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Reporting Incidental MRI Findings in the Canadian Alliance for Healthy Hearts and Minds Cohort: Implications and Impact

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Abstract

In the Canadian Alliance for Healthy Hearts and Minds (CAHHM) cohort, participants received magnetic resonance imaging (MRI) scans of the brain, heart, and abdomen, which produced incidental findings (IFs). Managing these unexpected results is a complex challenge. This study aimed to describe the CAHHM policy for IF management, assess the impact of disclosing IFs to healthy participants, and consider the ethical responsibilities of researchers in future MRI studies. From 2013 to 2019, 8,252 individuals (mean age 58 ± 9 years; 54% women) were recruited. A follow-up survey was completed by 909 participants (40% response rate) one year later. The CAHHM policy used a restricted strategy, meaning IFs were not routinely shared. Only severe structural abnormalities were reported. Severe abnormalities were identified in 8.3% (95% CI: 7.7–8.9%) of participants, with the highest rates in the brain (4.2%) and abdomen (3.1%). Of those informed, 97% reported no change in quality of life, while 3% noted a negative impact. Half of the participants experienced increased stress after learning about an IF, but in 95% of cases, IF disclosure did not affect life insurance. Most participants (90%) stated they would participate again and considered MRI scans beneficial, regardless of whether IFs were disclosed. Although the restricted policy was generally well-received, some participants showed signs of diagnostic misconception, highlighting the need for a clearer consent process to support autonomy. Handling IFs in research MRI remains a difficult issue, as disclosure can lead to stress and reduced quality of life for some participants. The restricted approach in CAHHM provided a reasonable balance between ethical principles of autonomy, wellbeing, and justice. This policy may offer a useful model for future research. Clinical trial registration: https://clinicaltrials.gov/ct2/show/NCT02220582.

Keywords: Incidental findings, Magnetic resonance imaging, Quality of life, Ethics

Background

The past thirty years have seen rapid growth in the use of imaging in medical research, driven by technological progress and enhanced computing power [1]. Alongside these advances, imaging has also produced a growing number of incidental findings—unexpected results unrelated to study objectives but potentially relevant to participants' health [2]. Because such findings are common in MRI-based studies, researchers are expected to anticipate their occurrence within protocols, mention their possibility during informed consent, and establish procedures for deciding how to respond when they arise [3, 4]. Yet, determining when and how to share these findings remains complex and contested [5–9].

Recent discussion by Oren *et al.* has underlined the challenges of incorporating IFs into research practice, calling for deeper analysis of their consequences as imaging becomes more embedded in research settings [5]. The variety of strategies currently employed to

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communicate IFs reflects uncertainty in the field and signals a need to examine the ethical reasoning that should guide decision-making [10–12]. The following sections review evidence on the prevalence of IFs in MRI research and discuss ethical approaches taken to address them.

Prevalence of incidental findings in MRI research

Incidental findings are frequently observed in MRI studies. A meta-analysis involving nearly 28,000 asymptomatic adults estimated that 3.9% had potentially serious IFs that could threaten life expectancy, quality of life, or essential bodily functions. When findings of uncertain significance were included, prevalence rose to 12.8% [13]. Comparisons across large studies show considerable variation. For example, in the UK Biobank study of 1,000 individuals, radiologists reviewing whole-body MRIs found potentially serious IFs in 18% of participants [14]. In contrast, the Multi-Ethnic Study of Atherosclerosis, which performed coronary magnetic resonance angiography in 254 participants free of cardiovascular disease, detected IFs in about 40% of participants, though only 7% were considered clinically important (grade 2 or higher) [15]. These differences are likely shaped by variations in study populations, imaging techniques, and criteria used to define clinically relevant findings [13].

Ethical perspectives on managing incidental findings

Researchers' obligations in managing IFs are commonly framed through the principles of autonomy, wellbeing, and justice. Autonomy is supported when participants are provided with access to health information that may influence their decisions [16, 17]. Wellbeing is protected when clinically significant IFs are disclosed, allowing timely intervention for conditions that may otherwise go untreated [18]. Justice emphasizes fairness, requiring that policies for IF management are applied consistently so that all participants are treated equitably [19]. Together, these principles highlight the need for ethically grounded and transparent policies that can navigate the tensions between potential benefits and harms of disclosure.

A continuing debate in the literature focuses on how incidental findings (IFs) should be addressed in imaging research. Phillips *et al.* have argued that researchers carry a duty to conduct comprehensive reviews of MRI scans and disclose all IFs to participants [17]. Their position is that the process imposes little cost on investigators, participants generally wish to receive this information, and disclosure carries minimal risk while offering potentially significant clinical benefit [17].

