing if they move is very complicated. That's why, in fact, […] we act when someone tells us that the address has changed.

This quote highlights a tension between the pursuit of completeness and accuracy in data collection and the limited resources available to investigators. This tension leads to the unfortunate circumstance where incomplete data, deemed less significant, are often completed on an opportunistic basis. This is not perceived as a breach by CR workers, as it does not hinder the functioning of the registers. Investigators are encouraged to exercise particular vigilance and to adopt an opportunistic approach to updating the addresses of previous cases as and when they are discovered fortuitously during the investigation of the year's cases in the patient files.

Case 1 illustrates that the process of repairing patient identity and location data is situated within a specific and constraining regime of knowing. CR agents conduct these repairs on the basis of their understanding of established practices, which enables them to identify what missing data to seek, where to locate them, and how to access them. They are compelled to balance the value system that defines the quality of the CR database against a set of constraints that includes the fragmentation of patient data across multiple sources and their own limited resources.

Case 2: Ensuring completeness and avoiding duplicate records

If a patient has been identified as having a cancer of a certain type in a certain year, their name is likely to reappear some years later if the cancer recurs. In such a case, the investigator must go back to the patient file to make sure that the tumour is a new cancer and not linked to the cancer recorded earlier.

> [Medical epidemiologist]: [When] a new cancer [gets reported] in the defined location, typically, a lady who has had cervical cancer. All went well in '90, then she comes back, we see her, and she's reported to us as carrying breast cancer in 2017. There was no previous history of breast cancer. On the other hand, if she had breast cancer in 1990 and now has a new breast cancer in 2017, so now, we're in the same topography, the same location. Our rules that are enacted at the international level are to look at the histological type, because there are groups. Tumours are classified. We know that they're the same tumours, the same group, so we're going to consider that if the 2017 tumour corresponds to the same histological type as the 1997 tumour, it's a recurrence of the 1990 cancer. On the other hand, if it's a different histological group, we'll consider it a new cancer diagnosis.

In order to avoid the occurrence of duplicates, CR workers check whether a new cancer case is a recurrence or a metastasis: they verify the date of diagnosis, the topography and location of the tumour, and the type of cancer cell. These data are not easily found and require a search of the patient's records and translation of medical information into cancer data that comply with international classification standards. In fact, medical information is produced in hospitals and laboratories to observe patients and their diseases from a perspective tailored to each domain. To align with the objectives of the CRs, the data must undergo processes of decontextualisation and recontextualisation carried out by the investigators who complete the files and by the encoders who read and interpret topographical and histological reports. These processes enable the repurposing of medical data and ensure the completeness and accuracy of the data produced for the CR.

Practically, the CR coders print record sheets (Figure 3) that are dispatched according to the care facilities and cancer topographies (Figure 4). These files are then distributed among the CR investigators, who collect and pre-code certain information by looking at patient files in the various facilities where patients are treated or where certain types of tumours are treated.

> [CR investigator]: For the pancreas, I've summarised everything on one page. And then there's all the details. In fact, it's because of what's behind it that I made myself a summary sheet to make it go faster.
> [Researcher]: You made your own summary sheets.

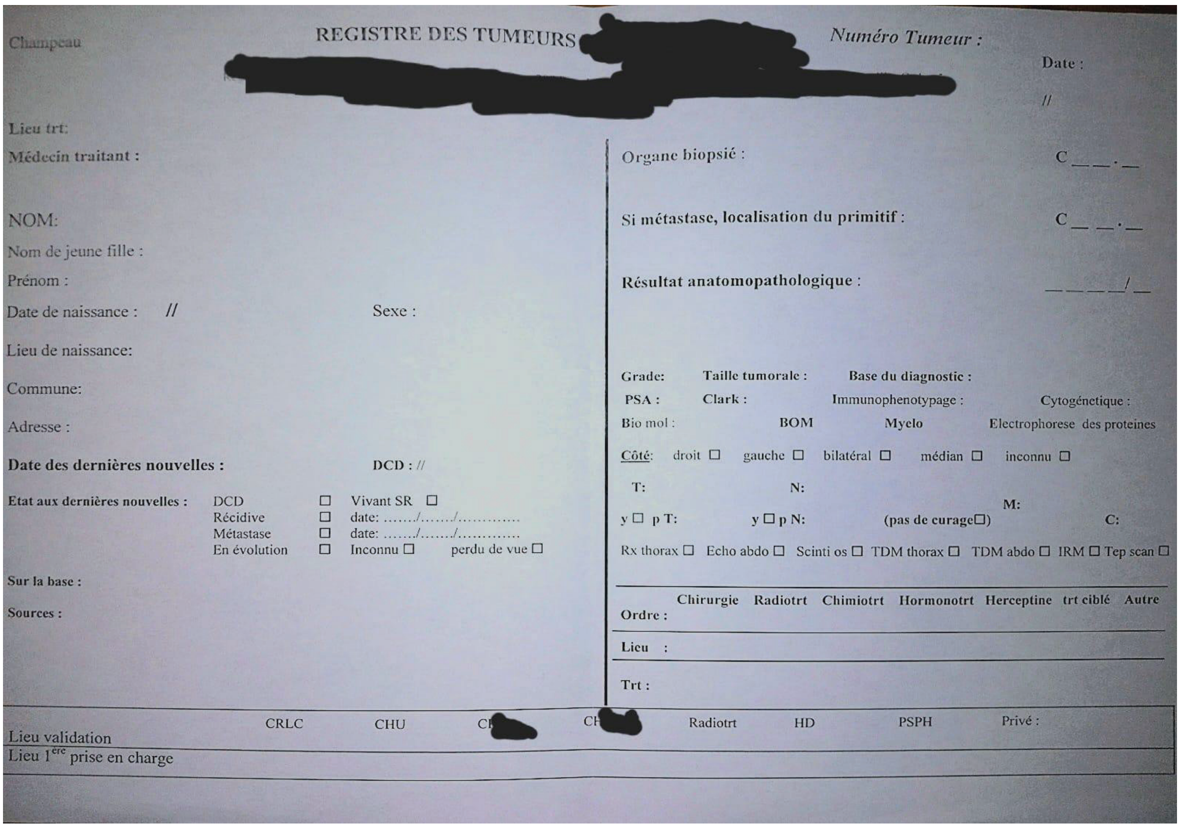
> [CR investigator]: Yes. So, when I go to the hospital, because we have a lot of them, I take these [the coding guide and its summary sheet] and if I'm doing pancreas, I get out my pancreas sheet and I do all the pancreas [cancer cases] at once. And I only need one thing. And if the next time I go for the liver, I take that out.

The investigators who collect data in the field have to know what the coders need. Similarly, the coders have to know what difficulties the investigators face in the field. Additionally, both the investigators and the coders have developed competencies for detecting inconsistencies in order to prevent data entry errors, as this interaction illustrates.

> [CR coder]: The diagnosis date doesn't match.
> [CR investigator]: Multidisciplinary meeting, University Hospital […] it's [other investigator], the University Hospital, I think … And what's wrong?
> [CR coder]: The diagnosis date doesn't correspond to the operation date. I think there's an error in the diagnosis date.
> [CR investigator]: Oh yes, that's okay … It's the 16th. Up there … [the patient] had the direct surgery … There was no surgery, so it's the biopsy.

As we can see in the extract above, the coder's daily work routine involves the maintenance of the CR database, with particular attention paid to the identification of inconsistencies as cancer cases are recorded, and the investigator must know where and how to look in the file to give thickness to the data to resolve discrepancies. In this particular instance, the coder identifies an apparent error and engages in a discussion with the investigator to ascertain whether it constitutes a breakdown. The basis of the discussion is the coder's and the investigator's shared knowledge of the practice.

Completing the record sheet also requires good knowledge of the organisation of hospitals and the ways data are acquired in their information systems, as well as good relationships with data owners. Hence, the CRs draw on a multiplicity of authority arrangements that connect them to hospitals, biopsy laboratories, and medical doctors, among others (see Figure 2), that produce data related to cancer patients and their socio-economic environment. These arrangements occur at different levels, from the national agreement between the registries network (Francim) and other national institutions, to indi-



Champeau

REGISTRE DES TUMEURS [redacted]

Numéro Tumeur :

Date :

//

Lieu trt:

Médecin traitant :

NOM:

Nom de jeune fille :

Prénom :

Date de naissance : //

Sexe :

Lieu de naissance:

Commune:

Adresse :

Date des dernières nouvelles :

DCD : //

Etat aux dernières nouvelles : DCD ☐ Vivant SR ☐
Récidive ☐ date: ……/……/…………
Métastase ☐ date: ……/……/…………
En évolution ☐ Inconnu ☐ perdu de vue ☐

Sur la base :

Sources :

Organe biopsié : C _ _ . _

Si métastase, localisation du primitif : C _ _ . _

Résultat anatomopathologique : _ _ _ _ / _

Grade: Taille tumorale : Base du diagnostic :
PSA : Clark : Immunophenotypage : Cytogénétique :
Bio mol : BOM Myelo Electrophorese des proteines

Côté: droit ☐ gauche ☐ bilatéral ☐ médian ☐ inconnu ☐

T: N: M:

y ☐ p T: y ☐ p N: (pas de curage☐) C:

Rx thorax ☐ Echo abdo ☐ Scinti os ☐ TDM thorax ☐ TDM abdo ☐ IRM ☐ Tep scan ☐

Ordre : Chirurgie Radiotrt Chimiotrt Hormonotrt Herceptine trt ciblé Autre

Lieu :

Trt :

Lieu validation CRLC CHU C[redacted] CH[redacted] Radiotrt HD PSPH Privé :

Lieu 1ère prise en charge

Figure 3. Record sheet for the H registry.

Figure 4. Cabinet containing the files to be investigated and patient files collected.

vidual arrangements designed to bypass the absence of a formal agreement. These arrangements are neither automated nor given but have to be maintained over time.

Case 3: Ascertaining and translating the stage of cancer for comparison purposes

To compare incidence and mortality rates in order to determine whether the number of cancers is increasing or decreasing from one year to the next, researchers must ensure that they are measuring the same things. The definitions on which the registration of a case of cancer is based are therefore aligned with internationally and nationally shared criteria.

> [Medical epidemiologist]: In fact, the [hospital] considers that it's a cancer for its own management, but we can't take it according to our own criteria, because we follow standard criteria, international standards … We must register a certain type of cancer, we have to register a certain benign tumour of the central nervous system, of the bladder, but we don't register everything.

To allow comparison, nationally or internationally, with other registries, the case registration must ascertain the diagnosis of cancer, the tumour's location, and the stage of the cancer, and code it according to the correct classification. However, hospital codes used by physicians draw on a nomenclature that is different to the oncology nomenclature used by the CRs, and the differences can create messiness in the codification of the cancer's stage.

The activity of coding and translation therefore requires a good knowledge of cancers and their specificities, as well as the ability to find information in patients' files and translate it using international coding standards. The following excerpt illustrates the knowing practices of an investigator who is explaining the use of annotated coding manuals to code the cancer stage using international nomenclature.

> [CR investigator]: With this, I have my coding [guide] for each topography and when I do the lungs, I take out my lungs folder and my coding [guides] [see Figure 5 and Figure 6] because the coding is totally different from one organ to another. So, there I have all my record sheets …
> [Researcher]: You annotate the guide progressively according to …?
> [CR investigator]: As things evolve. I've put some notes on [the front of the coding guide] because it's changed.

In this example, the CR investigator has translated the evolving guidelines into notes and used his know-how to determine what to look for and where to look to translate medical data into cancer stage codes. This illustrates how investigators' knowing practices evolve over time to meet the CRs' standards of accuracy as well as international norms ensuring comparability.

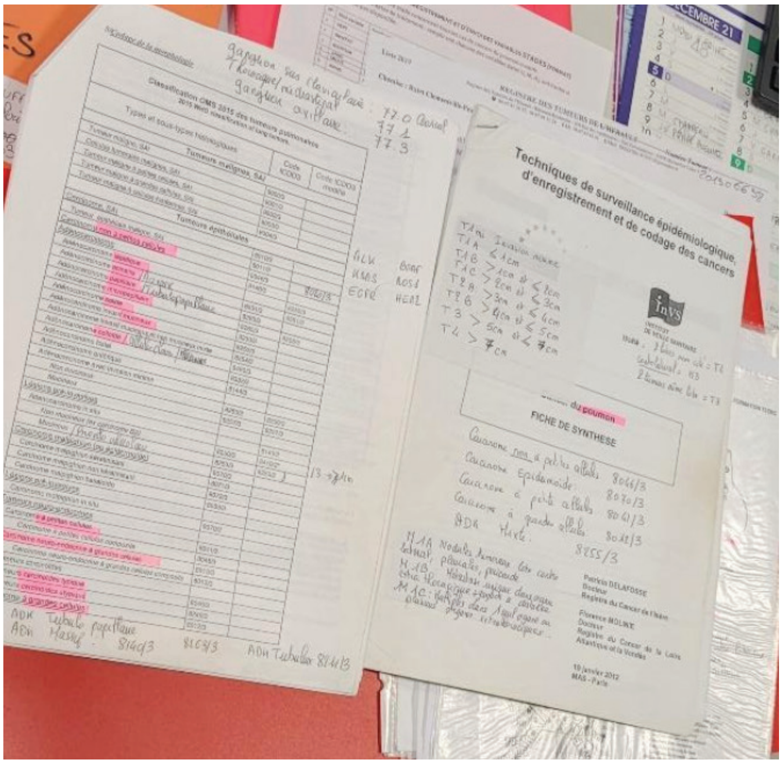


Figure 5. Coding guide 1 (lungs).

