WORKING THE CROWD FOR FORENSIC RESEARCH:
A REVIEW OF CONTRIBUTOR MOTIVATIONS AND RECRUITMENT STRATEGIES USED IN CROWDSOURCING AND CROWDFUNDING FOR SCIENTIFIC RESEARCH

By

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Declaration

I declare that this thesis does not contain any material submitted previously for the award of any other degree or diploma at any university or other tertiary institution. Furthermore, to the best of my knowledge, it does not contain any material previously published or written by another individual, except where due reference has been made in the text. Finally, I declare that all reported experimentations performed in this research were carried out by myself, except that any contribution by others, with whom I have worked is explicitly acknowledged.

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Part One

Literature Review

Working the crowd for forensic research:

A review of contributor motivations and recruitment strategies used in crowdsourcing and crowdfunding for scientific research

Abstract

Crowdsourcing and crowdfunding for scientific research have been used successfully in a range of fields. This review found that crowdsourcing can be a useful tool in scientific research, but project organisers must ensure that they develop clear goals and experimental protocols and provide instructions or training for contributors along with user-friendly tools and interfaces. There must be effective methods of validating data to ensure the study is robust. Effective communication strategies are essential to aid in recruitment and to provide feedback to contributors. Crowdfunding for scientific research provides an alternative source of funding for projects and particularly favours junior researchers and early-stage research. Research into scientific crowdfunding has demonstrated that platform selection, communication, use of rewards and promotion by other parties contribute to the success of a fundraising campaign. A key aspect of successful crowdsourcing and crowdfunding is targeting appeals to a motivated crowd of individuals. This opens up a new area of research to identify an appropriate target audience to support crowdsourcing and crowdfunding of forensic research.

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List of Abbreviations

ARC	Australian Research Council
COASST	Coastal Observation and Seabird Survey Team
DNA	Deoxyribonucleic acid
eDNA	Environmental DNA
NIH	United States National Institutes of Health
PCAST	President's Council of Advisors on Science and Technology
US	United States (of America)

1. Introduction

Success in research is often measured by publication (1-4), which creates an environment where scientific researchers are increasingly under pressure to collect large amounts of data from a diverse range of subjects at the lowest possible cost and at a rate that enables them to publish findings sooner than their counterparts (1). In forensic science, like all fields of science, any new technique or process must undergo rigorous testing and peer review in order to be validated and accepted (5). However, commentators note that in some forensic fields, equivalent standards for empirical testing and validation have not always been followed (6), particularly where change is occurring at a rapid rate (5).

Research laboratories provide an environment that is conducive to extensive empirical testing and has effectively delivered many advances in analytical techniques. As an example, in the years since it was first proposed that deoxyribonucleic acid (DNA) could be used for forensic purposes (5), analytical processes now enable forensic scientists to analyse samples much more quickly (7-9), and to target different regions of the DNA (7). These advances have been facilitated by the fact that DNA itself has not changed (5) so there is time to gather data, to test and re-test and to provide evidence that promotes acceptance of those new techniques. However, it can be difficult to gain financial support for novel enquiries or junior researchers (10), to gather the amounts of data required to test a hypothesis and to conduct extensive testing (10). Forensic researchers using scenario-based studies note the difficulties of attracting a diverse range of subjects, and in particular that these types of investigations rely heavily on university undergraduates (11) and are not reflective of the general population or even necessarily of a sub-population to which a study is relevant.

Privatisation of forensic services in some countries has seen a shift in priorities from high-quality, unbiased scientific support to a business model with key performance indicators and a focus on the company's return on investment (12). Before commencing research, businesses and academic institutions alike must allocate or secure funding, and applying for grants from major funding bodies is highly competitive (13-15). The Australian Research Council (ARC) suffered from budget cuts following the 2014-15 financial year (16, 17), and current projections to 2023 do not show a full recovery in grant funding (18). In other markets, while the dollar figure is increasing, when adjusted for inflation, available funds have decreased in real terms (19, 20). Meanwhile, the number of applications continues to grow, with the United States National Institutes of Health (NIH) reporting that in the past 20 years, applications for funding have more than doubled (21). However, as shown in Table 1, the rate of successful approvals has been unable to match that growth (21).