In contrast, other scholars emphasize the need to balance the potential value of IF disclosure against its drawbacks, such as misdiagnosis and over-diagnosis [20]. Ells and Thombs highlight that identifying IFs can be time-intensive and that follow-up investigations may create financial burdens for participants with limited health advantages [18]. In some cases, disclosure has complicated individuals' ability to secure insurance, particularly when the clinical relevance of a finding is uncertain [17]. Another concern is the psychological impact: participants may experience heightened anxiety after disclosure [18]. Evidence from the Rotterdam study, which used narrative accounts of participants' experiences, revealed significant effects not only on individuals but also on their families, including stress and second-guessing about whether it had been beneficial to learn of the finding [16, 17]. Furthermore, routine disclosure of all potentially clinically important IFs can reinforce the problem of diagnostic misconception, blurring the distinction between research, whose aim is to generate knowledge, and clinical care. These concerns raise important questions about the extent of harm disclosure may cause and the responsibility of researchers to minimize it.

Because of these potential downsides, many research programs have opted for restricted disclosure policies. Under such approaches, only select IFs are sought out or reported. For example, Hegenscheid *et al.* limited feedback to findings considered highly likely to reflect a relevant disease, with decisions made by an interdisciplinary advisory board [20]. Similarly, the UK Biobank disclosed only "potentially serious" findings that could threaten participants' health or quality of life [21]. These models aim to reduce unnecessary harm while ensuring that findings of greatest importance are communicated.

In Canada, national discussions about IF management gained momentum following the Tri-Council Policy Statement (TCPS) of 2010, which introduced an ethical requirement to disclose "material" IFs in research [19]. However, the guidance provided little direction on how researchers should manage this complex issue in practice. Substantial revisions in the 2018 update (TCPS-2) offered a more prescriptive stance [4]. Article 3.4 requires that researchers disclose material IFs to participants who have agreed to receive them during the

consent process. To be considered material, findings must demonstrate analytical validity, clinical significance, and actionability [19].

In this context, the Canadian Alliance for Healthy Hearts and Minds (CAHHM) developed its own policy for the management of IFs generated during MRI scans of volunteer participants. CAHHM is a large national research initiative linking multiple cohorts across 13 MRI centers, designed to investigate how socio-environmental and contextual factors influence cardiovascular risk, subclinical vascular dysfunction, and chronic disease outcomes [22]. Alongside health questionnaires and physical assessments, participants underwent MRI scans of the brain, heart, and vasculature, creating the possibility of uncovering structural abnormalities unrelated to study objectives. The CAHHM IF policy was developed to provide a standardized, ethically grounded framework to ensure consistent handling of such findings across all sites.

Although some research has examined lifestyle and sociodemographic factors associated with IFs [23], less is known about how reported IFs influence participants' quality of life in large-scale Canadian cohorts such as CAHHM [14]. This study therefore set out to achieve three aims: to describe the CAHHM policy for IF management, to evaluate the impact of IF disclosure on the wellbeing of healthy participants, and to reflect on the broader ethical responsibilities of researchers in future MRI-based studies.

Methods

Study population

Participants were recruited following procedures previously described by CAHHM investigators and included adults aged 30–69 years at enrollment in their parent cohort [22]. All participants provided written informed consent agreeing to study procedures and to undergo a full MRI scan covering the brain, heart, carotid arteries, and abdomen. Individuals were excluded if they had contraindications to MRI, such as claustrophobia, pregnancy, non-compatible pacemaker or defibrillator devices, or metallic implants in the eyes or brain. For this analysis, only data from the non–First Nations Alliance cohort were considered. Research ethics approval was obtained from the Hamilton Integrated Research Ethics Board and local REBs as appropriate, with consent secured at each site in accordance with site-specific regulations [22].

Framework for management of Ifs

The CAHHM approach to handling material incidental findings (IFs) was informed by international practices and aligns with ethical guidance in the national Tri-Council Policy Statement, 2nd edition (TCPS-2) [19]. This framework is based on three core principles: Respect for Persons, Concern for Welfare, and Justice [19]. Respect for Persons emphasizes the obligation to honor participant autonomy, ensuring individuals can make informed and voluntary decisions about research participation, while maintaining transparency and accountability [19]. Concern for Welfare directs researchers to consider potential impacts on participants' physical, mental, and spiritual health, as well as their social and economic circumstances, balancing the benefits of research participation with minimization of harm [19]. Justice requires fair and equitable treatment of all participants, ensuring benefits, burdens, and access to research are distributed evenly [19].