Overall, this data journey is taken care of by investigators and coders who draw on skills, scientific knowledge, methods, and tools to record all the cases of cancer in a given territory over a given period. The values of exhaustiveness, complete-

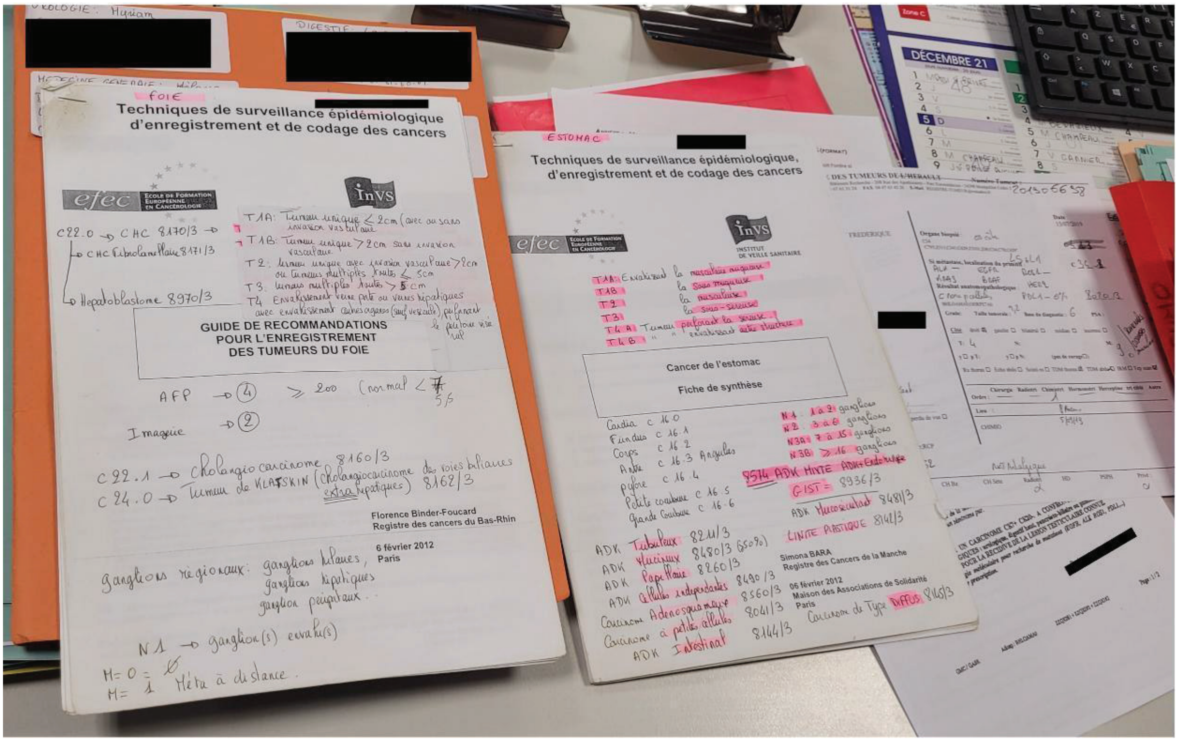


Figure 6. Coding guides 2 (liver, left) and 3 (stomach, right)

ness, accuracy, and comparability of recorded data drive the work of these investigators in achieving their mission. The CRs have built their authority and legitimacy on their methods of cross-checking and verification using multiple sources of data, which entails multiple agreements with source organisations. Their ability to preserve these agreements is dependent on their legitimacy as high-quality data providers who enable the production of scientific knowledge regarding public health issues, and on their belonging to an internationally recognised network of CRs.

How the transformation of healthcare data governance is shaking the CRs' regime of knowing

Access to sources of information (see the main sources in Figure 2) requires negotiations between the different organisations involved and is maintained over time through an ecosystem of fragile socio-technical relationships that are subject to constant threat and questioning according to socio-economic contingencies. Our empirical data reveal the fragility of the agreements that enable registries to collect and exploit data for public health purposes. Here, we analyse the fragilisation of the CRs' regime of knowing due to the transformation of health data governance that follows from the French NAS.

The turbulence started with the implementation of the General Data Protection Regulation (GDPR) in 2018, which triggered work to maintain the agreements with different sources of notification.

> [Medical epidemiologist]: So, we're negotiating now, like everyone else. Before, it was: "You'll come when the secretary isn't in, and you'll take her code to access the file". GDPR isn't really compatible with that. So, we're in the process of negotiating specific codes for the registry's investigators.

The creation of the HDH in 2019 as a central player in health data governance has made things even more complex for the CRs. By law, the HDH assumes the role of secretary of, the ethical and scientific committee for health research, studies and evaluations (CESREES) and facilitates procedures with the French data protection authority in charge of GDPR compliance (CNIL). The HDH has thus become an "obligatory point of passage" (Callon, 1984) for all data producers, including the CRs, thus complicating the negotiation of bilateral agreements.

Since 2021, the HDH is also responsible for the 'expanded' national health data system (SNDS), which no longer comprises only medico-administrative data but also data from registries, research cohorts, hospital data warehouses, and so on. These data are not centralised in a single file; instead, data producers are invited to share their data in a single 'HDH catalogue'. This expansion has created numerous tensions among data producers. In order to circumvent potential political difficulties with the HDH, the CRs have been transmitting restricted data sets to the HDH catalogue while retaining more precise and complete data for themselves. By this means, the CRs seek to safeguard the value of the data under their control, thereby supposedly sustaining the significance of their work and their authority over the data they produce.

> [Medical epidemiologist]: They [the HDH] had also approached the hospitals … Everyone has been tapping away. We're among those who give the least impression of having tapped on the sidelines, because nobody pointed out that those were the basic data that we already sent elsewhere [to the World Health Organization]. So, we didn't say anything. Santé publique France [the administrative body charged with promoting health at the population level] is well aware of this. The INCa [Institut national du cancer], too … We've kept some variables so we can say, "Oh well, no, if you need one more variable in your study, so it can't be the data of the Health Data Hub, it's ours you can use, but that's all".

However, the legitimacy and authority of the CRs as quality data providers is being contested. Recently, the registries' association lodged a formal objection regarding a misrepresentation of data by researchers of the SNDS, which is controlled by the HDH, in an article in a scientific journal concerning the quality of histological confirmation data:

> [Medical epidemiologist]: We [the registries] always give the histological confirmation rate of

> our patients. All the registries do this. The other European data were registry data, so the others had given their histological confirmation rates. The [author from the SNDS for the French data set] didn't bother, he just looked at it and said, "Ah 89, that won't hurt". He put in 89% [as the histological confirmation rate of our patients for the French data set]. This information does not exist in the SNDS.

The CR representatives were able to voice their concerns through a letter published in the journal. The purpose of this action was to defend the legitimacy and the quality of the data they produce, as explained in Case 2. However, they expressed scepticism about the letter's potential impact on the reputation and dissemination of the scientific article.

Repeated transformations in health data governance have thus generated additional maintenance and repair work that extends beyond the data itself. Increasingly, this work takes on a political-economic dimension, as the CRs seek to preserve access agreements with data sources and defend their legitimacy by invoking the domain-specific, high-quality nature of the data they produce. Nevertheless, they acknowledge that their capacity to safeguard the regime of knowing is constrained by their relatively weak position within the broader network of data governance actors. As we explain in the following example, the gradual transformation of the values that govern the production of health data has only accentuated the fragility of the registers.

Medical biology laboratories, despite their private status, are able to survive financially thanks to the financing provided by the health insurance industry, which largely reimburses the costs of biological examinations. The fees for each type of examination are determined by the health insurance industry and the Ministry of Health, enabling the latter to exert control over biological spending (Bienvault, 2019). In 2020, health insurance companies imposed savings of €170 million on spending in medical biology. Consequently, laboratories started a soft strike that resulted in a breakdown of access to their data by other institutions, including the registries. Following this strike, laboratories started to reorganise into larger groups, and this entailed a renegotiation of access to data.

> [Medical epidemiologist]: The problem is: our relationships … every time, we have to establish relationships with new structures. And when they join forces, we're faced with a new structure. For example, two labs in the T region are in the process of teaming up with the bad guys, so we don't really know how to proceed, because these people have always refused to transfer data to the registry. Whereas the two labs did so without any problem. So, we've been trying to get in touch with them for 6 months now.

To repair this breach caused by the reorganisation of labs (see Figure 2, Anatomopathological labs), the investigators have developed a tactical workaround: retrieving the medical biology reports by searching in the appendices of the patient files that are accessed in each hospital.

> [CR investigator]: I collect the anapaths from the [hospital centre] … I take all the binders; they're big binders and I take, I read, I look at the ADICAP[1]code, but I mostly read the minutes and when it's clear, I scan. I have a small computer with a portable scanner. And it gives results. Then, here, we have all the reports, just like that. Because they don't know how to make queries to give me all the names that match.

The ADICAP code does not directly indicate the stage of the cancer, but it is very important in determining the stage. To establish the stage, the CR investigator has to look closely at the anapath reports. This task may involve some discussion, especially with the medical epidemiologist, and the investigator must anticipate this and collect all the results to support it. As the access to anapath results has been compromised, the CR investigator must find another way to obtain this access. As it was not the hospital's job to provide access to anapath reports, there are no query tools to make it easier to find and collect them, making this repair work a tedious and time-consuming task.

The strike revealed that the data intensification resourcing movement (Hoeyer, 2019) has precipitated a shift in the prevailing value scheme, whereby the economic value of data as a bargaining chip prevailed over its value for therapeutic or scientific purposes. This illustration elucidates how disparities in data valences (Fiore-Gartland and Neff, 2015) engender concrete and unpleasant outcomes for the data work undertaken by CRs.

In this section, we have highlighted the additional repair work by the CRs on the prevailing regime of knowing that the transformation in the governance of healthcare data has triggered. We illustrate how this repair work concerns not only the data but also the political arrangements guaranteeing access to the data, the legitimacy of investigators as knowledgeable data workers, and the values of the data produced primarily for scientific and public health purposes.

Discussion

Our contribution to repair studies

Drawing on the regime of knowing, our empirical study extends repair studies by showing how care, expertise and power relations are intertwined within repair work. Although existing studies emphasise how each of these elements - care (Denis and Pontille, 2018; Jackson, 2014), expertise (Schubert, 2019; Henke, 2019), and power relations (Henke and Sims, 2020) - matter to understand repair, these studies do not question how their articulation advances our understanding of maintenance and repair. While Sims and Henke (2012) analyse repair articulating the material, institutional, and discursive as levers to negotiate infrastructure order, the concept of a regime of knowing provides us with an analytical angle that foregrounds what CRs care about and what it takes as technical, organisational skills and political arrangements to maintain or repair it.

The three cases presented in the first part of the analysis exhibit how the elements composing the regime of knowing sustain CRs data maintenance. Through their data work, CR members promote a specific conception of public healthcare and *the value scheme* (the representativity of the database, especially in relation to minority groups that are often forgotten in the system) that supports it. They are committed to their dual mission of providing high-quality data to assess current public health policies and to produce scientific research on prevention through testing, disparities in care trajectories, and health inequalities more generally. Thus, their practices draw heavily on the logic of care proposed by Jackson (2014: 232): "Care reconnects the necessary work of maintenance with the forms of attachment that so often (but invisibly, at least to analysts) sustain it. We care because we care". In order to achieve this mission, investigators have developed a *know-how*, a 'professional seeing' (Goodwin, 1995) that is highly specialised in the cancer research domain for collecting appropriate data and coding it according to international scientific standards. This work also requires the development of a socio-technical perspective (Neves et al., 2024) to access sources of notification in the field, to understand the practices of data work at the primary sources, and to detect potential breakages. Finally, it entails *agreements* with various sources of notifications and secondary sources for the validation of socio-demographic data. However, CR representatives do not perceive these agreements as unified and stable. Instead, they regard them as an "unsettled [and fragile] assemblage of partly unknown elements, constantly subject to external and internal disruptions" (Denis and Pontille, 2022: 288). This fragility gives rise to a further type of maintenance work of a political nature (Henke, 2019) that is required to preserve access to the various sources of data needed to constitute a registry's database while meeting its quality standards.

In the subsequent analysis, we highlight how the implementation of the French National AI Strategy (NAS) —via policy and resource allocation — has reshaped healthcare data governance, thereby destabilising the CRs' established regime of knowing. This transformation produces new uncertainties and attendant loss of control, leading to increased workloads and required improvisation (Schubert, 2019). Our findings contrast with the work of Jackson (2014) and Henke and Sims (2020) which tend to emphasise the transformative nature of repair. Instead, it reveals that CR experts resist these shifts and seek to maintain their increasingly fragile regime of knowing, aiming "to stabilize existing social and material relations with respect to a given infrastructure" (Henke, 2019: 272). In line with Sims and Henke (2012: 328), who argue that credibility is "a cultural and institutional process where everything from documents, methodologies, and scientific reputations come into play," we contend that

CR legitimacy is anchored in a regime of knowing. Thus, when registries repair their knowledge regime, they are simultaneously attempting to repair their legitimacy, existence, identity, and boundaries (Sims and Henke, 2012: 324).