Table 1 NIH Project Success Rates

Year	Number of Applications Reviewed	Number of Applications Awarded	Number of Unsuccessful Applications	Success Rate
1999	26,408	8,556	17,852	32.40%
2008	43,467	9,460	34,007	21.80%
2018	54,834	11,071	43,763	20.20%

An additional challenge for newer researchers is that traditional funding application processes tend to favour researchers who are already established in their fields and probing more deeply into existing research areas (16), so it is hard to gain recognition in this environment.

These challenges are not unique to forensic science, and a range of other scientific disciplines have already successfully turned to crowdsourcing and crowdfunding in order to combat these issues.

2. Discussion

2.1. Crowdsourcing

The term *crowdsourcing* was first used to describe a process where businesses or organisations turned from paid *outsourcing* to using the internet to draw on the skills of an unidentified *crowd* to solve problems (22). Early examples describe companies openly sharing their research and development problems and offering financial rewards of up to $100,000 to a contributor who could successfully provide a solution (22). Put simply, *crowd science* or *citizen science* is crowdsourcing for scientific research (23). More detailed definitions for crowd science and citizen science exist, with the critical aspects including the intentional involvement (24-32) of volunteer contributors (33-37) to scientific research.

The tasks involved in scientific projects vary greatly, so some definitions differentiate three project categories, *contributory, collaborative* and *co-created*, based on the level of involvement of volunteers (25, 30). Others make a distinction between crowdsourcing and crowd science based on the level of interaction between the researchers and the contributors (1). The overlapping relationship between these distinctions is explained in Figure 1.

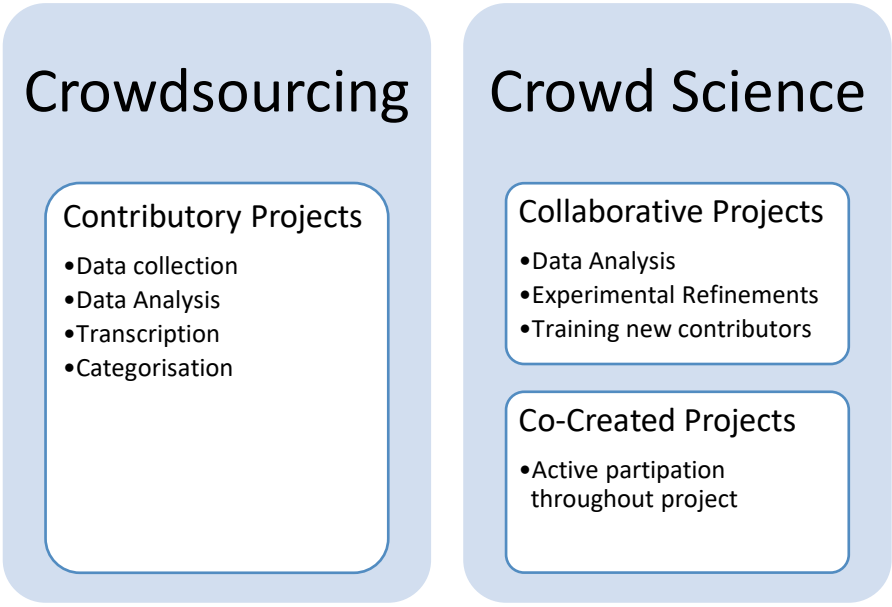

Figure 1 Levels of involvement of volunteer contributors to crowd science projects

Contributory projects fit into the crowdsourcing definition, which shows a predominantly one-way flow of information; researchers seek input from large numbers of contributors in the form of data collection or analysis (25, 30), transcription or categorisation (37, 38), but don't necessarily provide feedback or share data and results with contributors (1). Conversely, in collaborative and co-created projects, contributors are active participants in the project and may be involved not only in data analysis but also in project design, experimental refinements, training newly recruited contributors and even in the preparation of publications (1, 3, 30). Collaborative and co-created projects, which are characterised by a two-way interaction between contributors and project organisers, are representative of crowd science (1). For the purposes of this review, these distinctions are not being considered, and the terms crowdsourcing and crowd science will be used interchangeably.