Informed consent process

The Tri-Council policy emphasizes that respecting autonomy involves obtaining free and informed consent from participants [19]. In CAHHM, the written consent process was designed to ensure participants understood the study and the IF protocol, and to allow them to decide whether to enroll and whether to receive results of clinical IFs [24]. Participants were informed that MRI scans were conducted for research purposes and not reviewed for diagnostic purposes, so routine feedback of individual results was not provided. The consent form also explained potential risks, including the possibility that a structural abnormality might be identified requiring medical follow-up.

Participants could choose whether significant IFs would be disclosed to themselves and their family physician (or another physician of their choice). Importantly, they were also informed of their right not to know, allowing them to make an autonomous decision regarding whether disclosure was in their best interest. For participants opting to receive IF results, the information could be incorporated into their medical record and potentially accessed by insurers or employers if authorized by the participant. In cases of an immediately life-threatening

finding, participants were directed to emergency care [24].

The CAHHM policy for the management of incidental findings

The CAHHM policy was designed with the primary goal of promoting and protecting participants' wellbeing [24]. Given the large, multicenter nature of the study, the potential negative consequences of reporting false-positive findings were carefully considered, particularly regarding the psychological and financial burden if follow-up investigations revealed no actionable condition. Literature shows that IF disclosure can provoke anxiety for participants and their families and may carry additional social and economic costs, even when findings are of uncertain or benign significance [16, 18]. While not captured in the CAHHM questionnaire, limited evidence from other studies with systematic follow-up indicates that only about 20% of individuals with a potentially serious IF eventually receive a clinically significant diagnosis [13].

In response, the CAHHM planning committee adopted a restricted approach: routine feedback was not provided, and only severe structural abnormalities—those likely to affect longevity or quality of life and for which effective therapeutic options exist—were reported. Guided by the ethical principle of Concern for Welfare, this strategy aimed to maximize participant benefit by enabling treatment or prevention of serious conditions while minimizing harm from over-reporting or misdiagnosis of findings with limited clinical relevance. The committee concluded that this approach offered the most effective balance between the benefits and burdens of IF disclosure and was consistent with the Tri-Council policy's guidance on reporting material findings. Similar strategies are used by other large population-based studies, including the UK Biobank [21]. This method also supports ethical principles of autonomy, as participants are informed of clinically significant abnormalities and can plan their healthcare, and non-maleficence, as they are shielded from unnecessary stress or social and financial consequences of less relevant findings.

To safeguard participant welfare, the timing of IF disclosure was carefully planned. Prompt reporting is crucial when a severe structural abnormality is identified, as timely intervention may be necessary. Given the study's scale and the time required for analysis and report generation, a target of three months was established for returning results. This timeframe was considered achievable while providing participants and their physicians sufficient time to respond appropriately.

Definition of incidental findings of severe structural abnormalities

Four imaging core laboratories independently reviewed MRI scans from specific anatomical regions: brain (University of Calgary and Sunnybrook Hospital), cardiac (Montreal Heart Institute), carotid (Sunnybrook Hospital), and abdomen (Institut universitaire de cardiologie et de pneumologie de Québec). A standardized reading protocol ensured consistency in identifying and reporting IFs, supporting the Tri-Council principle of Justice. When an IF was detected, readers documented the type, location, and extent of the abnormality. Only severe structural abnormalities were reported, defined as conditions potentially threatening lifespan, quality of life, or major bodily functions, and for which preventive or therapeutic interventions were available. These criteria were explicitly described in the consent forms.

Severe, reportable findings included brain infarcts (excluding lacunes), myocardial infarctions (defined by high signal on late gadolinium-enhanced imaging or segmental wall thickening <10% in ≥1 of 16 segments), aortic dilatation (thoracic >50 mm in men, >45 mm in women; abdominal >45 mm in men, >40 mm in women), moderate or severe valvular dysfunction with LV dilation or dysfunction, and masses meeting criteria for malignancy or causing significant compression or infiltration of vital structures. MRI readers—physicians with specialty expertise in each region—used their judgment to classify structural features as severe. Each scan was reviewed by four physicians across the core labs. Data were then sent to the Population Health Research Institute (PHRI) at Hamilton Health Sciences and McMaster University, where findings were linked to the participant's clinical data, distinguishing between previously diagnosed and newly identified conditions. Results were sent to participants and their family physicians as consented.

Communication with participants and family physicians

In the Canadian universal healthcare system, family physicians serve as the primary gatekeepers for clinical follow-up, including referrals, testing, prescriptions, and specialist care. Participants who consented to receive IF

information had findings communicated both to themselves and their family physician through a formal letter from the site principal investigator, ideally within three months of the MRI. The site investigator also contacted the family physician directly to discuss the findings, their limitations as research scans, and potential next steps. Investigators documented that the participant and physician received all necessary information to determine whether further action was warranted. Research funding did not cover additional scans, but physicians could request access to the original MRI for consultation purposes.

