

Figure 1: Number of cardiology outpatient referrals to Health New Zealand – Te Whatu Ora Waitematā, 2014–2023.

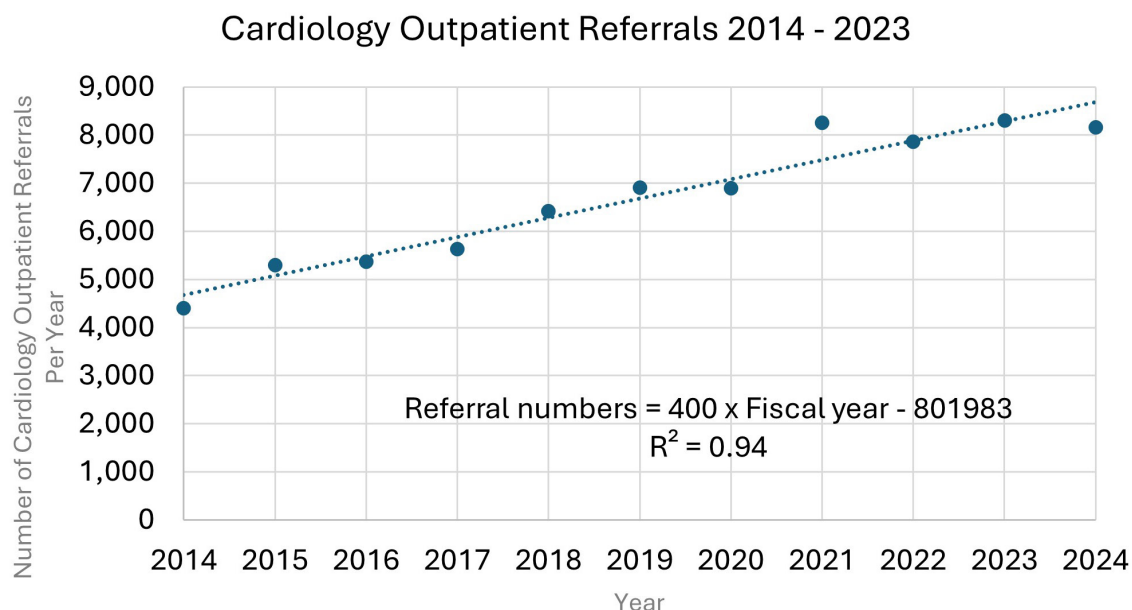


Table 1: Outpatient referral pathway.

Node	Aim	How to achieve aim
A) GP referral	Capture information that is structured and adequate	Information fields filled by clicks and drop-downs, or by voice recognition
	Facilitate GP efficiency	GP dashboard
B) Referral triage	Increase appropriate declines and acceptances	Iterative development of algorithms/decision trees
	Facilitate triager efficiency	Triager dashboard
C) Accepted referral	Increase proportion of FSA done at triage (combined triage and non-contact FSA)	Incentivise triagers
D) Clinic FSA	Reduce need for follow-ups	Incentivise contingent planning in initial FSA letter
	More remote evaluations	Test novel approaches such as telehealth and biomarkers

Possible intervention points to improve the outpatient referral process and prepare the ground for AI: A) Instead of free text, decision trees capture an adequate amount of information in a structured way. Informational aspects are built in to assist GPs in determining what conditions and severity warrant referral. A dashboard containing representations of (and links to) all pertinent information on one screen enhances efficiency and reduces clicks per task. B) Decision trees are iteratively refined until they can reject or accept a proportion of referrals without human intervention. A dashboard allows triaging cardiologists to access relevant cardiac information for the patient more readily. C) Not covered in this study, but once referrals are accepted, a greater proportion of FSA are carried out as a virtual non-contact FSA by the triager providing written advice to the GP. Concluding the FSA at this stage avoids the bulge of referrals moving on to increase wait times for clinic FSA and procedures such as echocardiography and Holter monitoring. D) Not addressed in this study. See text for details. GP = general practitioner; FSA = first specialist assessment; AI = artificial intelligence.

Table 2: Elements of automated decision support for GP referrals.

Term	Description
Structured information	Required for whatever decision support method is chosen. Provides a minimum dataset, which makes ML predictions less variable and facilitates more rapid training of AI.
Human-designed decision trees (transparent predictions)	<p>Designing these will facilitate cardiologists' consensus in the development of reference decisions for training ML.</p> <p>Can be improved iteratively as cases are encountered that don't fit the current tree decision.</p> <p>Contain domain knowledge of cardiologists that can frontload the training of ML.</p> <p>Can replace human oversight of ML decisions.</p> <p>Interacts in a continuous feedback loop whereby new predictors from ML are added to the decision tree, which then provides a more complete dataset on every patient. This makes ML predictions more consistent and reliable.</p>
Machine learning (opaque predictions)	<p>Extends the predictive power of decision trees by incorporating free-text information contained in referrals.</p> <p>Identifies new predictors that are then incorporated in the structured questionnaire, thus improving the minimum dataset obtained on each patient.</p>

GP = general practitioner; ML = machine learning; AI = artificial intelligence.