Since the beginning of the implementation of the French NAS, CRs' regime of knowing has been challenged from all sides. In preparation for the GDPR, a number of bilateral contacts were initiated to prevent any disruption in the logic of maintenance. However, the establishment of the HDH as an 'obligatory passage point' (Callon, 1984) has substantially disrupted the pre-existing, often interpersonal ad hoc *arrangements* that existed between CRs and other institutions. It has led to unexpected political work involving the creation of a new authority agreement with the HDH. Arrangements to access data are also being reconsidered by the changing perception of data as a source of wealth. The French NAS-supported data intensification resourcing, which posits that data-driven innovation can catalyse economic growth, has precipitated a paradigm shift, underscoring the economic value of data in contemporary value schemes. This shift was revealed by the lab strike, which led to a renegotiation of the data-sharing agreements between private labs and other organisations. The resulting frictions (Bates et al., 2016) constrain the movement of data to and from CRs. When the arrangement with private labs breaks down, it is the access to data that is broken from a political point of view. This disruption in the flow of data necessitated a repair process on the part of the CR investigators, who devised a bypass for accessing data from hospital files. Such repairs rely on investigators' capabilities to locate the required data and their legitimacy in the eyes of nurses and hospitals facilitating access to the relevant files. However, their legitimacy is being eroded as other institutional players, such as the SNDS (controlled by the HDH), doubt their uniqueness in producing high-quality data. This leads them to question the need for CRs to provide data on cancer, given that the SNDS claims that its database already contains this information. CRs therefore face a dilemma: by withholding the full dataset through HDH, they seek to protect their assets and bargaining power; however, doing so limits their visibility and opportunities to demonstrate the distinctiveness of their data compared to other datasets.

Hence, restoring their regime of knowing to a "normal order" in the sense of Ureta (2014) entails an extra burden that seems useless, since the transformation of the French healthcare data infrastructure appears irreversible. Therefore, should the CRs recognise that their regime of knowing is irreparable and move beyond repair (Ureta, 2014 : 388)? In other words, should the CRs take this failure as an opportunity to move from a logic of maintenance to a more transformative one (Henke, 2019)? Future research is needed to determine whether CRs can adapt from one mode to another—thereby preserving their legitimacy in cases where exclusive data access is lost or where material and expertise are fundamentally altered by digitisation.

Our contribution to the field of healthcare data work studies

The present study responds to the call made by Bertelsen et al. (2024) for new theories to be introduced to the field of healthcare data work studies. The introduction of a new framework enables a thicker understanding of data work in healthcare, which cannot be reduced to production/collection/interpretation, and makes it possible to elaborate a description of the knowledge, values, and arrangements required to prevent data in healthcare from being broken, through maintenance or repair.

The study also contributes to the existing body of knowledge by offering an ethnography of data work in the French healthcare system. Research in this field is dominated by studies in countries considered leaders in the digitalisation of health, such as the Netherlands, Denmark, and Finland. The French ecosystem of healthcare data is fragmented and subject to numerous power struggles, which makes the sharing and centralisation of data difficult to achieve. The use of paper files in the CRs to retrieve data from hospitals exemplifies this fragmentation and its repercussions for CR data work. This may suggest that France is less advanced in the digitalisation of healthcare, or it may be perceived as a manifestation of democratic vitality, where the discourse surrounding data sharing and the inherent value of AI (Hoff,

2023) remains a subject of debate. Future research should address this debate.

Finally, we shed light on the activities on the ground (Bossen et al., 2019) of data workers in second- or third-order organisations that are less often investigated. In particular, we demonstrate the maintenance and repair efforts necessary to recontextualise data for cancer research purposes. Recontextualisation, as defined by Leonelli (2016: 194), is the process of rendering data comprehensible to researchers who are unfamiliar with them, making it possible to assess the evidential value of the data and utilise them for specific research endeavours. Haase et al. (2023: 526) delineated the evidential value of data as the extent to which they can be employed to substantiate a specific claim. It is clear that recontextualisation is an inherent aspect of the process by which data attain evidential value. Our findings are thus consistent with the conclusion of Torenholt and Tjørnhøj-Thomsen (2022) that recontextualisation necessitates professional competencies and experience, as well as collaboration with colleagues, to substantiate specific interpretations of data. Notably, however, our study builds on previous research by emphasising that recontextualisation constitutes a pivotal aspect of the data work conducted by CR investigators. Consequently, it cannot be disregarded, as is the case for general practitioners concerning data from patients' wearable devices (Haase et al., 2023). Instead, recontextualisation is a key element in the effort to repair and maintain data so as to secure their evidential value.

Conclusion

Throughout this ethnographic investigation, we have demonstrated that the work of CRs cannot be reduced to mere technological data management but must be understood as the ongoing repair and maintenance of a regime of knowing. We show that the maintenance of this regime entails painstaking work that includes political and institutional contingencies. All these efforts are made to ensure data quality and to preserve the legitimacy of CRs in the healthcare public health system. It is evident that the French ecosystem of healthcare data remains fragmented, and this context is likely to be a contributing factor to the additional repair work that we identified. Further research on registries in different countries, in less fragmented contexts, can offer a more comprehensive perspective on the findings.

Our study also provides a critical reflection on AI policies that frequently construe data production as content-agnostic (Alaimo and Kallinikos, 2022), thereby disregarding the labor that domain-specific knowledge production entails. As public health data governance evolves rapidly in the name of AI innovation, it is imperative to render visible the often-overlooked work of maintenance and repair that underpins data quality as defined within fields such as cancer research and social epidemiology. Health is not the only sector experiencing tensions between AI-driven innovation and the production of domain-specific knowledge. Future research might investigate these tensions in other contexts where human labor is central to the construction of data—for instance, in open-source knowledge repositories such as Wikipedia or Stack Exchange.

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References

Alaimo C and Kallinikos J (2022) Organizations Decentered: Data Objects, Technology and Knowledge. *Organization Science* 33(1): 19–37.

Balka E and Leigh Star S (2016) Mapping the body across diverse information systems: Shadow Bodies and How They Make Us Human. In: Bowker G C, Timmermans S, Clarke A E and Balka E (eds) *Boundary Objects and Beyond: Working with Leigh Star*. Cambridge: MIT Press, pp. 417–434.

Bates J, Lin Y-W and Goodale P (2016) Data journeys: Capturing the socio-material constitution of data objects and flows. *Big Data & Society* 3(2): 2053951716654502.

Bareis J and Katzenbach C (2022) Talking AI into Being: The Narratives and Imaginaries of National AI Strategies and Their Performative Politics. *Science, Technology, & Human Values 47*(5): 855-881. https://doi.org/10.1177/01622439211030007.

Bertelsen P S, Bossen C, Knudsen C and Pedersen A M (2024) Data work and practices in healthcare: A scoping review. *International Journal of Medical Informatics 184*: 105348. https://doi.org/10.1016/j.ijmedinf.2024.105348.

Bienvault P (2019) En grève, les laboratoires de biologie protestent contre la baisse de leurs tarifs. *La Croix*, 23 September. Available at: https://www.la-croix.com/Sciences-et-ethique/Sciences/En-greve-laboratoires-biologie-protestent-contre-baisse-tarifs-2019-09-23-1201049445 (accessed 3 November 2024).

Boisson M and Denis J (2024) Faire remonter les chiffres du Covid. *Revue d'anthropologie des connaissances 18*(4): 4.

Bonde M, Bossen C and Danholt P (2019) Data-work and friction: Investigating the practices of repurposing healthcare data. *Health Informatics Journal 25*(3): 558-566. https://doi.org/10.1177/1460458219856462.

Bossen C and Bertelsen PS (2023) Digital health care and data work: Who are the data professionals? *Health Information Management Journal*: 18333583231183083.

Bossen C and Pine KH (2023) Batman and Robin in Healthcare Knowledge Work: Human-AI Collaboration by Clinical Documentation Integrity Specialists. *ACM Transactions on Computer-Human Interaction* 30(2): 26:1-29. https://doi.org/10.1145/3569892.

Bossen C, Pine KH, Cabitza F et al. (2019) Data work in healthcare: An Introduction. *Health Informatics Journal* 25(3): 465–474.

Bourgoin A, Bencherki N and Faraj S (2020) "And Who Are You?" : A Performative Perspective on Authority in Organizations. *Academy of Management Journal*, *63*(4), 11341165. https://doi.org/10.5465/amj.2017.1335.

Callon M (1984) Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review* 32(1_suppl): 196-233. https://doi.org/10.1111/j.1467-954X.1984.tb00113.x.

Combes S and Maquart B (2021) *Charte responsable de données : Les engagements de la plateforme des données vis-à-vis de ses partenaires responsables des données*. Available at: https://health-data-hub.fr/sites/default/files/2021-04/Charte%20Responsable%20de%20Donn%C3%A9es-compressed.pdf (accessed 3 November 2024).

Choroszewicz M (2022) Emotional labour in the collaborative data practices of repurposing healthcare data and building data technologies. *Big Data & Society* 9(1): 20539517221098413.

Delcambre P (2009) L'activité d'évaluation et les systèmes d'information. L'évaluation est aussi un travail : langagier, assisté, organisé. Études de communication. langages, information, médiations (33): 79–100.

Denis J and Pontille D (2015) Material Ordering and the Care of Things. *Science, Technology, & Human Values* 40(3): 338–367.

Denis J and Pontille D (2020) Maintenance epistemology and public order: Removing graffiti in Paris. *Social Studies of Science* 51(2): 233–258.

Denis J and Pontille D (2022) *Le soin des choses: Politiques de la maintenance*. Paris: La Découverte.

Fianu A, Favier F, Naty N, et al. (2022) Analyse des déterminants sociaux pour concevoir une intervention de santé publique locale. *Revue d'Épidémiologie et de Santé Publique* 70: S166.

Fiore-Gartland B and Neff G (2015) Communication, mediation, and the expectations of data: data valences across health and wellness communities. *International Journal of Communication* 9: 1466-1484.

Goodwin C (1995) Seeing in Depth. *Social Studies of Science* 25(2): 237–274.

Haase C B, Ajjawi R, Bearman M, Brodersen J B, Risor T and Hoeyer K (2023) Data as symptom : Doctors' responses to patient-provided data in general practice. *Social Studies of Science 53*(4): 522-544. https://doi.org/10.1177/03063127231164345.

Henke C R (2019) Negotiating Repair : The Infrastructural Contexts of Practice and Power. In: Strebel I, Bovet A and Sormani P (eds) *Repair Work Ethnographies : Revisiting Breakdown, Relocating Materiality*. Singapore: Springer Nature Singapore, pp. 255-282. https://doi.org/10.1007/978-981-13-2110-8.

Henke C R and Sims B (2020) *Repairing Infrastructures : The Maintenance of Materiality and Power*. Cambridge: The MIT Press. https://doi.org/10.7551/mitpress/11771.001.0001.

Hoeppe G (2020) Sharing Data, Repairing Practices: On the Reflexivity of Astronomical Data Journeys. In: Leonelli S and Tempini N (eds) *Data Journeys in the Sciences*. Heidelberg: Springer Nature, pp. 171–190.

Hoeyer K (2016) Denmark at a Crossroad? Intensified Data Sourcing in a Research Radical Country. In: Mittelstadt BD and Floridi L (eds) *The Ethics of Biomedical Big Data*. Law, Governance and Technology Series. Cham: Springer International Publishing, pp. 73–93.

Hoeyer K (2019) Data as promise: Reconfiguring Danish public health through personalized medicine. *Social Studies of Science* 49(4): 531–555.

Hoff J-L (2023) Unavoidable futures? How governments articulate sociotechnical imaginaries of AI and healthcare services. *Futures 148*: 103131. https://doi.org/10.1016/j.futures.2023.103131.

Hogenhout E (2020) *Artificial Intelligence in Health*. Report commissioned by the Netherlands Enterprise Agency, December 2020.

Jackson SJ (2014) *Rethinking Repair. Media technologies: Essays on communication, materiality, and society*. Cambridge: MIT Press, pp. 221–239.

Kallinikos J and Tempini N (2014) Patient Data as Medical Facts: Social Media Practices as a Foundation for Medical Knowledge Creation. *Information Systems Research* 25(4): 817–833.

Lang T (2018) Histoire : Éléments pour une histoire du « Numéro de sécurité sociale ». *Statistique et Société* 6(1): 37–45.

Leonelli S (2016) The philosophy of data. In: Floridi L (ed) *The Routledge Handbook of Philosophy of Information*. London: Routledge, pp. 191-202.

Leonelli S (2020) Learning from Data Journeys. In: Leonelli S and Tempini N (eds) *Data Journeys in the Sciences*. Heidelberg: Springer Nature, pp. 1–26.

Leonelli S and Tempini N (2020) *Data Journeys in the Sciences*. Heidelberg: Springer Nature.

Lomborg S, Langstrup H and Andersen TO (2020) Interpretation as luxury: Heart patients living with data doubt, hope, and anxiety. *Big Data & Society* 7(1): 2053951720924436.

Marent B and Henwood F (2021) Digital health. In: Chamberlain K and Lyons A (eds) *Routledge International Handbook of Critical Issues in Health and Illness*. London: Routledge, pp. 261-275.

Martin-Scholz A, Mayère A, and Lambotte F (2021) Rendre compte du travail d'instauration et d'assemblage des données en santé : Le cas de Registres des cancers en France. *Communication et organisation* 59: 215-230. https://doi.org/10.4000/communicationorganisation.10195.