Direct participant-only disclosure, without informing the family physician, was not provided to ensure proper clinical oversight. If a participant did not have a listed physician, the results were provided directly, along with contact information for local physicians or walk-in clinics to support informed follow-up. Ultimately, participants and their physicians retained discretion over subsequent investigations, with the understanding that the scans were research-based and not reviewed for diagnostic purposes.

Follow-up questionnaire

A brief online survey consisting of nine open-ended and multiple-choice questions was administered 12 months after study completion. Participants included 350 individuals recruited through the Montreal Heart Institute (MHI) Biobank in Montreal, Quebec, and 559 participants recruited from the CAHHM cohort of Chinese-origin Canadians living in the Greater Toronto Area (GTA), Ontario. The survey assessed participants' overall experience in the CAHHM study, their MRI experience, and the perceived impact of receiving information about an incidental finding (IF). The full questionnaire is available in Additional file 1: STable 1. Conducting the survey at the 12-month mark allowed sufficient time for return of potential IF results and follow-up investigations as recommended by participants' primary care providers.

Table 1. Incidental findings detected across anatomical regions in the CAHHM cohort

Anatomical region scanned	Abdomen	Brain	Cardiac	Carotid	Overall
Scans read for severe structural abnormalities	8196	8219	8188	8179	8127*
Scans not read / unavailable	62	39	70	79	—
Total scans	8258	8258	8258	8258	8252*
Total IFs discovered	257	346†	105	8	683
Mass	252	208	3	8	456
Myocardial infarction	4‡	—	76	—	78
Aortic dilatation	1	—	7	—	8
Brain infarct	—	139	—	—	139
Valvular dysfunction	—	—	19	—	19

*One count per participant

†One participant had both mass and infarct IF

‡Confirmed by extended scan

Statistical analysis

Follow-up questionnaire data, baseline demographics, disease history, and IFs were summarized using counts with proportions or means with standard deviations. The Mantel-Haenszel chi-square trend test was applied to evaluate the proportion of participants with IFs across age decades. Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Between 2014 and 2018, 8,258 participants were recruited (mean age 58 ± 9 years; 54% women), with baseline characteristics summarized in Additional file 2: STable 2. Nearly all participants (99.7%, 8,235/8,258) provided consent for potential IF disclosure. Overall, 8.3% (683/8,252; 95% CI 7.7–8.9%) of participants were found to have at least one severe structural abnormality, most commonly in the brain (4.2%, 346/8,252), followed by the abdomen (3.1%, 257/8,252), cardiac (1.3%, 105/8,252), and carotid (0.1%, 8/8,252) regions **(Table 1)**. Participants with two or more IFs were rare (0.4%, 34/8,252). The likelihood of having an IF increased with age ($p < 0.0001$) **(Table 2)**. Men showed a slightly higher prevalence of IFs (9%) compared with women (7.6%), although this difference was accounted for after adjusting for age.

Table 2. Proportion of incidental findings by age

	30–39	40–49	50–59	60–69	70–79
N	**136**	**1419**	**2987**	**2903**	**807**
			Number of IFs		
0	96.3% (131)	95.0% (1348)	93.2% (2783)	90.7% (2634)	83.4% (673)
1	3.7% (5)	4.9% (70)	6.6% (196)	8.8% (255)	15.2% (123)
2	0%	0.1% (1)	0.3%(8)	0.5%(14)	1.4%(11)

Mantel Haenszel Chi-square for trend, p < .0001

All 909 participants from the MHI Biobank and Chinese-origin cohort were invited to complete the 12-month follow-up questionnaire. The overall response rate was 40% (357/909). Among respondents, 21% (74/357) had been informed of an incidental finding (IF), while 79% (283/357) had no IF. Of those notified about a clinical IF, the majority (85%, 63/74) reported no change in their quality of life, 12% (9/74) reported an improvement, and 3% (2/74) indicated a decline in quality of life following notification **(Figure 1)**.

Following the identification of a clinical IF, 68% of participants (50/74) underwent additional investigations, which included repeat MRI scans and/or other medical tests. Among these 50 individuals, 31 (62%) received a repeat MRI, 21 (42%) underwent an additional diagnostic test, and 2 participants had both a repeat MRI and another test performed.

A smaller subset of participants (8%, 6/74) reported changes to their medical management as a result of the MRI findings: 2 participants had new medications prescribed or doses adjusted, while 4 participants received additional treatments. One of these six individuals experienced a side effect or complication associated with the new therapy.