A difference of opinion is observed relating to the contributors themselves, who are variously described as non-scientists (4, 31, 39-42), non-specialists (42, 43), non-experts (36) or non-professionals (25, 31). However, some researchers state that one of the benefits of drawing on the crowd is cheaper access to specialised and possibly rare skillsets (1, 29, 35). In fact, some crowd science projects rely on contributors who have particular skills or expertise that the scientists do not have, such as scuba diving qualifications (44, 45).

Crowd science has traditionally been the domain of wildlife projects (24, 31, 35, 37, 46), particularly ornithology (31), but is also widespread in fields such as meteorology (24, 32), environmental science and monitoring (24, 32, 47, 48) and astronomy (1, 24, 49). Perhaps the earliest documented use of crowd science was the gathering of observations of an 1833 meteor shower from across the United States (US) (49). The US National Audubon Society's Christmas Bird Count, which takes place annually, commenced in 1900, earlier even than the establishment of the Society (50). Driven by the expansion of the internet (40, 51, 52) and advances in mobile technology, such as smartphones (53), the use of crowdsourcing in research is growing, in both online and hands-on projects (3, 4, 53). In recent years, crowd science has been adopted in a more diverse range of fields, including biochemistry (1, 32), genetics (1) and medicine (1, 47).

One of the benefits of crowdsourcing for scientific research is the ability to gather much larger volumes of data (4, 29) at much lower costs (4, 29, 35). A 2015 study investigated the contributions made to seven online projects hosted on Zooniverse.org in 2010 and found that during the first six months after each project was initiated, 100,386 individual site users contributed a total of 129,540 hours of labour, which was estimated

to be worth over US $1,500,000 (29). A separate study of 388 hands-on biodiversity projects estimated the ongoing contributions to those projects as being valued at up to $2.5 billion each year (4). Additionally, wildlife studies, ecology and environmental science projects benefit from the ability to gather data from a much larger geographical area than research teams alone can achieve (4, 35, 37, 42, 46, 54-59), including from areas that are not accessible to the public (25, 60, 61), and to gather data over a more extended period of time (2, 31, 37, 42, 48, 56, 58, 60, 61). Forensic studies into topics such as environmental DNA (eDNA) (62) might be able to extend the boundaries by reaching out to a higher number of contributors.

The secretive nature of the publish-or-perish environment is no longer sustainable as funding bodies are increasingly requiring researchers to make data available and participate in community outreach and education programs (1, 2, 35, 37). The use of crowd science can facilitate these requirements (1, 2, 35, 37). Focus group research conducted with marine science participants found that the identification of education and outreach strategies during the planning phase of a project can also assist in identifying desirable contributors based on their existing skills and knowledge (38).

Crowd science has been criticised for lack of rigour (63, 64) and issues with data quality (31, 44, 63) despite demonstrated evidence that the increased scale of data collection acts to negate the effect (25, 38). A 2017 study surveyed 423 published biodiversity scientists to investigate the reasons why the increasing number of crowdsourced projects continues to generate a relatively low number of publications (63). Findings showed that scientists who had not used crowdsourced data continued to place more emphasis on data collected by academic research scientists, that they believed that

crowd-contributed data is of a lower quality or is inconsistent, that they did not know about relevant crowd science projects, and finally that they believed that not all types of projects were suited to the crowdsourcing model (63). Scientists who had used crowdsourced data placed a high value on proper training of contributors to ensure accuracy and consistency, and the study emphasised the importance of designing projects with appropriate methodologies to produce data that is relevant to scientific goals (63). This finding aligns with recommendations by other researchers who stress that successful projects must include attention to experimental protocols (3, 55, 57), contributor training (3, 28, 43, 56, 65, 66) and appropriate tools (25, 30).