Mathieu-Fritz A and Esterle L (2013) Doctors and the Single Electronic Health Record. *Reseaux* 178179(2): 223–255.

Mayère A (1990) *Pour une économie de l'information*. Lyon: Éditions du CNRS.

Neves BB, Omori M, Petersen A, et al. (2024) Navigating Artificial Intelligence in Care Homes: Competing Stakeholder Views of Trust and Logics of Care. *Social Science & Medicine*: 117187.

Nicolini D (2009) Zooming In and Out: Studying Practices by Switching Theoretical Lenses and Trailing Connections. *Organization Studies* 30(12): 1391–1418.

Pachidi S, Berends H, Faraj S, et al. (2021) Make Way for the Algorithms: Symbolic Actions and Change in a Regime of Knowing. *Organization Science* 32(1): 18–41.

Paltieli G (2022) The political imaginary of National AI Strategies. *AI & SOCIETY 37*(4): 1613-1624. https://doi.org/10.1007/s00146-021-01258-1.

Pine KH and Bossen C (2020) Good organizational reasons for better medical records: The data work of clinical documentation integrity specialists. *Big Data & Society* 7(2): 2053951720965616.

Pine KH, Landon LA, Bossen C, et al. (2023) Innovations in clinical documentation integrity practice: Continual adaptation in a data-intensive healthcare organisation. *Health Information Management Journal* 52(2): 119–124.

Pink S, Ruckenstein M, Willim R et al. (2018) Broken data: Conceptualising data in an emerging world. *Big Data & Society* 5(1): 2053951717753228.

Ribes D and Jackson SJ (2013) Data Bite Man: The Work of Sustaining a Long-Term Study. In: Gitelman L (ed.) *Raw Data Is an Oxymoron*. Cambridge: MIT Press, pp. 147–166.

Reiss-Sorokin A (2023) Stewards of the Organization: The Management of Repair and Maintenance Work in Large Organizations. *Engaging Science, Technology, and Society* 9(3): 100–120. https://doi.org/10.17351/ests2023.1347.

Ruckenstein M and Schüll ND (2017) The Datafication of Health. *Annual Review of Anthropology* 46(1): 261–278.

Schubert C (2019). Repair Work as Inquiry and Improvisation : The Curious Case of Medical Practice. In: Strebel I, Bovet A and Sormani P (eds) *Repair Work Ethnographies : Revisiting Breakdown, Relocating Materiality*. Singapore: Springer Nature Singapore, pp. 31-60. https://doi.org/10.1007/978-981-13-2110-8.

Schwennesen N (2019) Algorithmic assemblages of care: imaginaries, epistemologies and repair work. *Sociology of Health & Illness* 41(S1): 176–192.

Sims B and Henke C R (2012) Repairing credibility : Repositioning nuclear weapons knowledge after the Cold War. *Social Studies of Science 42*(3): 324347. https://doi.org/10.1177/0306312712437778.

Tanweer A, Fiore-Gartland B and Aragon C (2016) Impediment to insight to innovation: understanding data assemblages through the breakdown–repair process. *Information, Communication & Society* 19(6): 736–752.

Torenholt R and Tjørnhøj-Thomsen T (2022) 'Is this something I should be worried about?' : A study of nurses' recontextualisation work when making clinical decisions based on patient reported outcome data. *Social Science & Medicine 294*: 114645. https://doi.org/10.1016/j.socscimed.2021.114645.

Ureta S (2014) Normalizing Transantiago : On the challenges (and limits) of repairing infrastructures. *Social Studies of Science 44*(3) : 368392. https://doi.org/10.1177/0306312714523855.

Villani C (2018) *Rapport de Cédric Villani : Donner un sens à l'intelligence artificielle (IA)*. Available at: https://www.enseignementsup-recherche.gouv.fr/fr/rapport-de-cedric-villani-donner-un-sens-l-intelligence-artificielle-ia-49194 (accessed 4 March 2025).

Notes

1 Reference terminology for the field of anatomo-pathology in France, produced by the ADICAP association (Association for the Development of Information Technology in Cytology and Pathological Anatomy). This terminology is used to code an anatomo-cytopathology analysis (sample origin, sampling mode, analysis technique, and result).

The Darker Qualities of Repair

Minna Ruckenstein
University of Helsinki, Finland/minna.ruckenstein@helsinki.fi

Abstract

This article investigates the darker dimensions of repair, departing from STS scholarship that portrays repair as a productive force of learning and renewal. It focuses on moments when repair fails to generate insight or restore stability, examining the aftermath of the Apotti data management platform's implementation in Finland. Drawing on documents outlining the platform's aims and discussions with medical doctors, the analysis traces persistent disruptions and misalignments in clinical workflows. The study identifies three forms of darker repair: corrective clicks, workflow fixes, and cosmetic repair. These manifestations reveal how efforts to upgrade and renew technology can deepen and mask organisational tensions. Central to the analysis is the recognition that multiple, qualitatively different repair processes are simultaneously at play. Research into the darker qualities of repair provides an evaluative lens to identify and anticipate the breakages and dissatisfaction accompanying data-driven reforms, suggesting that such issues can be detected before they become permanently irreparable.

Keywords: Datafication of Health, Qualities of Repair, Data Management Platform, Epic, Apotti, Workflows

Introduction

In April 2016, a collaboration agreement was signed between the Apotti company – jointly owned by the HUS hospital district, the City of Helsinki, and several municipalities in Southern Finland – and the US-based corporation Epic Systems to build a new data management system. Epic is a provider of electronic health record software used by hospitals and healthcare organisations to manage patient data, clinical workflows, and administrative processes. The plan was that while Epic delivers the underlying electronic health record and enterprise platform, the Apotti company integrates this platform with Finnish social and healthcare services, legal requirements, and language interfaces through customisation by the regional consortium that manages the system.

The planned Apotti platform set an ambitious goal: to renew healthcare by creating the world's first integrated system for both healthcare and social services. It was intended to replace earlier information systems that were considered obsolete and inefficient in handling information flows. According to company materials (see www.apotti.fi), Apotti promised to renew organisations by promoting data gathering on work processes and guiding professionals' actions by making them traceable and comparable.

The platform was officially launched at Peijas Hospital in November 2018. Prior to this, hundreds of healthcare professionals participated in the preparatory phases of the platform's 'user-driven adaptation'. Usability was prioritised during the procurement phase by setting user-centred design requirements, ensuring the selection of the system with the highest usability potential (Raatikainen et al., 2021: 7). Throughout the project, professionals contributed to design workshops, and numerous assessments were conducted to maintain a focus on their needs.

Despite the emphasis on usability, critical issues became apparent after the data management platform was rolled out (Raatikainen et al., 2021; Tyllinen et al., 2021) and progressively introduced across regional hospitals and public health stations. Physicians voiced their dissatisfaction with Apotti's features, citing complicated workflows, cumbersome pharmaceutical dispensing, difficulty in finding timely and relevant patient information, incomprehensible language due to business jargon, poor machine translation, and an unwieldy vocabulary that attempted to address both social and healthcare workers (Hertzum et al., 2022).

In October 2020, the Managing Director of the Apotti company responded to the critique by explaining that implementation and related operational changes take time, arguing that the benefits of the system might only become visible after years of use (see Grön, 2021: 8). The promises of future efficiency framed an everyday hospital reality in which the struggles and misalignments that medical doctors faced with Apotti were repeatedly ignored, as they were characterised as temporary issues that would be resolved once the platform was fully operational.

When physicians in the Helsinki-Uusimaa region were surveyed in 2021 about their experiences (see Hertzum et al., 2022), the percentage of those who agreed with the claim that information systems help improve the quality of care had dropped from 44 percent before Apotti to less than 10 percent after its implementation. All information systems have flaws that must be tolerated and worked through. With Apotti, however, the professional stakes were higher for physicians, due to concerns surrounding the quality of care, patient safety and inefficient uses of public healthcare resources.

This article mobilises the notion of 'repair' (Denis and Pontille, 2023; Jackson, 2014) to examine how Apotti's efforts to reform healthcare organisations disrupted existing workflows, thereby necessitating further repair. A growing body of research explores the specificities of repair in relation to data management and algorithmic systems, paying attention to how the repair work undertaken by those who use the system facilitates its operations (Conrad, 2019; Kaun and Liminga, 2023; Schwennesen, 2019, 2021). My analysis departs from the disruption caused by the data-driven initiative, which is itself an effort to repair and reorganise organisational workflows to generate the data required to gradually improve healthcare. The main focus, however, is on the consequences that this disruption had for physicians.

The renewal promised by Apotti aligns with the broader trend of 'the datafication of health', which promotes healthcare reforms by means of data sourcing, circulation, and the utilisation of patient and healthcare data, making it available for multiple purposes (Helén and Tarkkala, 2024; Hoeyer, 2023; Hogle, 2016; Ruckenstein and Schüll, 2017; Salovaara, 2024). The aim is to speed communication, introduce novel organisational and professional practices, utilise data-enabled guidance, and replace existing methods with preset standard tasks (Grön, 2019).

The introduction of datafied workflows is not repair in a 'getting back on track' or 'back to order' manner (see Denis and Pontille, 2023); rather, it is transformative (Sims and Henke, 2012), or even disruptive, repair. Sims and Henke (2012: 327) define transformation as "a repair strategy that seeks more radical change in existing structures and practices in order to maintain what actors see as core elements of a system". Transformative repair upgrades existing practical and institutional structures while balancing between stability and change. It is a process that can lead to learning and improvisation (Pink et al., 2018; Tanweer et al., 2016). Gradual adaptation functions as "a feedback loop of experimentation which, through many small increments in practical knowledge, can produce large changes" (Graham and Thrift, 2007: 5).

However, to emphasise the disruption that Apotti generated and the associated discontent of medical doctors, this article departs from the productive notions of repair and highlights its darker qualities (Ribes, 2017). The focus on darker qualities introduces repair as an evaluative lens. It recalls Star's (1990: 43) proposition: "Cui bono?" With the question of who benefits, Star urges researchers to examine whose interests are served by a system, classification, or infrastructure. Aligning with Star's proposition, the repair lens can expose the social and political dimensions hidden in seemingly neutral technical arrangements (Velkova and Kaun, 2021). It can highlight how technologies and standards never serve everyone equally.

In March 2023, an interdisciplinary project that I lead arranged four workshops for medical doctors to assess whether the post-implementation phase of Apotti had settled into a more satisfactory situation. The goal was to explore what had changed with Apotti and how any resulting disruptions at work had been or could be addressed and repaired. What became apparent in these workshops were the darker aspects of repair processes, described by Hoeyer and Wadmann (2020) as 'meaningless work'. Drawing on the workshop discussions that detail how repair efforts may fail to improve the overall situation, I describe responses to disruptions within the workflows. In addition to the workshop materials, my analysis has benefited from publicly available reports and blog posts, news about the Apotti implementation, and discussions at seminars and conferences with researchers studying Epic-based systems. Apotti's building process, reconstructed using publicly available materials, provides crucial context for understanding physicians' perspective. Central to the analysis is the recognition that various repair processes are simultaneously at play and that they differ qualitatively.

In what follows, I treat as darker qualities of repair those instances when the physicians' practices feel pointless and frustrating and do not lead to meaningful improvement. I first explain how I develop the notion of repair to discuss the aftermath of Apotti's implementation. I then introduce Apotti's building process to explain the breakages that demand a response from physicians. These breakages range from medical records that have become fragmented and contain unnecessary information to the Apotti system's constant demands on attention. By analysing how medical doctors express discomfort with what Hoeyer and Wadmann (2020: 439) describe as "a sense of digression from the goal of helping the patient", we gain a sense of what troubles them in datafied workflows. By specifying what kind of repair is at stake, we can begin to observe who or what transforms existing workflows and who repairs them. This allows the various qualities of repair to be contrasted with what desirable repair *should* or *could* be.

Conceptual coordinates

The different qualities of repair

Discussions of repair often begin with Heidegger's notion that being in the world involves practices and tools used in 'handy' and 'invisible' ways (Verbeek, 2005; Graham and Thrift, 2007). Typically, people do not focus on tools or equipment when they engage in tasks; rather, their attention is directed towards the activities themselves. A hammer or a computer only becomes an object of attention when it cracks or becomes inoperable. For instance, if a laptop freezes and cannot be used for writing or scrolling, it necessitates repair. This type of repair is situated in a relatively stable world, where tool handlers have coherent interactions with their surroundings and can easily identify when tools break or stop functioning. Repair practices serve to restore the stability that brokenness disrupts, allowing tool handlers to resume their regular activities. However, it is not always clear what 'stability' means or how it should be restored. Transformative and disruptive repair can explicitly aim to interrupt the current status quo and, as a result, things may never return to their previous state. Despite efforts to restore stability, they can continue to feel broken and out of rhythm.

Ongoing testing and experimentation with digital tools and services, along with their updates and evolving nature, create a terrain where repair needs are constantly emerging. Repair positions algorithmic technologies as negotiable and unfinished, and needing further work (Jackson, 2014; Schwennesen, 2021). To build and maintain connections that enable productive relations between the system and its users, an algorithmic system might have to be adjusted and creatively repaired (Schwennesen, 2019). Yet if the algorithmic system conflicts with publicly cherished values, such as privacy, autonomy or equity, it might also be seen to be beyond repair, and in need of shutting down or rethinking (Ratner and Schrøder, 2024; Ruckenstein and Trifuljesko, 2022).