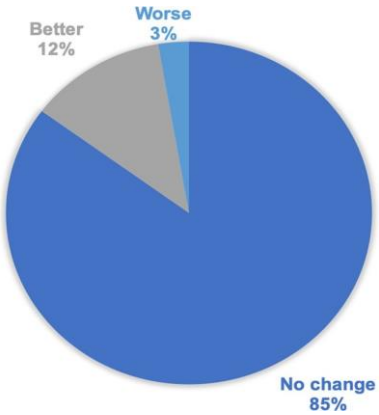

Figure 1. Reported change in quality of life in respondents with incidental findings of severe structural abnormalities (overall N = 74)

Regarding stress associated with the disclosure of an incidental finding (IF), half of the respondents (50%, 37/74) reported experiencing no stress, 35% (26/74) reported some stress, 14% (10/74) reported moderate stress, and 1% (1/74) reported high stress **(Figure 2)**. For the majority of participants (95%, 70/74), receiving information about an IF had no negative impact on their life insurance policy. Among the four participants who indicated that their insurance was affected, two stated they would neither participate in the study again nor recommend that the general public undergo an MRI scan (the survey did not clarify whether this referred to research or clinical settings). Three of these participants still believed that study participation was beneficial to their health.

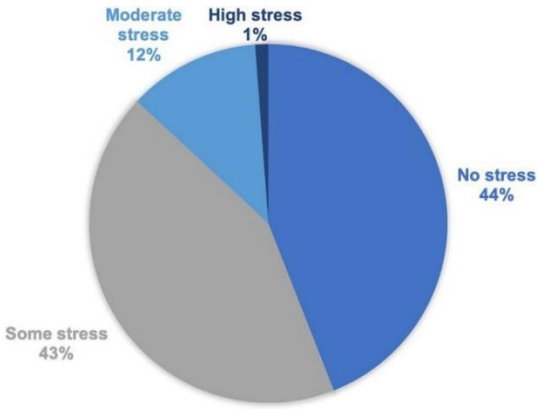

Figure 2. Degree of stress **caused** in respondents with incidental findings of severe structural abnormalities (overall N = 74)

When asked about the overall impact of study participation and undergoing the MRI scan on their health, 23% of respondents (81/357) perceived it as beneficial, 75% (266/357) reported a neutral effect, and 3% (10/357) considered it harmful. Among participants who had been informed of an IF, 64% (47/74) viewed participation as beneficial, while 34% (25/74) answered neutral. Conversely, among participants without IFs, 12% (34/281) reported a beneficial impact, and 85%

(239/281) were neutral. The proportion of participants reporting a harmful effect remained consistent at 3% in both groups.

The efficiency of IF reporting improved over the course of the study. In the first year, the median reporting time was 242 days, which decreased to 100 days in the second year as research teams became more familiar with protocols and prioritized timely reporting. By the third year, the median reporting time was 83 days, and by the fifth and final year, it had improved to 43 days, achieving a timeline close to the ideal three-month target.

Participants' free-text comments

Selected examples of participants' open-ended responses regarding the perceived benefits or harms of study participation are summarized in **Table 3**. Several key themes emerged related to participants' understanding of MRI results and the health impact of the study. Many participants who received IF results reported satisfaction in learning about their condition and being able to take appropriate steps to manage their health. For instance, one participant noted that the detection of a thyroid abnormality allowed them to initiate treatment and monitor the condition, which positively affected their health and care management. Other respondents reported similar benefits from discovering abnormalities such as cysts, a liver hemangioma, and a brain tumor. These responses indicate that the restricted IF reporting approach was effective in identifying clinically relevant abnormalities while minimizing potential harm, demonstrating a tangible health benefit for participants in several cases.

Table 3. Examples of participants' responses to the question "Did you feel it beneficial, neutral or harmful to your health to take part in the Canadian Alliance for Healthy Hearts and Minds (CAHHM) and have the MRI scan?"

Response to question	Specific comments
Beneficial	Assurance that there are no major health problems at this level
Beneficial	At the psychological level, a personal security and a feeling of being able to help advance science
Beneficial	I became aware of some of my lifestyle habits
Beneficial	I feel reassured
Beneficial	I realized I needed to lose some weight… which is very positive…
Beneficial	Increased awareness of taking care of my mental and physical health
Beneficial	Reassuring that there were no major problems
Beneficial	MRI detected a thyroid problem that I can now treat and monitor
Beneficial	A mass has been detected, fortunately this is of no consequence (at least for the moment)
Beneficial	Possibility to have an MRI
Beneficial	Finding out nothing is wrong health-wise
Beneficial	It provides any medically significant finding so as to enable necessary follow-up
Beneficial	You didn't call me back, so everything was fine!
Harmful	I didn't like being in that machine too long on the inside.
Harmful	I found out I'm claustrophobic
Harmful	Stressful noise
Harmful	Headaches and dizziness more often
Harmful	How do you expect me to know? I haven't had any results from that magnetic resonance. I would have liked to have had more information on that test
Harmful	The next year I was diagnosed with breast cancer
Harmful	Harmful is not the right word, but there were consequences, as I was found to have a mass in the fourth ventricle of the brain which turned out to be an ependymoma and is under surveillance
Harmful	Because the MRI result didn't reveal that I have cancer in the left lung until I had a CT Scan a few days after the MRI