Perhaps the biggest challenge for crowd science is the recruitment and retention of volunteer contributors (1, 29, 40). The question of how contributors are being identified and recruited to scientific research remains mostly unanswered. In cases where specific target contributors were described, it was commonly in generic terms, including members of the public (43), skilled observers (59), hikers (67) or divers (45). Some projects describe selection criteria such as age requirements (11, 68), while in a report on a particular study relating to the analysis of using online games with a purpose (23), researchers note that the goals of this project dictated recruitment of different contributors than for an earlier project on the same game activities (69). Similarly, recruitment processes describe recruitment strategies in non-specific terms, such as press releases (43), media exposure (43) or social media (43). A rare few include information on the number of people being targeted (67, 70) and when they do, the recruitment is shown to be very low. One study reported targeting hikers who visited the Appalachian Mountain Club facilities and quantified this at approximately 500,000 people per year, but over five years, managed to

recruit only 1,775 contributors to their project (67). Another study reported specific details of audience numbers who listened to radio interviews, circulation numbers of printed publications that ran articles, numbers of project-produced pamphlets and brochures, the number of visitors to online articles along with Facebook analytics relating to the number of times the article was shared (70). Initial recruitment numbers were not provided, but at the final workshop, only 16 contributors remained who had been involved throughout the entire eight months of the project (70).

Participation rates are typically low for online projects (66). Foldit is an online project that enables contributors to decode protein structures in a competitive, gaming-style application (1, 40). In the four months after it was launched, 50,000 contributors, or players, had registered, and by the end of the first year, the number had grown to approximately 200,000 (1). However, a more in-depth look at contributor profiles and associated online discussion boards revealed that the actual number of active contributors was likely to be under one thousand (40), less than 0.5% of the total number. Longer-term studies display a cyclical pattern of contribution with increased activity following any additional promotion of a project (43). An online medical imaging classification project, launched in October 2012, described an initial recruitment drive via a press release, which was broadcast by several online media outlets and on television (43). A month later, an online article saw an additional 15,000 contributors register for the project, with similar spikes in activity occurring after promotion on social media and other outlets (43). Over 100,000 contributors participated during the eight-month project, but on an average daily basis, only a few hundred contributors were active, and the average number of

classifications per contributors was low, with 95% performing 47 classifications or fewer (43).

Attrition is seen in hands-on projects as well, but not to the same extent (66), and smaller projects report intentionally over-recruiting to overcome this problem (71). A small number of studies report retention rates after 12 months of a project (59, 66, 71), and they can be as high as 71% (59). The Coastal Observation and Seabird Survey Team (COASST) project, a project which recruits north-western US coastal residents to record bird carcasses found on the beaches, reported retention of 14% after five years of participation (66). Further analysis of the contribution of retained participants in the COASST project revealed that while the long-term contributors represented a higher number of hours of participation, it didn't correlate with their actual results in terms of recording birds, and as many as one third had never actually submitted any bird-sighting data (66). It would appear that success isn't driving the continued participation of contributors to this project.

Contributor motivations have been studied, and common driving forces include interest in the subject of the study (44, 58, 61, 72), the desire to make a difference by contributing to scientific research (31, 42, 44, 73-75) and to learn more about the subject of the study (42, 61, 72) or science in general (40). Ornithology studies in particular recruit avid birdwatchers (58), while some contributors report that engaging in a scientific project gives their hobby a purpose, allowing them to justify spending more time in the pursuit of something they enjoy (76). It has also been seen in longer-term studies that motivations change, and while initial participation may be driven by an interest in a subject, over time, participants increasingly report being motivated by learning (44).

Social aspects of crowd science are poorly understood, with descriptions of crowd science suggesting that contributors are mainly unknown to research organisers or each other (1), yet some contributors report that they are motivated by the social connections that they make through participation (29, 61, 76) There is also evidence to suggest that face-to-face interaction with project organisers increases other motivational factors (77) and it is certain that contributors use their own social networks to aid in additional recruitment (3, 61).

A consistent finding is that it is crucial that research teams continue to communicate with contributors through the life of the project, and even after their contributions have finished (38, 39). It is essential to provide feedback to contributors (35, 53, 61). Mechanisms for communication include email reminders with tips on how to perform project activities (71), newsletters or letters (61, 71), magazines or press releases (71). Feedback should go beyond merely thanking contributors for their participation (53) to provide information on results and progress as the project progresses (38). Communication has also been highlighted as a potential issue for research teams who may feel apprehensive about working with volunteers (2).