Usefully for this discussion, Houston (2017) argues that the very notion of repair tends to convey a linear sense of time along which people move 'back' through repair work. Thinking about repair in this way obscures "the complex forms of change and their temporal unfolding – that both lead to breakdown and are enacted through repair work" (Houston, 2017: 38). Acknowledging the complexity of change suggests that repair should be understood in terms of differentiation rather than mere restoration (Houston, 2017; see also Denis and Pontille, 2023).

The implementation of any new data platform can be seen as "a disturbance coming from the outside", as Conrad (2019: 316) phrases it, because "it stirs up the existing information infrastructure consisting of well-established and well-known tools and their entanglement with the ways of doing things". Consequently, the implementation phase can be a messy and disorganised process wherein nobody knows exactly what the system is or when it will be completed. The success of the implementation process typically varies depending on who is evaluating it. The data management reform might meet the needs of managers and administrators, while physicians find themselves in a situation where implemented changes disrupt their usual practices and call for repair. This scenario, which is by no means limited to Apotti, exemplifies the complex nature of repair.

Furthermore, platforms like Apotti, built on data and algorithmic techniques, are open to very different kinds of use. The Apotti platform includes data-driven management tools, research tools, public health applications, and a customer portal. It contains different versions for different healthcare units and professionals. This adds to the difficulty of talking about 'a system' or 'a platform', as adaptation and related repair are likely to produce varying outcomes within the same platform. In practice, this means that the platform engages people differently. When things do not work as planned, they can be repaired through careful customisation, allowing Apotti's features to be tailored to specific workflows. Physicians can also personalise Apotti to meet their needs. Health professionals may find Apotti effective and helpful, but they might also perceive it as permanently flawed and laborious—an experience that was prominent in the workshop materials.

The modifiable and constantly updated features make it apparent that it is increasingly difficult to pin down exactly what constitutes repair in an evolving system. Does it involve maintaining and developing hardware, software, and workflows, or the divisions of labour and knowledge formation that the system promotes? What about the repair efforts of the broader operational environment that the system both disrupts and enhances? To emphasise the disruptive aspects of repair might appear counterintuitive: is it still considered repair if the aim is to disrupt? Undoubtably, in this context, repair raises the question of how far we can stretch the notion.

Questioning the limits of repair suggests that it is more productively employed as a situated lens rather than as a fixed definition. The lens of repair invites us to consider how external disruption might break existing practices and what consequences this has for professionals and organisations. Depending on the context and aims of the analysis, repair can be defined as anticipatory, disruptive, transformative, emancipatory or reflexive (Conrad, 2019; Henke and Sims, 2020; Sims, 2017; Velkova and Kaun, 2021). These different qualities can be thought of as an analytical toolkit that effectively reveals underlying or projected system features and their flaws. It is with this aim in mind that I attend to the darker qualities of repair.

Repair as a burden

In considering what might be 'dark' in the repair efforts of medical doctors, I emphasise the need "to broaden the meaning of repair to include affect and care" (Ribes, 2017: 56). In what follows, I discuss the repair work carried out by physicians in the aftermath of Apotti as a collective experience that is not only frustrating but raises concerns about the quality of care. Ribes (2017: 56) emphasises the finite nature of maintenance and repair resources, suggesting that repair activities bring into focus what should be cared for and restored. Like all investments, repair and maintenance need to be allocated thoughtfully: "they cannot be distributed equally to all things that may need them" (Ribes, 2017: 56). Ribes urges scholars to adopt a less romanticised view of the productive qualities of repair, asking "at whose expense" the repair is conducted. As I demonstrate, this is a matter that should not be overlooked. The physicians who participated in the workshops shared the concern that attending to Apotti takes time away from patient care, which remains their unquestioned priority.

Disruptive repair challenges existing organisational practices and forces people to adjust and 'work things out' (Strauss, 1988). Working things out includes modifying workflows to accommodate the interdependencies between the new system and the various human tasks and roles. These practices have been studied as 'articulation work' (Strauss, 1988), which is often invisible and underappreciated yet crucial for the functioning of organisations, especially in environments like healthcare, where tasks are interdependent and require coordination across different teams and units.

I could discuss physicians' responses to the disruption caused by Apotti as articulation work, but my aim is to demonstrate that this approach would not adequately address the darker qualities of repair and related forms of invisible labour. The breakages in physicians' workflows trigger responses that extend beyond mere articulation work, adding repetitive repair tasks on top of the invisible labour that is already well-documented in the healthcare field (Oudshoorn, 2008; Schwennesen, 2021). The darker aspects highlight how disruptive repair becomes a burden that derails workflows rather than aids in getting back on track. It leads to dissatisfaction rather than renewal or hope. What is crucial, then, is to make visible the difficulty or even impossibility of adapting to the new situation.

Modes of inquiry

Contextualising a collective experience

Before discussing the workshop materials, I offer selective background information to contextualise physicians' experiences. The aim is to set up the analysis, not to provide a comprehensive or evaluative review, which would be beyond the scope of this study. Epic is currently the dominant vendor of data management platforms for healthcare globally and has recently secured new contracts in several European countries, including Denmark, Norway, and Finland (Grön, 2021; Hoeyer, 2019). Notably, these Nordic countries are welfare states in the Scandinavian tradition, with tax-based, universal healthcare systems, which fundamentally distinguish them from the US model that Epic has primarily served (Raatikainen et al., 2021: 8).

The Apotti platform is based on Epic's software packages, which have been locally implemented with the assistance of health and social care personnel. Customisation of generic software packages is laborious and time-consuming (Conrad, 2019), and, as in Denmark, physicians in Helsinki recognised the complexity of the overall process (Bansler, 2019). Epic offers construction materials, but the final results depend on how those materials are utilised. To illustrate this concept, one might think of Epic providing a Lego set that allows the buyer to build whatever they choose according to their needs and desires.

In Denmark, the configuration work of Epic's generic software was carried out at the hospital level by so-called 'physician builders' who have attended Epic's classes to learn how to code and work with the tools, templates and reports (*builds* as they are called in Epic's jargon) in ways that would support the workflows of a specific hospital department or medical specialty (Bansler, 2021). In Finland, physician builders have been affiliated with hospital departments, promoting localisation efforts. In addition, healthcare professionals have worked in various supporting roles, spending between ten and fifty percent of their time with Apotti-related tasks.

Bansler (2021: 6) identifies tensions in the Danish implementation process between standardisation and local variation, and centralised control and local autonomy, and argues for balancing top-down and bottom-up approaches. Developers in Finland acknowledge that Apotti increasingly participates in care activities performed by professionals, guiding them towards a predefined operating model. As one director puts it, “this sort of guidance is relatively new, and it feels foreign and unpleasant” (Raatikainen et al., 2021: 8). One of the medical specialists confirms this experience, referring to Apotti as a *jötkäle*, a Finnish term used by fishers to describe a fish of massive size. For him, Apotti feels remote: an unwieldy obstacle, too slow and cumbersome to adapt and change. Despite using Apotti daily, he positions the platform outside the interactional realm, as if it were ‘a thing’ he observes from the outside but cannot relate to.

When healthcare professionals collaborate closely with IT specialists during an implementation process, they act as mediators and brokers between technical questions and local applications, often facing criticism when things do not go as planned. As a result of local adaptations, the platform can evolve into a patchwork of ‘builds’ and related repair efforts. The varying amounts of resources and effort invested in implementation shape its outcomes in different units and specialties. Naturally, this also raises questions about what is seen as worth investing in during the building process.

By following physicians’ attempts to restore breakages caused by the data management platform, we can trace the discrepancies and misalignments between Apotti’s operational routines and clinical work. Markham’s (2021: 388–389) observations are helpful here, as they highlight the need for workable pathways when engaging with digital platforms. Pathways are sequences of actions or procedures established through initial usage, which, over time, become habitual practices for accomplishing a task. The pathway, Markham explains (2021: 389), steers the action and its direction. Over time, pathways become ingrained in workflows, causing both the pathway itself and the underlying process to fade away from conscious awareness. Guidance is no longer needed, as actions occur in a routine manner without conscious effort. In the case of Apotti, such pathways might not be where they are needed, leading to breakages and persistent repairs. Their absence becomes observable in the efforts of medical doctors to repair their daily workflows.

Workshop materials

The recruitment of physicians for the workshops that provided the empirical foundation for this article was conducted in collaboration with the Finnish Medical Society, Duodecim, which published an open invitation in its magazine and on the website. The workshops took place in Helsinki at the society’s premises, with a total of 25 physicians: the first workshop had nine participants, the second six, the third seven, and the fourth four. One of the medical doctors participated in two sessions, as we offered the option. At the time of registration, the participants filled out a background questionnaire but, due to a technical glitch, data from one participant was not stored. Therefore, the description of the participants is based on information provided by 24 individuals. Among them, 19 were specialist doctors, three were specialising doctors, and two were non-specialised doctors. Many of them worked in several different units. Ten reported working in primary healthcare, 21 in conservative specialties, and four in surgical specialties. Their experience as medical doctors ranged from two to thirty-five years. Most (21) had been using Apotti for over a year, while the remainder had been using it for three to twelve months. Except for one participant, all used Apotti daily.

The participants included medical doctors with advanced degrees in computer science; others had taken IT courses or simply enjoyed experimenting with information systems and software. Many had also worked as Apotti support, and those less experienced benefited greatly from their assistance. As one doctor wrote on a post-it, “A doctor is the best IT support.” This reflects a shared understanding of patient care and explains why doctors turn to fellow professionals for help with Apotti and daily workflows.

Aware of the critique surrounding Apotti, we inquired about the participants’ current attitudes toward the platform in advance, which were negative (18), neutral (5) or positive (1). In light of this negative predisposition, we actively sought to recruit physicians who had spoken about Apotti in positive terms in the media or in marketing materials, or who were Apotti experts that had contributed to the building of the system. Many promised to participate but ultimately did not attend. Afterwards, one of them explained that those who think positively about Apotti are tired of being hectored about the shortcomings of the platform. The atmosphere surrounding the Apotti assessment continues to be tense and polarised.

The workshop discussions were conducted in small groups of three to five participants, with trained facilitators managing their progress. Participants were encouraged to use their own observations as examples and describe their Apotti experiences as concretely as possible on post-it notes, which were then displayed for all participants to review. In addition to the facilitators and participants, researchers (2–4 per workshop) were present to observe, record proceedings and provide their insights at the end of each workshop. All discussions were recorded and later transcribed.

As a method, a series of workshops enables iterative approaches whereby insights from earlier sessions can be integrated into future ones (Ørngreen and Levinsen, 2017; Ruckenstein and Trifuljesko, 2022); striking in Apotti workshops was the uniformity of medical doctors' responses. Unlike the format more generally, where experiential divides can soon develop, Apotti experiences were shared, and hardly any tension or disagreement emerged. Considering the hierarchical nature of the medical profession, where surgical specialties are ranked higher than general practitioners, this was even more conspicuous.

At the conclusion of the first workshop, I revisited a concern raised by one of the workshop participants about the representativeness of the research material, collected with the aid of self-selected participants, most of whom held negative views about Apotti. Physicians value data-driven forms of reasoning, and it is difficult for many of them to appreciate that a collectively shared experience, with each participant building upon the details provided by the previous speaker, counts as evidence. What we heard in the workshop discussions did not address Apotti in its entirety, but it did reveal a consistent view of workflow disruptions attributed to the healthcare reform. This specific view anchors my analysis of the darker qualities of repair.

Reduced visibility

Due to the uniformity of Apotti experiences, it was possible to develop hypotheses concerning what had changed with the new data management platform only after two workshops. These hypotheses were based on recurring themes of the workshop discussions. The first hypothesis, which provided the trigger for the analysis presented in this article, states, "The visibility of the patient's situation has decreased." In the latter two workshops, the doctors (referred to by a participant number 1–25) were asked to respond to this hypothesis. They collectively confirmed that visibility of the patient's situation had indeed diminished.

> P25: Well, I don't really have much else to say except, yes, finding relevant information is more difficult.
> P24: Well, I definitely endorse that hypothesis completely…the medical record is totally fragmented, it's really difficult to fish out information, and it contains unnecessary data which takes an unreasonable amount of time to click open.
> P23: Yes, I agree…to the extent that I feel that no matter what I do, I cannot fix it myself, even if I spent a lot of time on something that doesn't exist, that's not available. It's not just that this issue is a bit unclear and messy, it has been completely blown apart, the whole material I need for doing my job.

Visibility into a patient's situation is essential for physicians to perform their work, as it forms the basis of patient care. The doctors described how they piece together information by digging into "tiny text boxes" or using "a crochet hook", referring to the meticulous process of information collection by comparing it to how a crochet hook connects strands of yarn into a unified fabric.

In analysing the workshop data, I traced how the physicians talked about the mending and fixing necessitated by the breakages within workflows. I used the emotionally charged relationship between Apotti and the healthcare professionals as an entry point to explore workflow breakages and consequent repair work. Methodologically, investigating the 'feel' of technology relations provides an opportunity to unpack experiences with evolving systems (Choroszewicz, 2022; Ruckenstein, 2023). Workshop participants were aware that their dissatisfaction could be dismissed as resistance to change stemming from a general reluctance to adopt new work practices (Raatikainen et al., 2021: 8). Their non-compliance might be interpreted as a reason for Apotti's failures, causing 'cumulative mess', where "patience grows thin, frustration mounts, and ideologies clash" (Strauss, 1988: 171), and each new misalignment in tasks adds to the complexity and difficulty of change. To counter this claim, many of the physicians explicitly stated that they had not resisted the change or advanced technology. They had looked forward to the improvements that Apotti promised, contributed to the user-driven development workshops and spent countless hours studying the data management platform. As if to confirm this, the workshop discussions spontaneously descended into repair sessions, with participants explaining how they strengthen incomplete and missing pathways in workflows. They recounted how they improvise and manage their daily tasks: copying and pasting their texts with Word or creating their own shortcuts, 'smart phrases' that trigger an automatic insertion of longer text.