Another recurring theme in participants' feedback was the sense of reassurance experienced when they were not informed of any IFs or major MRI abnormalities. Many participants interpreted the absence of an IF report as confirmation that they had no significant health issues, reflecting the aim of the CAHHM IF policy to report only major abnormalities. However, not all participants fully understood the restricted reporting approach. For example, one participant assumed that the lack of IFs meant there were "no health problems," while another viewed the study as beneficial because it provided "any medically significant finding." These responses indicate

that some participants misunderstood the restricted IF reporting policy, assuming that no reported abnormalities equated to perfect health—a phenomenon the study terms "diagnostic misconception," further discussed below.

Participants also identified additional benefits from study participation, including contributing to scientific research and gaining greater awareness of their lifestyle and health risks. These responses highlight an educational aspect of the study, with participants gaining insight into how lifestyle and physiological factors may influence their health. Overall, there was a strong interest among participants in learning more about their health and wellbeing through the MRI scans and associated questionnaires.

Participants who viewed the study as harmful raised various concerns. Some described negative experiences related to the MRI procedure itself, such as claustrophobia or discomfort from the machine's noise. Others expressed frustration or anxiety related to the IF management process. For instance, one participant felt unsettled by not receiving more information, despite the consent process specifying that only major IFs would be disclosed.

Several participants reported concerns about the IF diagnoses they received. One participant was anxious after an IF revealed a brain ependymoma under surveillance. Another participant, diagnosed with breast cancer the following year, felt that the MRI had failed to detect an important abnormality. A third participant expressed similar concerns regarding a lung cancer discovered via a subsequent CT scan. These cases suggest instances of potential false-negative results, where clinically relevant abnormalities were not reported. They also indicate a common assumption among participants that all abnormalities should be reported, highlighting a misunderstanding of the CAHHM IF policy.

Despite these concerns, approximately 90% of respondents (322/357) indicated they would participate in the study again, with no difference between those with or without IFs. Similarly, the majority (94%) would recommend that the general public undergo an MRI scan, regardless of IF status.

Discussion

The CAHHM IF management policy was designed based on the Tri-Council's three core principles for ethical research: Respect for Persons, Concern for Wellbeing, and Justice. The framework aimed to respect participant autonomy, maximize benefits while minimizing harm, and ensure fair and equitable treatment of participants. The results from CAHHM provide important insights into optimizing these principles in future MRI studies.

A notable finding relates to the informed consent process: 99.7% of participants agreed to be informed of IFs. This is an exceptionally high rate, particularly considering the potential risks associated with IF disclosure. Participants were informed that receiving IF information could result in the findings being added to their medical records—potentially accessible to employers or insurers—and were given the option to decline.

Many participants were motivated by personal health considerations and the opportunity to access high-cost MRI scans, which may be otherwise difficult to obtain for healthy individuals. Feedback indicates that participants valued the IF process and the ability to learn "useful information" about their health. One participant even described the primary benefit of participation as the "possibility to have an MRI," demonstrating the MRI scans and their findings were key motivators for enrollment. This aligns with findings from other imaging studies, such as the Rotterdam study, where participants cited a desire to "take responsibility" for their health by obtaining detailed health information as a primary motivator [16].

Overall, the high rate of consent to receive IFs indicates participants' strong desire to learn about their health and exercise autonomy in managing it. The CAHHM policy, by offering disclosure of IFs, supports this autonomy while maintaining ethical standards regarding the type and significance of information shared.

It was notable that only 3 out of every 1,000 participants chose not to receive information about IFs. This discrepancy raises questions about whether participants truly understood the benefits and risks of the IF process during consent. As reported by Bomhof *et al.* in the Rotterdam study, many participants had not anticipated the possibility of receiving an IF and felt unprepared when they did, even though they had consented to IF disclosure with the intention of assessing their health [16]. This suggests that despite reading and understanding the consent form, some participants may underestimate the likelihood or significance of an IF occurring in their own case. Consequently, participants might agree to receive IF information without fully reflecting on its potential benefits and harms. The Rotterdam study also noted that even a detailed

discussion of IFs during consent may not fully prepare participants for receiving an actual finding. Nevertheless, providing more comprehensive information about the prevalence, benefits, and risks of IFs during consent could help participants make more thoughtful, autonomous decisions, including exercising their right not to know about abnormalities. This might reduce the exceptionally high rate of consent to receive IFs.