Crowdsourcing has been demonstrated as a useful tool in scientific research, as long as projects are designed carefully to include clear goals or hypotheses (35, 38, 56, 57), clear experimental protocols (1, 35, 37, 49, 78), instructions or training for contributors (37, 38, 43, 44, 54, 56, 65), user-friendly tools (56) and interfaces (35), effective methods of validating data (35, 37, 56, 65-67), and effective communication strategies to provide feedback to contributors (35, 38, 54, 61). Based on demonstrated low participation rates and high attrition rates, it may be more appropriate to use crowdsourcing in projects that

require discrete, tasks that are low in complexity (1, 29) and allow for opportunistic involvement, rather than sustained, scheduled or high-demand tasks that require significant time commitments (29, 70).

2.1.1. Lowlands Science Program

Instead of crowdsourcing, some forensic researchers have chosen to take their research to the crowd. The Lowlands Science Program in the Netherlands is a collaboration between *New Scientist* and the Lowlands Music and Performing Arts Festival (79). The annual festival runs over three days and draws around 50,000 attendees each year (11). The science program commenced in 2015 and enables researchers to involve festival visitors in science projects in an enjoyable way (79). Festival-goers volunteer to participate in experiments and researchers are able to gather data in the process (79). Projects are selected each year based on proposals that are submitted by interested researchers (79) and the 2019 science program listed 13 research activities (80). In the past, the Netherlands Forensic Institute and Police Academy have been involved with research studies conducted at the festival (79) and three forensic-based studies performed at the festival have been published in peer-reviewed journals (11, 68, 81).

In 2015, researchers from the Netherlands Forensic Institute teamed up with representatives from two universities to determine the main contact locations that should be targeted for forensic trace evidence recovery when a body has been relocated (81). 705 volunteers participated in 305 experiments over the three days (81). Ages of volunteers were reported in ranges, with the youngest volunteers aged 10-14, and the oldest aged 60-64 (81). It was noted that the age distribution was similar to the age distribution of Dutch

offenders who had been convicted of homicide, but the study's population had a much higher proportion of female participants at 59% compared with only 10% of convicted offenders (81).

Also in 2015, behavioural science researchers investigated the use of virtual reality to study processes of criminal decision-making (11). For this study, participation was restricted to males aged over 18 (11). The 145 participants ranged in age from 18-48 years, with the distribution being reflective of the age distribution of prison populations of male offenders (11). This study also gathered data on volunteers' highest level of prior educational achievement and found a diverse range that included varying levels of high school education, higher professional education and university-level qualifications (11).

In 2016, the Netherlands Forensic Institute was back again, this time working with university researchers to try to predict activity based on fingermarks on a two-dimensional surface based on the distribution of the marks (68). 176 participants generated 132 full sets of usable data (68). Participation was restricted to over 18 years of age, and included both males and females, with a slightly higher percentage of females (68).

All of the studies were conducted over the three days of the festival (11, 68, 81), an approach that enabled the research teams to collect a relatively large amount of data in a short period (68, 81). Across the three studies, an average of 195 usable sets of data was collected. Two of the studies describe the process of briefing participants and obtaining signed consent forms from volunteers (11, 68), which must be a consideration when planning these activities. Participants were diverse in age and educational background (11, 68), which contrasted with the observation that these types of scenario-based studies are frequently dominated by university undergraduates (11).

2.2. Crowdfunding

In a similar way to the evolution of the term crowdsourcing, crowdfunding emerged as an alternative means of procuring financial investment for a range of activities, including business ventures (82-85), creative and artistic projects (78, 86) and charitable donations (82). At its most basic definition, crowdfunding may be described as an open call for financial resources (83, 85, 87, 88). This approach reduces the reliance on a single source of finance and may be able to provide additional funds or replace other methods of funding by connecting a research team with multiple financial contributors (20, 89-91) who are able to donate an amount of their choosing (82, 91). Crowdfunding is commonly achieved using an online crowdfunding platform (12, 13, 78).