I grouped the different ways of talking about repair and found that it can be discussed as a fairly neutral, everyday activity. At times, however, the discussion shifted into a heavier register, in which the darker qualities of repair were detectable. While there is no uniform 'dark zone' to capture, these darker aspects emerge in the difficulties of piecing together information about a patient's situation. Another recurring theme was the resources wasted on Apotti-related tasks. It appeared that, whereas an integrated system assumes shared information needs, different professionals dealing with the same patient may require very different information. As a result, healthcare professionals who complain about the system receive too much or too little information, or information structured in the wrong way (Tanninen et al., 2025).

In the analysis of darker qualities, I focused on the repetitive attempts to repair Apotti engagements using the means available to the physicians. These engagements highlight how repair may not lead to meaningful improvement – it is repair that fails to repair. Below, I present evidence from workshop materials that illustrates a persistent state of repair. Corrective clicks and workflow fixes exemplify the work physicians do to repair visibility into patients' situations and the misalignments in workflows. I also describe how physicians write detailed service tickets to IT support to report problems and suggest improvements. However, these efforts often encounter long delays and responses indicating that certain issues cannot be fixed. The notion of cosmetic repair underscores the possibility that repair fails to achieve its projected aim. The darker qualities of repair speak to attempts at renewal that fall short of their intended purpose, confronting the losses that accompany data-driven reforms.

Forms of repair work

Corrective clicks

Originally developed for the US healthcare system, Epic's software packages have served a specific model of insurance-based healthcare and associated documentation. This means that the clicks and workflows they suggest may be irrelevant in the Nordic context, yet they are so deeply embedded in the software that they cannot be easily reconfigured (Hertzum et al., 2022). The countless clicks required by the platform are a way to talk about increasing requirements of data production. When data is needed to make the organisation and workflows legible, it drives a 'logic of escalation' in data work (see Hoeyer and Wadmann, 2020: 443). In terms of repair, however, the talk about clicking serves as a means to address the lack of visibility regarding the patient's situation. In pursuit of relevant information about the patient's history, overall situation and medication, the physician must work to restore fragmented information, one click at a time.

> P24: The medical records have been fragmented into such small references. And then you never know from those references where there is something essential and where there is something

> like changing a diaper. You have to click there like, aha, the nurse has changed the diaper there, there a lab test has been taken, okay, and then you click them one by one as you try to find something important, like where the cardiologist has given instructions on how the patient should be treated.

The quoted physician describes how the clicking and scrolling through text boxes is part of the search for clues about the patient's condition. As part of their repair work, the physicians engage in filling knowledge gaps to ensure patient safety. "The diaper change" serves as a typical example highlighting that Apotti cannot distinguish between relevant and irrelevant information. It is an annoying detail displayed alongside medical procedures, which symbolises information that doctors would prefer to ignore.

Physicians confirm critical details regarding treatments. Still, some of them believe that patient safety has been compromised, or they suspect that this is the case: "I can't, or dare not say for certain that this is definitely the case, but I have a strong suspicion it's been compromised in some situations", as one of them (P23) put it. Another doctor (P24) is more confident, referring to difficulties with prescribing medications and asserting, "I feel that patient safety has often been compromised with this information system."

The potential loss of critical details triggers a new kind of uncertainty. To avoid "ethical stress" physicians meticulously search for information that may have been overlooked. Piecing together the patient's situation is slow and requires careful attention. The repair of knowledge gaps takes its toll, producing breakages that are felt in the body – after a day at work, the wrist hurts. Here, the darker qualities of repair become manifest as bodily discomfort. Alongside concerns about bodily ergonomics, physicians worry about their cognitive ergonomics. The inability to concentrate arises from the laborous clicking through the data management platform while hunting for bits of information. As one of the medical doctors (P5) explains:

> You have to click yourself to so many places, [without forgetting] what that place even was… where did I need to go? In that time, the other things that I should keep in mind have been forgotten. And then you end up forgetting to do the thing you were going to do.

The need to think about what to click and where to go next is concrete proof of the lack of pathways that calls for repair. If the interaction between the physician and the platform were sufficiently aligned, the interaction would appear 'automatic' (Markham, 2021: 388); however, the clicking has not sunk into an inconspicuous part of workflows. If it had, the clicks would no longer bother the physicians, having become an imperceptible routine. The awareness of clicks, along with the experience of them as cumbersome and pointless, speaks to the darker aspects of repair. Clicks fit into the data-driven logic, which defines what each click means. The resulting click-based approach to handling information leads to workflow fixes that compensate for the limits of standardisation, a theme that I turn to next.

Workflow fixes

In primary healthcare, which is typically the first point of contact within the healthcare system, the breakages caused by Apotti underscore how difficult it is to fit the diverse requirements of both doctors and patients into standardised workflows. The accomplishment of tasks requires the alignment of workers and workflows (Strauss, 1988: 168). One of the doctors (P23) voiced frustration over the developers' inability to grasp the everyday realities of their work environment.

> If they think my job is just about having somebody come in every three months for a 45-minute blood pressure check, and then I just order a certain routine lab set, and it keeps going like that forever, well, no, our job is definitely not like that. We get people randomly from here and there, and they have all kinds of issues and concerns. There's just this huge lack of understanding here. If they don't understand what people do in different workplaces, then this can never turn out well.

The quoted doctor is referring to developers, but the problem might as well be that required standards need to be comparable across contexts. When tasks are standardised, they become defined by general rather than specific needs assessments (Star and Ruhleder, 1994). Despite decades of research demonstrating that all work tasks, regardless of their simplicity, must be understood within the specificity of their human and organisational context, implementation processes continue to overlook this fact (Berg, 2001). While introduced as user-driven, the implementation of Apotti was described by physicians as top-down. They expressed dissatisfaction that neither the Apotti organisation nor HUS management had shown much interest in the aftermath of the implementation process in their unit. Experiences of having to handle the consequences of the change process independently resonated with those described in earlier studies, with care workers feeling they are left to their own devices when adopting new technologies (Schwennesen, 2021).

The misalignments in workflows lead to repair tasks that maintain additional interaction with the platform, while actively dealing with its gaps and flaws. For instance, the repair work can focus on simplifying and 'hiding' unnecessary features of Apotti to streamline the data management platform, ensuring that work tasks are interrupted as little as possible:

> P21: When we get a new employee, I redo the pages, I hide that, and all that is in forms.
> P19: And you hope that the update will not delete them later.
> P21: Yes, yes. But that probably needs to be done separately for everybody.
> P19: Yes, I do that as Apotti support; I hide things because twenty tabs are visible and we use these four.
> P20: In my opinion, this emphasises how we doctors, together, are trying to find ways to cope with Apotti.

Doctors' collective coping consists of working things out. However, through the evaluative lens of repair, it should not be seen merely as articulation work. By focusing on the ongoing efforts to mend breakages, we can recognise more serious misalignments that, as Ribes (2017: 56) suggests, occur at the expense of the physicians. The doctor who redoes the Apotti pages for an incoming employee aims to ensure that the guiding pathways are available when the shift begins. The systematic flaw is that these pathways have to be secured repeatedly.

If doctors worked in standardised ways, with predefined work tasks, Apotti might provide ample guidance. Ideally, the doctor should remain stationary in front of a personalised screen. However, the reality of a big hospital is that new employees must quickly adapt to the data management platform. People also work in different units, which means that customised and personalised workflows might not be at all what is needed. As one of the doctors (P19) explains,

> In Apotti, you should create a view for every single user, so it would be relevant in that sandbox, which is not the reality, because it doesn't correspond to our treatment system and the fact that we move from one place to another.

The doctor describes how Apotti's data management logic treats work at the hospital with an atomistic framing: one person for one screen. This sandbox reality clashes with the hospital reality, which is characterised by a flow of interactions among patients and colleagues in different units. Rather than accessing their own personalised screens in isolation, doctors might prefer to share their screens with nurses. If each screen is different, sharing becomes demanding. Here, the fixing of workflows might mean "leg work" or talking about what is not on the screen.

The extra work associated with the workflow fixes explains why the workshop participants longed for more stable and consistent information systems, frequently mentioning alternatives (Pegasus, Miranda/Uranus, Finstar, Navitas) that, while clumsy and far from perfect, were easier to work with. Although these earlier systems may have disrupted daily workflows, the doctors had figured them out. This longing for earlier systems should not be interpreted as a desire to move back in time. Medical professionals are not against change, but they would like to see transformation that provides stability and does not call for repetitive repair.

Cosmetic repair

Physicians tell how they try to influence the repair of workflows and other misalignments in the Apotti system by writing service "tickets" (*tiketti*) to IT support, detailing the problems they have encountered. These tickets were discussed in the workshops in an ambivalent, frustrated and disappointed manner. Some had written tickets, or should have written them but ended up not doing so because they had been informed that there were already too many tickets in the backlog. Others had written tickets, but had waited for a response for weeks, months or even over a year, as explained by one workshop participant (P7) when talking about "extremely sluggish" development work:

> When I make a development request to Apotti, it might take a year before they respond, and then they ask questions about things that were clearly stated in [my] request. It's like they didn't understand the question at all, or where the issue originated.

Suggestions are typically small, but much needed in daily work (P14):

> So, two years ago we made a bunch of proposals which were really important to us and, as of last week, I would have said that none of them had led to anything, but now one has. On the death certificate, there's this location code that needs to be entered, which has maybe 15 numbers, but we always have the same code. Since it's always the same for all of us, now it gets entered there automatically.

One of the physicians (P19) has written dozens of tickets: "It is always the fault of the user", he says, referring to the notion that if the data management platform fails to work as planned, the human is the weaker link, not the system. The local developers confirm this notion by stating that users 'blame the system for something that in fact isn't even the system's fault' (Raatikainen et al., 2021: 9). The physician continues to describe a structural problem: Apotti platform is adapted to local conditions, but the adaptation is constrained by Epic's software packages. He thinks that the Apotti company is merely a *bulvaani* – a Finnish word for 'a front' – acting on behalf of Epic, disguising the true control of software assets. The Apotti company has no ability to repair the data management platform because it is assembled from parts owned by Epic, which cannot be changed.

Without a clear understanding of how to turn the vision into reality, "disruptive problems will haunt the entire project", Strauss (1988, 53) predicts, echoing the experience of the workshop participant (P19), noting that Apotti support often replies, "We can't fix this," because the issue is a feature of Epic's system and outside their remit. "And this leads to the situation where all this development work is just tinkering because they don't actually change Epic's stuff, nor do they have the rights to change it."

The Apotti critique recalls the widespread experience of muteness and inaccessibility associated with big tech platforms, emphasising the informational asymmetry and unequal power relations in which no actual dialogue occurs (Ruckenstein, 2023). People send queries and requests to companies in an attempt to understand why the platform and its algorithmic functions operate as they do. In return, they receive automated responses or answers that feel unjustified or unfair. At times, they get no response at all. In the Apotti case, doctors perceive the lack of communication as a systemic failure, alternatively attributing it to Epic or the Apotti company.

Using the analogy of a mouldy house, one of the doctors (P20) explains how the repairs are merely cosmetic, as the underlying issues, related to Epic's software packages and the outcomes of local implementation processes, are not properly addressed.

> I don't have the energy to make out tickets for Apotti because they just get deleted when they don't have the time to respond to them; it feels like it's the same kind of thing as if mould were found in a building and it were just scraped off and painted over to make it look good – so it doesn't look like there's mould anymore.

The "making it look good" speaks to the idea of surface-level fixes that mask structural problems. Workflows are patched, templates tweaked, and interfaces adjusted, yet the fundamental mismatches between clinical practice and the platform's design persist.

Confronting the losses

By writing up their tickets, healthcare professionals are trying to inform 'someone' who might care, although they are unsure who is ultimately in charge of the process or whether the overall system can ever be modified to support their work. The post-its written during the workshops reflect this notion:

> P7: Then I wrote here, can Apotti be fixed, or is its foundation so flawed that it can't be modified anymore? Is it fundamentally such that we can't build the things we need? I don't know how to answer that.
> P6: I've written that the development doesn't seem to focus on the core structure, meaning the user interface, but rather on minor details. On the other hand, developing those minor details is important too, but it doesn't change the fact that the underlying system is bad.

The medical doctors spoke of "some pretty fundamental changes" (P18) needed for Apotti to assist them, even though they remain unsure about what belongs to 'the system' and what is possible. Some physicians reported losing faith in the implementation process. They did not think that management knew what it was doing. Given the current misalignments, physicians continue to improvise and tinker, trying to make the best of the platform. In the face of economic pressures, however, the workshop participants are increasingly aware that such efforts are not without cost. The darker aspects of repair manifest in various kinds of losses, including time and promised efficiency. As suggested by one (P18): "What concerns everyone the most now is our poorly utilised work resources. Everything costs quite a lot, in terms of indirect costs. You can't directly calculate how much this has cost".