The results from CAHHM also provide insights regarding the restricted approach to IF management. Among over 8,000 participants, 8.3% (95% CI 7.7–8.9%) were found to have at least one severe structural abnormality on MRI. For most participants, disclosure of IFs had little or no impact on quality of life. However, approximately half experienced increased stress, and a small proportion reported a negative effect on quality of life. Both quality of life and stress were self-reported by participants using an electronic follow-up questionnaire (Additional file 3: Supplementary Comment 2).

A notable finding was the discrepancy between stress and quality-of-life reports. Nearly 50% of participants reported some degree of stress after receiving IF feedback, with 15% experiencing moderate to high stress, yet most reported minimal effects on quality of life. Intuitively, one might expect stress related to health concerns to reduce quality of life. This discrepancy aligns with findings from the Rotterdam study, which suggest that the true impact of IFs on participants and their families may be greater than standard survey measures capture [16]. It is possible that while participants reported minimal impact on overall quality of life months after receiving feedback, short-term stress and anxiety experienced immediately after disclosure were not reflected in these later assessments. Alternatively, participants may not consider stress as a central component of quality of life, which raises the question of whether stress should be weighed heavily in IF management frameworks if it does not meaningfully impair participants' wellbeing.

Another key finding relates to participants' disappointment in not receiving reports for certain abnormalities and highlights the prevalence of diagnostic misconception in the CAHHM study. Diagnostic misconception, adapted from the concept of therapeutic misconception, occurs when participants mistakenly believe that research participation provides individualized diagnostic information, failing to distinguish research from clinical care [25, 26]. This misunderstanding can compromise participant autonomy, as individuals may overestimate the personal health benefits of participation without fully considering the limitations and risks. In CAHHM, participants who believed the MRI scans provided comprehensive health assessments might assume that a negative result meant they were completely healthy. While this may reduce anxiety, it could also lead to a false sense of security, decreased vigilance in routine health checks, or a reduced likelihood of seeking care for emerging symptoms, potentially causing harm.

Participants' questionnaire responses highlighted the presence of diagnostic misconception. For instance, those who perceived the MRI scan as beneficial often described it as providing "useful information about [their] health," allowing them "to understand [their] current health status," to "know more about [their] health," or to confirm that "[their] health is ok." Similar to previous studies, it appears that some participants may have interpreted the absence of reported IFs as a sign of good health, which is concerning because it reflects a misunderstanding between research and clinical care, and may even have influenced participation [27]. If participants assumed that the MRI results offered a comprehensive assessment of their health, they may have joined the study without fully reflecting on the risks and limitations. Likewise, those with negative findings may have felt overly reassured about their health. Ensuring that participants have a clear understanding of the benefits and risks of research participation is essential for informed consent and for enabling participants to manage their health knowledgeably. It is important that participants recognize that IF reports indicate only certain specific abnormalities, rather than providing a clinical-level health evaluation. Although consent forms clearly outlined risks and benefits, these findings suggest the need for more in-depth discussions about the IF process. Future studies should emphasize thorough explanations of IF disclosure during consent and reinforce the distinction between research imaging and clinical care. The prevalence of diagnostic misconception observed in CAHHM participants highlights the importance of addressing this issue in future imaging studies.

Evaluation of the CAHHM framework

The CAHHM results offer valuable insights regarding the application of the Tri-Council Policy's three ethical principles. Respecting participants' autonomy began

with the consent process, which described the MRI procedure, the types of abnormalities that could be reported, and the potential consequences of receiving such information. This ensured participants understood both the benefits and risks of IF disclosure prior to participation. The policy also upheld participants' right not to know about severe structural abnormalities, allowing them to choose the option that best served their interests rather than having the research team impose the decision.

Another key aspect of respecting autonomy was the provision of actionable information about severe IFs to consenting participants. This enabled participants to make informed decisions about their healthcare. Participants' feedback indicated that receiving information about significant IFs allowed them to monitor and manage their health, reinforcing the importance of disclosing clinically relevant findings to support autonomy and health management.

Despite these measures, some participants demonstrated diagnostic misconception, as indicated by disappointment when abnormalities discovered months after the study were not reported. These responses suggest that participants did not fully understand the limitations of the MRI scans, which may have constrained their ability to make informed decisions about IF disclosure and subsequent healthcare actions. This highlights an area where future MRI studies should focus on improving participant understanding of consent limitations.