There are a number of specific research-focussed crowdfunding platforms (13), such as Experiment (http://www.experiment.com), which is based in the US and Italy's Consano (http://www.consano.org), but other platforms such as the German Science starter (https://www.startnext.com/pages/sciencestarter) and US-based Kickstarter (https://www.kickstarter.com) also host research projects. Scientific research has also successfully received crowdfunding via organisational websites, such as the Dutch Heart Foundation (10). Standard features of crowdfunding platforms include a description of the project and its goals (13, 92), the target funding amount (13, 92), a payment processing system (92) and indicators of the number of contributors (92) and fundraising progress (13).

The most common approach to the disbursement of funds is the all-or-nothing model (13). In this type of appeal, the research team sets a limited timeframe for achieving the target amount (13, 93), but receives no funding if the target is not met by the deadline

(13, 87, 93, 94). This has been described as a benefit to contributors (95), who make their contribution as a pledge, but retain their funds if the project does not go ahead (13, 87). However, it can be frustrating for researchers who spend valuable time preparing a campaign and promoting a project only to have the funding appeal fail (95).

A second common crowdfunding approach is the keep-it-all, or donation, model (13, 87). With this type of appeal for funds, researchers set their financial goal and may stipulate a defined period for fundraising, but in this model, contributed funds are disbursed at the end of the fundraising period regardless of whether the goal is achieved (93). In fact, forensics is not a stranger to the donation model with law enforcement having worked closely with the DNA Doe Project (96, 97), an organisation which is funded entirely by donation and staffed by volunteers (98). The DNA Doe Project was set up in 2017 (97) and uses genetic genealogy to identify unknown human remains and reunite them with their families (98). The DNA Doe Project has so far achieved success in the identification of 14 people, which includes ten confirmed or suspected victims of crime (96, 99).

Charity-based crowdfunding is similar to the keep-it-all model already described but is used to raise funds for a particular cause or benevolent organisation, and there is usually no target or time limit to the appeal for funding (85). Equity-based, royalty-based and lending-based crowdfunding models are growing in popularity in business arenas (85, 87). These particular crowdfunding models are not applicable to research crowdfunding and will not be addressed here.

The primary benefit of crowdfunding for research is the ability to raise money outside traditional public and private funding networks (85). In addition to high competition for diminishing funds, another challenge with conventional funding sources is

that the application processes tend to favour researchers who are already established in their fields (16). Research into successfully crowdfunded scientific projects demonstrated that contributors are more likely to fund less established researchers (14, 85, 100), a finding that is in direct contrast with research into business crowdfunding, where backers look for evidence of past success (100). This support for junior researchers may be linked with the findings across all crowdfunding types that there is a high reliance on family and friends to contribute (85, 88, 101, 102), particularly in the early stages of the fundraising campaign (101). Experiment estimates that on average, family and friends make up more than half of the total number of contributors (85) and an early case study estimated that as many as 60% of contributors came from the single organiser's social networks (89). An alternative proposition is that younger scientists have more extensive social networks and are able to mount more effective appeals for funding (85). It has also been suggested that crowdfunding is more successful in funding early-stage and proof of concept studies (13, 90), riskier research (103) or projects that have been rejected by funding bodies (85).

Platform selection has been demonstrated to contribute to crowdfunding success, and for scientific research, selection of a research-specific platform is essential (13, 91, 104, 105) as research crowdfunding platforms platforms typically achieve higher success rates than other crowdfunding platforms (85, 104). This difference is demonstrated by the statistics posted on the sites with Experiment and Kickstarter currently report success rates of 46% (106) and 37% (107) respectively. While 46% higher than for other funding methods, it's still low – there is no guarantee that a project will secure funding via the crowd. When comparing research platforms, Experiment has a higher success rate than Consano, but the latter shows a higher amount raised for successful projects (104). It has also been observed

that crowdfunding for medical research typically benefits from being hosted on a platform that is specific to medical research as this generates a larger number of more generous donations (13). It is important to consider all the features of the platforms during the selection process.

An additional benefit of using a research crowdfunding platform, such as Experiment is that it provides a guide for researchers that contains information on the design and creation of the project, tips on promoting the project, measuring progress and sharing and updating information about the project (108), all of which may be very useful to the novice project creator. Crowdfunding for scientific research has been criticised for a lack of oversight (85) and the risk that people will not make choices on the scientific merits of a project (85). Regardless of the platform used, if acceptance in the scientific community is the goal, it is vital to adhere to the highest standards and to aid in this Experiment provides information about the approval process, including the criteria and process for acceptance and requirements for ethics approvals for projects that involve human or animal subjects (108).