To illustrate the loss of resources, the physicians engage in number-based reasoning, comparing the time before Apotti and after, observing, for instance, that they treated nine patients in a day in the past and now only seven. Yet they have no official data to back up their claims.

Rethinking from here

The darker range of repair

I have suggested that the lens of repair invites us to think about the different qualities of repair. Depending on the context and evaluative stance, repair can be defined as anticipatory, disruptive, transformative, emancipatory or reflexive. Disruptive repair presents an opportunity for renewal, but it can also derail workflows and lead to repetitive repair tasks. To make such tedious tasks visible, I focused on the darker qualities of repair, suggesting that their analytical power lies in identifying moments when repair becomes a burden. These darker qualities bring to the fore attempts at restoration that fall short of their intended purpose. Even if repair is ongoing, it may feel pointless when it fails to improve the overall situation.

In the case of Apotti, these darker qualities reveal how data-driven improvements, and their underlying database logic can unsettle organisational flows, with taxing consequences. Medical doctors' efforts to regain visibility of the patient's situation, lost through the data-driven reform, make clear that this work is carried out at their expense. They must engage in daily click work and workflow fixes to operate the data management platform.

While such repetitive tasks divert attention away from patient care, medical doctors are effectively maintaining a platform whose gaps and flaws appear systemic rather than isolated. The notion of cosmetic repair, used to characterise the shortcomings of efforts to fix Apotti, is telling. Successful repair requests may add a button, a line of code, or a new feature, yet still fail to improve the overall system. Physicians' discontent appears as a longing for simpler information systems with predictable and shared workflows. Such systems do not feel as overwhelming, uneven, or distracting.

Repair requests can culminate in an impasse: the platform is built to support purposes that differ from the practices and expectations of professionals. "I am a doctor, not an IT nerd," one doctor concluded, referring to the constant need to think about the data management platform. This doctor was contemplating abandoning their medical specialty to work as a general practitioner in the private sector, thereby avoiding interactions with Apotti. If there is little scope for repair that would improve what most needs improvement, it might be time to let go. The cost of such a decision is personal, but in this instance, it is also societal, with the public healthcare system suffering the consequences.

Towards reflexive repair

The problems associated with Epic-based platform implementations in the Nordic countries are by now well-known, yet it remains unclear what will be learned about the failed promises and lost resources. Differentiating between forms of repair offers new entry points for this discussion. The qualities of repair are useful for distinguishing between those forms that compel people to adapt and adjust, even in the absence of improvement, and those that are emancipatory, creating opportunities to rethink and renew infrastructural relations and information flows.

The workshops held in Helsinki stand as a testament to the sheer magnitude of work invested in repairing workflows and securing pathways. As with any emerging system, the healthcare professionals' engagements with Apotti develop over time; what they thought about the system a year ago may have already shifted. Expectations and priorities continue to evolve, and the processual nature of repair means that practices of repair do so as well. Even as people gradually adapt in the wake of disruptive changes, the darker aspects should not be disregarded, as they can offer valuable lessons about whose aims and interests are served.

In the midst of data-driven reforms, listening to what people feel or think needs repair, and observing how they engage in repair practices, offers a corrective. Medical doctors are accustomed to being valued, yet in this instance, they have been downgraded to click workers and workflow fixers, which explains their frustration. Their privileged position makes them more vocal about their situation than many others, drawing attention to the need to attend to the darker qualities of repair among those who are heard even less. To understand the limits of repair and its qualities, it is crucial to examine not only what is seen as broken but also how the act of repair might illuminate breakages. This invites us to consider the potential for repair to fail in its intended purpose and to ask at whose expense the repair work is conducted.

In future work, the notion of reflexive repair (Henke and Sims, 2020) can be mobilised to encourage a more critical and transformative stance on the darker qualities of repair. Reflexive repair suggests stepping back and rethinking how we undertake repair. Instead of simply fixing problems as they arise, it asks us to consider the wider consequences of large, interconnected infrastructures, including how power, scale, and time shape what is built, who benefits, and who bears the costs. In this light, reflexive repair poses a simple but demanding question: how can we repair or renew information systems so that they do not create new burdens or lock in unsustainable practices?

Reflexive repair encourages a two-way approach: tracing the broader political and economic implications of the datafication of health, while also attending to bottom-up realities of data management systems, such as how repair shapes clinicians' work, their ability to care for patients, and the quality of their professional lives. Connecting the qualities of repair to care and affect brings unacknowledged practices into view and offers insight into ongoing processes of change. Rather than merely exploring and describing the darker range, a focus on the qualities of repair allows processes to be unpacked and treated as material for rethinking data-driven developments.

Research into the darker qualities of repair provides a productive lens for identifying and anticipating the breakages and dissatisfaction that accompany data-driven reforms, helping ensure that these issues are acknowledged before they become permanently irreparable.

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References

Bansler JP (2019) Adaptation of Clinical Information Infrastructures by and for Users. *Infrahealth 2019 - Proceedings of the 7th International Conference on Infrastructures in Healthcare 2019*. European Society for Socially Embedded Technologies (EUSSET). Vienna, Austria, 30-31 May 2019. https://doi.org/10.18420/ihc2019_001.

Bansler JP (2021) Challenges in user-driven optimization of EHR: A case study of a large Epic implementation in Denmark. *International Journal of Medical Informatics* 148: 104394.

Berg M (2001) Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics* 64(2-3): 143-156.

Choroszewicz M (2022) Emotional labour in the collaborative data practices of repurposing healthcare data and building data technologies. *Big Data & Society* 9(1): 20539517221098413.

Conrad L (2019) The organization is a repair shop. *Ephemera: Theory & Politics in Organization* 19(2): 303–324.

Denis J and Pontille D (2023) Before Breakdown, After Repair: The Art of Maintenance. In: Mica A, Pawlak M, Horolets A and Kubicki P (eds) *Routledge International Handbook of Failure*. London: Routledge, pp. 209–222.

Graham S and Thrift N (2007) Out of order: Understanding repair and maintenance. *Theory, Culture & Society* 24(3): 1–25.

Grön K (2019) *Apotti-hanke ja sosiaali- ja terveydenhuollon tulevaisuuden odotukset*. Master's Thesis, Faculty of Social Sciences, University of Helsinki.

Grön, K (2021) Common good in the era of data-intensive healthcare. *Humanities and Social Sciences Communications* 8:230. https://www.nature.com/articles/s41599-021-00911-w.

Helén I and Tarkkala H (2024) Adjusting expectations actionable: Personalised treatment plan in anticipation of data-driven healthcare. *Big Data & Society* 11(4): 20539517241285384.

Henke CR and Sims B (2020) *Repairing infrastructures: The maintenance of materiality and power*. Cambridge: MIT Press.

Hertzum M, Ellingsen G and Cajander Å (2022) Implementing large-scale electronic health records: experiences from implementations of Epic in Denmark and Finland. *International Journal of Medical Informatics* 167: 104868.

Hoeyer K (2019) Data as promise: reconfiguring Danish public health through personalized medicine. *Social Studies of Science* 49(4): 531–555. https://doi.org/10.1177/.

Hoeyer K (2023) *Data Paradoxes: The Politics of Intensified Data Sourcing in Contemporary Healthcare*. Cambridge: MIT Press.

Hoeyer K and Wadmann S (2020) 'Meaningless work': How the datafication of health reconfigures knowledge about work and erodes professional judgement. *Economy and Society* 49(3): 433–454.

Hogle LF (2016) Data-intensive resourcing in healthcare. *BioSocieties* 11(3): 372–393. https://doi.org/10.1057/s41292-016-0004-5.

Houston L (2017) The timeliness of repair. *Continent* 6(1): 51– 55.

Jackson S (2014) Rethinking repair. In: Gillespie T, Boczkowski PJ and Foot KA (eds) *Media Technologies: Essays on Communication, Materiality, and Society*. Cambridge : MIT Press, pp. 221–239.

Kaun A and Liminga A (2023) Welfare service centers: Maintenance, repair, and care at the analog interfaces of the digital welfare state. *New Media & Society 27*(5): 3039-3054. https://doi.org/10.1177/14614448231220362.

Markham A (2021) The limits of the imaginary: Challenges to intervening in future speculations of memory, data, and algorithms. *New Media & Society* 23(2): 382–405. https://doi.org/10.1177/1461444820929322.

Ørngreen R and Levinsen KT (2017) Workshops as a research methodology. *Electronic Journal of E-learning* 15(1): 70–81.

Oudshoorn N (2008) Diagnosis at a distance: The invisible work of patients and healthcare professionals in cardiac telemonitoring technology. *Sociology of health & illness* 30(2): 272–288. https://doi.org/10.1111/j.1467-9566.2007.01032.x.

Pink S, Ruckenstein M, Willim R and Duque M (2018) Broken data: Conceptualising data in an emerging world. *Big Data & Society 5*(1): 2053951717753228. https://doi.org/10.1177/2053951717753228.

Raatikainen P, Pekkola S, Nurminen M and Mäkelä M (2021) Masterplots in information systems implementation. ECIS 2021 Research Papers, 136.

Ratner HF and Schrøder I (2024) Ethical plateaus in Danish child protection services: The rise and demise of algorithmic models. *Science and Technology Studies* 37(3): 44–61.

Ribes D (2017) The rub and chafe of maintenance and repair. *Continent* 6(1): 71-76.

Ruckenstein M (2023) *The Feel of Algorithms*. Berkeley: University of California Press.

Ruckenstein M and Schüll ND (2017) The datafication of health. *Annual Review of Anthropology 46*: 261-278.

Ruckenstein M and Trifuljesko S (2022) Algorithmic futures and the unsettled sense of care. In: Lanzeni D, Waltorp K, Pink S and Smith RC (eds) *An Anthropology of Futures and Technologies*. London: Routledge, pp. 79–92.

Salovaara S (2024) *Tietojärjestelmät osana sosiaalityön tiedonmuodostusta*. PhD thesis, University of Lapland.

Schwennesen N (2019) Algorithmic assemblages of care: Imaginaries, epistemologies and repair work. *Sociology of Health & Illness* 41: 176–192.

Schwennesen N (2021) Between repair and bricolage. In: Peine A, Marshall B, Martin W and Neven L (eds) *Socio-Gerontechnology: Interdisciplinary Critical Studies of Ageing and Technology.* London: Routledge, pp.175–188. https://doi.org/10.4324/9780429278266

Sims B and Henke CR (2012) Repairing credibility: Repositioning nuclear weapons knowledge after the Cold War. *Social Studies of Science* 42(3): 324–347.

Star SL (1990) Power, technology and the phenomenology of conventions: on being allergic to onions. *The Sociological Review* 38: 26–56.

Star SL and Ruhleder K (1994) Steps towards an ecology of infrastructure: complex problems in design and access for large-scale collaborative systems. In: *Proceedings of the ACM conference on Computer supported cooperative work,* pp. 253-264.

Strauss A (1988) The articulation of project work: An organizational process. *Sociological Quarterly* 29(2): 163–178.

Tanninen M, Helén I and Ruckenstein M (2025) Epic disappointment: Physicians' experiences of steerability in data-driven healthcare. *SSM - Qualitative Research in Health*. https://doi.org/10.1016/j.ssmqr.2025.100667.

Tanweer A, Fiore-Gartland B and Aragon C (2016) Impediment to insight to innovation: Understanding data assemblages through the breakdown-repair process. *Information, Communication & Society* 19(6): 736–752.

Tyllinen M, Kaipio J and Lääveri T (2019) Usability analysis of contending electronic health record systems. In: Francis L, Bartle-Clar JA, Bliss G, Borycki EM et al (eds) *Improving Usability, Safety and Patient Outcomes with Health Information Technology*. Amsterdam: IOS Press, pp. 430–435.

Velkova J and Kaun A (2021) Algorithmic resistance: Media practices and the politics of repair. *Information, Communication & Society* 24(4): 523–540.

Verbeek PP (2005) *What things do: Philosophical reflections on technology, agency, and design*. University Park: Pennsylvania State University Press.

Calzati Stefano and de Kerckhove Derrick (2025) Quantum Ecology: Why and How New Information Technologies Will Reshape Societies. Cambridge: MIT Press. 288 pages. ISBN: 9780262546218.

Luca M. Possati

l.m.possati@utwente.nl

Quantum Ecology by Stefano Calzati and Derrick de Kerckhove presents a comprehensive analysis of how quantum technologies are poised to transform the very fabric of human society, politics, and environmental engagement. The book argues that humanity is entering a new sociotechnical paradigm, which the authors term 'quantum ecology.' This paradigm builds on and moves beyond earlier language-based and digital ecologies, fundamentally altering how humans understand and interact with reality. Unlike its predecessors, the quantum ecology introduces principles from quantum mechanics – such as superposition, entanglement, uncertainty, and discreteness – into sociotechnical systems, challenging foundational assumptions of classical and digital thinking.

The authors begin by exploring the historical evolution of societal paradigms. The language ecology, rooted in oral, alphabetic, and logographic systems, provided humanity with tools for representation, collective organization, and meaning-making. These systems, while essential for structuring human experience, are tied to a fixed, representational understanding of reality. The digital ecology, emerging in the late 20th century, introduced algorithmic processes that emphasize computation, performance, and scalability. By transforming reality into measurable and processable data, digital systems facilitated global connectivity and optimization but often did so at the expense of nuance, context, and meaning. The authors contend that the limitations of these ecologies – namely, their inability to fully account for complexity, emergence, and relational interdependencies – make way for the quantum ecology, which embodies an entirely new ontological and epistemological framework.