The principle of Concern for Wellbeing, encompassing beneficence and non-maleficence, was central to the restricted approach to IF management. Following the duty of easy rescue outlined by Koplin *et al.* [28], the protocol aimed to inform participants about potentially life-saving or life-improving IFs. The follow-up study showed that 8% of participants received additional management as a result of their IFs, demonstrating the protocol's success in providing meaningful health benefits.

Overall, participants reported high satisfaction with study participation. Most indicated they would enroll again and considered the MRI beneficial, irrespective of whether they were informed of IFs. These findings align with prior research, such as the UK Biobank, where over 95% of participants who received IF feedback valued the information and were glad to have participated [14,27]. Only a small proportion (3%) reported that participation negatively impacted their quality of life, suggesting that the CAHHM protocol effectively minimized harm. Nonetheless, nearly half of participants experienced some stress upon receiving an IF, with 15% reporting moderate to high stress, indicating that while overall quality of life was largely unaffected, the IF reports did produce some harm. Similar patterns have been observed in other studies, such as the Study of Health in Pomerania (SHIP), where nearly 30% of participants experienced moderate to severe psychological distress after IF disclosure [25], and the UK Biobank, where about 20% reported negative emotional impacts from IF notifications [14].

The relatively high proportion of participants experiencing stress from IF reports highlights a key advantage of the restricted approach to IF management, as it limits the number of notifications about findings of minimal or uncertain significance, thereby reducing unnecessary stress. For most participants, the disclosure of an IF did not affect life insurance policies or cause adverse consequences; however, four out of 74 participants with an IF reported that their insurance was impacted. This illustrates another potential harm from IF disclosure, which can be mitigated by the restricted reporting approach.

Another area of concern raised by participants was the occurrence of false-negative reports, where abnormalities were identified after the study but not reported during IF feedback. While the protocol screened for malignancies and other serious abnormalities, it is possible that small cancers were either not considered material enough to report or developed after the MRI, being diagnosed a year later. This underscores the importance of minimizing false negatives, in line with the duty to reduce harm. Even if these findings were outside the study's list of reportable abnormalities, a more comprehensive scan review might have detected them. This highlights a potential limitation of restricted IF reporting: although it reduces false-positive reports, it may inadvertently omit clinically significant findings for some participants. Future MRI studies should carefully consider which abnormalities are included in analyses to minimize missed diagnoses (Additional file 3: Supplementary Comment 3, Supplementary Comment 4).

Regarding the principle of Justice, the CAHHM restricted approach ensured that all participants received information on the same types of abnormalities, promoting fairness and consistency across the study population. Additionally, efforts were made to minimize

delays in reporting IFs, with reporting times improving as the study progressed.

Overall, IF management is a complex ethical challenge that requires balancing multiple considerations. In CAHHM, the restricted approach provided tangible health benefits to some participants while minimizing harms associated with false positives and stress from IF disclosure. Participant satisfaction was high, and only a very small proportion viewed participation as harmful. Nonetheless, ethical tensions remain; while participants may desire information about all potential IFs, researchers have a responsibility to limit harm by avoiding reports of findings with minimal or unknown significance. This underscores the need to balance autonomy with non-maleficence. Although practices for handling IFs vary widely in clinical studies [29], the CAHHM framework for managing severe structural abnormalities, and the lessons learned, offer a practical guide for future research.

Limitations

Several limitations should be noted. First, only a small subset of CAHHM participants were invited to complete the follow-up questionnaire due to logistical constraints, limiting the number of individuals with clinical IFs available for follow-up. Second, the questionnaire was designed to capture basic parameters regarding study impact and did not include input from other stakeholders, such as family physicians or relatives, nor did it gather longer narrative data through in-depth interviews, which may better capture the full impact of IF disclosure [16]. Conducting follow-up interviews, while time-consuming, would be valuable to understand the true consequences of IFs for participants. Third, complete information on outcomes and final diagnoses for participants with clinical IFs was not available. A systematic follow-up to assess these outcomes would clarify the impact of IF reporting and the prevalence of false positives. Finally, the COVID-19 pandemic introduces additional complexities for managing IF follow-up in ongoing studies, highlighting the need for careful consideration of participant safety and research protocols.

Conclusion

Managing incidental findings from research MRI scans remains challenging, as disclosure can cause stress and affect quality of life. A restricted, transparent approach—limiting routine feedback and reporting only severe structural abnormalities to consenting participants—addresses both clinical and psychosocial considerations. This study demonstrates that the restricted approach can balance respect for participant autonomy, concern for wellbeing, and fairness in research. While further work is needed to understand diagnostic misconception and the risks of false-positive and false-negative reports, the CAHHM policy adds to current knowledge and provides a framework for future MRI research studies.

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