Communication is critical in promoting the crowdfunding campaign (85) and in seeking funding, it is important to provide detailed information, using language that is easily understood (109). Some researchers describe hiring writers to ensure that the information provided meets this brief (10). As with crowdsourcing, contributors to crowdfunding also want to be updated with information about the progress of the project (85), which is consistent with findings relating to other crowdfunding types (94, 100). Studies have also found that project organisers who provide short videos about their project have a higher chance of success (78, 91) and medical researchers have used case

study videos of patients describing their struggles with disease and health care to promote research projects (10). This finding is in direct contrast with research findings relating to business crowdfunding, where contributors preferentially support campaigns that provide detailed text information (109).

Other factors contributing to successful crowdfunding campaigning include the endorsement of a project by a third party (10, 13, 85) or professional organisation (104), which helps to build confidence in the project and the research team (85). The offering of rewards is also strongly correlated with crowdfunding success in all fields (10, 78, 85, 86, 104) and the types of rewards stated for scientific research crowdfunding include T-shirts (104), a personal message (10) or signed copies of research papers (104), meetings with scientists or visits to the lab (85, 104) or photos of animal subjects (85). While not essential, if planning to use crowdfunding for research purposes, it is worth considering if a suitable reward can be offered.

In a similar way to how crowdsourcing contributions showed predictable patterns of activity based on promotion of a project, crowdfunding has a particular pattern of participation characterised by an early rush of input, and rapid attainment of around 20% of funding, followed by a slower period of activity, and then a second rush once 80% of the target has been met (88, 89). As the project gets closer to reaching the goal, it becomes more likely that it will succeed (88, 89, 94).

One of the most significant drawbacks to crowdfunding is the high cost of using a third party to manage the financial contributions. Experiment takes a hefty 8% of total funds from successfully funded projects as well as additional payment processing fees of up to 5% (106). As might be expected, research projects with lower targets have a higher

success rate (85, 104), which is consistent with the findings in other types of crowdfunding (92, 109) and it becomes clear that it can be challenging to succeed in this arena.

Across the board, there is limited research into what motivates a person to contribute to crowdfunding (92, 110, 111), but a recent study that identified non-profit goals as an indicator of success in scientific research crowdfunding (85), and success that has been seen with specific disease research (10) suggest the possibility that, like crowd science, contributors want to make a difference. Investing in forensic projects would allow contributors to have an impact on scientific research that has a direct effect on public safety and the ability to prevent, reduce and detect crime.

Crowdfunding for scientific research provides an opportunity to attract funding from alternative sources (81) and has been shown to support less established researchers (14, 85, 100) and proof-of-concept studies (13, 90). Platform selection (85), the offering of rewards (85).

Research into scientific crowdfunding has demonstrated that platform selection, communication, use of rewards and promotion by other parties contribute to the success of a fundraising campaign. A key aspect of successful crowdsourcing and crowdfunding is targeting appeals to a motivated crowd of individuals. This opens up a new area of research to identify an appropriate target audience to support crowdsourcing and crowdfunding of forensic research.

2.3. Targeting the Crowd

Social networks are essential to the success of any crowd recruitment. It is not enough just to broadcast, it is necessary to build up a following (86, 112) and the attraction of influencers has been identified as a significant factor affecting successful ongoing recruitment to crowd science projects (66). A recent study into the social networks of the Coastal Observation and Seabird Survey Team (COASST) identified the value of contributors who individually recruited as many as 30 additional participants (66). Researchers pointed out that these influencers weren't necessarily the highest performing contributors in volume or accuracy, but the indirect effect on data collection from increasing the number of contributors was substantial (66). Similarly, It has been proposed that equivalent crowdfunding influencers may add value to a campaign by promoting the project on their own social networks and attracting funding indirectly, even if their financial contribution is small (104).