Central to the argument is the idea that quantum mechanics disrupts classical notions of a fixed, objective reality. Instead, reality is relational and emergent, shaped by the interplay between observer and observed. The authors extend this principle to sociotechnical systems, suggesting that the quantum ecology is not merely a technological shift but a reimagining of human experience, politics, and environmental interaction. In this ecology, concepts like entanglement and superposition challenge binary and deterministic thinking, encouraging more holistic and interconnected approaches. The political implications of this shift are examined in depth. The authors propose 'quantum realpolitik,' a framework for understanding how quantum technologies redefine power relations. Traditional political systems are built on linear causality, predictability, and territorial sovereignty. However, quantum principles – particularly entanglement and nonlocality – undermine these assumptions, suggesting that power and influence are increasingly distributed and interdependent. Geopolitical competition over quantum technologies, particularly between global powers such as the United States and China, highlights the strategic importance of this paradigm. Quantum technologies like quantum cryptography and quantum sensing are becoming critical tools in shaping global power dynamics. The authors emphasize that these technologies could reinforce existing inequalities if monopolized by dominant actors or could enable more decentralized and equitable systems if approached inclusively. Governance in the quantum ecology must address the ethical and accountability challenges posed by the inherent uncertainty and complexity of quantum systems.

The ecological dimension of the quantum paradigm is equally transformative. The authors propose a 'quantum ecology' framework that applies the principles of quantum mechanics to environmental systems. Traditional ecological models, influenced by classical mechanics, often view ecosystems as discrete, deterministic entities. In contrast, the quantum ecology emphasizes interconnectedness, emergence, and adaptability. For example, the phenomenon of quantum entanglement offers both a powerful metaphor and a practical model for understanding the interdependencies within ecosystems. Quantum sensing technologies could revolutionize environmental monitoring by providing precise, real-time data on ecological changes, while quantum computing could enable advanced modeling of complex phenomena such as climate change and biodiversity loss.

The book also critiques current sustainability practices, arguing that they often rely on mechanistic and reductionist approaches that fail to address the dynamic and adaptive nature of ecological systems. A quantum-based approach to sustainability would prioritize resilience and adaptability, recognizing that ecological systems are constantly evolving. However, the authors caution that quantum technologies could exacerbate existing inequalities if deployed without careful ethical oversight. They advocate for a holistic approach that integrates the principles of quantum mechanics into environmental policy and governance, ensuring that these technologies promote equity, inclusivity, and sustainability.

Throughout the book, the authors stress the need for interdisciplinary and transdisciplinary collaboration to navigate the transition to the quantum ecology. Drawing on insights from philosophy (Heidegger, 1977; Agamben, 2009), computer science (Hofstadter, 1979), sociology and media studies (De Kerckhove, 1996), and quantum physics (Aaronson, 2013), they construct a comprehensive framework for understanding the sociotechnical implications of quantum technologies. They argue that the quantum ecology synthesizes the representational strengths of the language ecology and the computational efficiencies of the digital ecology, while introducing new possibilities for understanding and engaging with reality. This synthesis challenges anthropocentric and instrumentalist views of technology, emphasizing the co-evolution of human, technological, and environmental dimensions. This might seem like nothing new within the contemporary STS landscape, but the book instead shows that quantum technologies open up a different perspective—one that encourages a rethinking of established paradigms.

While the book presents a compelling vision of the quantum ecology, it is not without its weaknesses. One potential criticism is its reliance on speculative connections between quantum mechanics and sociotechnical systems. Although the authors acknowledge the philosophical underpinnings of their arguments, the leap from quantum physical principles to societal and ecological paradigms risks being overly metaphorical and lacking in empirical grounding. Critics might argue that this weakens the book's claims about the transformative potential of quantum technologies in fields like governance and ecology. A second criticism concerns the lack of specific concrete policy recommendations or actionable strategies for navigating the transition to the quantum ecology. While the authors emphasize the importance of ethical oversight and interdisciplinary collaboration, they stop short of providing detailed frameworks for implementation, leaving readers with a vision that may feel abstract or idealistic. It is also true that the starting point of this work is and remains (critical) media theory and semiotics more broadly, so that governance is sketched more because it is a near horizon of the work rather than the central interest. This aspect can also be considered an advantage; in this way, the book creatively extends the long tradition of studies on language and media and the relationship between media and society begun by McLuhan.

Despite these potential shortcomings, *Quantum Ecology* offers a provocative and thought-provoking exploration of a paradigm shift that could redefine human society and non-human lives. By integrating the principles of quantum mechanics into discussions of politics, ecology, and technology, the book challenges readers to rethink fundamental assumptions about reality and to embrace a more interconnected and emergent worldview. This book serves as a significant resource especially for the contemporary STS community. Rather than merely reiterating established analytical frames—such as those developed around nanotechnology and biotechnology—it invites a deeper, more self-reflective engagement with what "quantum technologies" mean, how they are taking shape, and what kinds of social, political, and epistemic commitments they mobilize. Whether or not all of its claims prove empirically robust, it succeeds in opening new avenues for interdisciplinary dialogue and inquiry. One of the key strengths of this work is its ability to approach emerging technologies from a fresh perspective, avoiding both the simplistic alignment with the rhetoric of responsible innovation (a particularly European framing) as well as an empty, generic ethics of technology.

References

Aaronson S (2013) *Quantum Computing Since Democritus.* Cambridge: Cambridge University Press.

Agamben G (2009) *What Is an Apparatus?* Translated by Kishik David and Pedatella Stefan. Stanford: Stanford University Press.

de Kerckhove D (1996) *The Skin of Culture: Investigating the New Electronic Reality*. London: Kogan Page.

Heidegger M (1977) *The Question Concerning Technology*. Translated by William Lovitt. New York: Garland Publishing.

Hofstadter D (1979) *Gödel, Escher, Bach: An Eternal Golden Braid.* New York: Basic Books.

Birch Kean (2023) Data Enclaves. Cham: Palgrave Macmillan. 139 pages. ISBN: 978-3-031-46401-0

Muhammad Bilal
m8bilal@yorku.ca

Kean Birch's *Data Enclaves* presents a theoretically and methodologically engaged contribution to critical scholarship on data capitalism, digital data governance, and the political economy of technoscience. It examines the infrastructures, ideologies, and institutional practices through which digital personal data is transformed into political-economic assets. Birch's key intervention lies in demonstrating how *'Data Enclaves'* – i.e. private, controlled, and monopolized ecosystems constructed by Big Tech – undermine the ideal of open markets and aggravate informational asymmetries. Drawing from STS, political economy, and critical digital data studies, Birch argues that the contemporary data-driven economy no longer reflects the traditional functioning of markets, but constitutes a new form of rentier techno-capitalism through data enclaves that are driven primarily by parasitic innovation. The book is not only an analytical deconstruction of the assetisation of data but also a call to rethink the governance structures surrounding collection and use of digital personal data. It challenges orthodox techno-libertarian and economistic narratives that dominate policy debates around innovation, privacy, and digital data regulation. Birch invites scholars as well as policymakers to confront the performative power of data enclaves in how they reconfigure market dynamics, concentrate power, and restructure knowledge production in digital economies.

In the book, Birch analyses how Big Tech firms primarily Apple, Google (Alphabet), Amazon, Meta (Facebook), and Microsoft have constructed proprietary environments to extract, hoard, and monetise digital personal data. These enclaves are not merely technical spaces but political-economic formations, sustained by infrastructural dominance, legal protections, and exploitative informational asymmetries. Birch thus emphasises that data, instead of being 'raw' or naturally occurring, is produced through what he terms 'techcraft'; the socio-technical practices and architectures that render personal data measurable, legible, and monetisable. A central argument for this is that data is not a commodity, but an artefact or construction of digital collection architectures that have particular purposes. This moves away from commodification to assetisation, which aligns with Birch's broader project on technoscientific capitalism (Birch and Muniesa, 2020). Data assets are from this perspective both speculative as well as relational: they generate value not through direct exchange, but through anticipated future rents based on their entanglements. Birch argues that markets are no longer functioning in the conventional sense; they are being replaced by pseudo-markets, governed by a handful of monopolistic firms. Unlike traditional narratives of innovation as inherently progressive or beneficial, Birch also identifies parasitic innovation as extractive, deceptive, and exclusionary. He argues that innovation in Big Tech is less about creating public value and more about entrenching dominance by locking users into ecosystems, exploiting vulnerabilities, circumventing regulation, and maximising engagement metrics for profit.

Birch's conceptual framework intervenes in multiple scholarly conversations. Within STS, it contributes to ongoing debates about the co-construction of technology and society by showing how digital architectures both reflect and reproduce existing power relations. More specifically, the notion of techcraft – inspired by 'statecraft' (Scott, 2020) – is used to explain platform capitalism. Birch identifies accounting and valuation practices complicit in techcraft, reshaping social life under digital regimes. Within political economy, the text builds on and extends critiques of neoliberalism and market fundamentalism. Birch makes a compelling case that rentier logics, instead of competition or innovation, are the dominant force behind data-driven technological development. This critique is related to shared concerns of governments around the world to regulate data monopolies and platform power effectively. Birch's critique of valuation practices, particularly the opaque and performative processes through which personal data is rendered economically valuable, intersects with broader conversations in accounting and financialisation studies. Birch argues that even though personal data is widely recognised as a valuable resource, it remains absent in accounting standards and formal economic models, thereby evading public accountability and democratic oversight.

Among the compelling strengths of *Data Enclaves* is its theoretical synthesis. Birch brings together strands of STS, political economy, as well as accounting and valuation studies to craft a multidimensional analysis of data capitalism. The clarity with which concepts such as techcraft, assetisation, parasitic innovation, and data enclaves are presented, is commendable. These concepts are not only analytically powerful but also insightful for interdisciplinary scholars and other readers. The extended discussion of Google's AdTech ecosystem for example offers a clear demonstration of how data enclaves operate in practice, entrenching asymmetrical power relations under the guise of market exchange. Another strength of the arguments and discussion of the book is its normative direction. Birch does not merely critique existing arrangements but calls for new forms of collective data governance that would open up space for alternatives such as data co-operatives, trusts, or public mandates for open data that could democratise access to and control over digital infrastructures.

As limitations of the book, the text is theoretically rich, yet relatively light on empirical details beyond select case studies like Google's advertising infrastructure or Tinder's discriminatory pricing models. While Birch's methodological preference for abstraction is justified within his framework, a deeper empirical grounding particularly in how different data valuation models operate across sectors could have strengthened the text's evidentiary base. Additionally, the text's engagement with Global South contexts is minimal. Given that Big Tech's data extraction and enclosure are profoundly transnational, it would have been useful to explore how data enclaves manifest in diverse regulatory environments beyond North America and Europe. This omission is especially notable in discussions about surveillance capitalism and platform governance, where regional variance plays a significant role in shaping user experiences and regulatory possibilities.

Within STS, *Data Enclaves* contributes to a growing subfield concerned with the material, infrastructural, and economic conditions of knowledge production through digital technologies. It complements existing work (Srnicek, 2017; Viljoen, 2021; Birch and Bronson, 2022; Zuboff, 2023) while offering a distinct focus on innovation, valuation, and rentiership. A key perspective for Birch is stressing the importance of the economic architecture of data capitalism; i.e. its asset forms, performative capabilities and practices, accounting opacity, and pseudo-market dynamics. The book is here particularly insightful with regard to regulatory and policy debates around antitrust, privacy, and digital sovereignty. Birch's argument that ''there are no markets anymore" (p. 120) challenges the foundational assumptions of market-based regulation. If data enclaves constitute pseudo-markets governed by a monopolistic logic, then current antitrust frameworks that rely on assumptions of market competition are ill-suited to address the concentration of power in the digital economy.

The book is recommended reading for scholars in STS, political economy (of technoscience), and digital platform governance. It will also be of interest to policy analysts and regulators contending with the economic and ethical challenges of Big Tech as well as students and researchers seeking to understand structural logics of digital platform capitalism. *Data Enclaves* makes a bold statement towards uncomfortable truths about the political economy of data. By theorising the rise of parasitic innovation, the reframing of data as assets, and the demise of traditional markets, Birch provides a compelling framework for rethinking how personal data is produced, governed, and valued. In a world increasingly governed by invisible infrastructures and opaque algorithms, *Data Enclaves* is a reminder that data is never neutral, and neither is its governance.

References

Birch K and Bronson K (2022) Big Tech. *Science as Culture* 31(1): 1-14.

Birch K, Cochrane D T and Ward C (2021) Data as asset? The measurement, governance, and valuation of digital personal data by Big Tech. *Big Data & Society* 8(1): 20539517211017308.

Birch K and Muniesa F (eds) (2020) *Assetization: Turning Things into Assets in Technoscientific Capitalism.* Cambridge: The MIT Press.

Scott J C (2020*) Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven and London: Yale University Press.

Srnicek N (2017) *Platform Capitalism*. Cambridge: Polity.

Viljoen S (2021) A Relational Theory of Data Governance. *The Yale Law Journal* 131: 573–654.

Zuboff S (2023) The age of surveillance capitalism. In: Longhofer W and Winchester D (eds) *Social Theory Re-Wired, 3rd Edition*. New York: Routledge, pp. 203–213.

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