There appears to be very little information published on how to identify a responsive target audience as potential contributors to projects, both as research participants or financial contributors, other than identifying the importance of deciding what skills are required to perform project tasks (38). Crowd science projects often rely on the general appeal of research topics (23) and while some papers discuss the benefits of targeted approaches to recruitment (3), they don't provide detailed information on how campaigns were launched and communicated and even less on the size of the target population compared with the resulting contributor numbers.

This review aims to identify common motivators that are applicable to contributors of crowdsourced and crowdfunded research projects and to propose an appropriate target crowd for forensic research purposes.

3. Experimental Design

3.1. Review of Existing Literature

A systematic review will be conducted to assess existing literature to determine whether contributors to crowd science and crowdfunding for scientific research share common motivations and whether there are defined strategies to employ to maximise the success of appeals to the crowd. The systematic nature of the review will provide a structured approach to ensure that relevant research is identified and selected based on specified search approaches, terminology and criteria for inclusion (47).

Automatic and manual searches will be used to identify relevant literature for the review from databases that include, but may not be limited to, Proquest, PubMed, Sage Journals, Science Direct, Scopus, Web of Science Core Collection and the Wiley Online Library.

Keyword searches will be used to identify possible articles for inclusion. To review motivations and recruitment strategies for crowdsourcing, search terms will include crowd science, crowd sourc*, crowdsource*, citizen science, participatory research, crowd fund*, crowdfund*, scientific research, motiv*, engage, engagement, engage*, recruit*, retain,

retention, strategy*, success*. Related searches will be performed based on the results and keywords used in articles that are selected for inclusion.

Search results will be limited to English language, peer-reviewed literature and the first 50 search results when sorted by relevance. Articles will be included in the review if they contain one or more of the following:

- Analysis of motivations for participation in crowdsourced or crowdfunded research projects.
- A detailed description and evaluation of strategies used to identify potential contributors to crowd science or crowdfunded projects.
- Specific details of promotional campaigns used to recruit participants to research projects or financial contributors to crowdfunding campaigns.

Articles generated through the keyword search will initially be judged on the content of the title and the abstract. Literature that is included based on this preliminary search will be read in its entirety to determine relevance for inclusion in the systematic review. Additionally, references cited in articles selected for inclusion will be sought by manual searches and analysed for inclusion based on the same criteria.

4. Project Aims, Objectives and Hypotheses

4.1. Research Aims and Objectives

This systematic review aims to determine whether there are common motivations shared by contributors to crowd science and crowdfunding for scientific research and to determine whether this information can be used to inform the selection of an appropriate target population to maximise the success of recruitment to crowdsourced and crowdfunded forensic science projects. This will be achieved by:

1. Researching the processes currently in use to determine target populations for recruitment to crowdsourced and crowdfunded scientific research.

2. Researching the motivations of contributors to crowd science and crowdfunding for scientific research.

3. Providing recommendations of an appropriate crowd to target to seek participation or funding for forensic research.

4.2. Research Hypotheses

H1: Analysis of the motivations of contributors to crowd science and crowdfunding for scientific research will identify common factors that drive the selection of research projects to support.

H2: A structured approach to defining the characteristics of contributors to crowd science and crowdfunding for scientific research can be used to identify a target group that is motivated to support forensic research.

5. Conclusions

Crowdsourcing presents an opportunity for forensic researchers to increase the amount of data that can be collected from a diverse range of subjects in a reduced period of time and at a reduced cost, while crowdfunding has the potential to offer access to an alternative or supplemental source of funding. In order to be successful, it is essential to identify an appropriate crowd who is motivated to participate in or contribute funds to forensic research projects, and to reach out to them with a targeted campaign.

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Part Two

Manuscript

Working the crowd for forensic research:

A review of contributor motivations and recruitment strategies used in crowdsourcing and crowdfunding for scientific research

Abstract

Crowdsourcing and crowdfunding have been successfully used in a range of scientific disciplines. These options present opportunities for forensic researchers to draw on the power of large numbers of people to contribute to research projects through participation or by providing an alternative source of funding. This review aimed to examine whether contributors to crowd science and crowdfunding for scientific research are motivated to participate or provide financial support by the same factors, and to examine recruitment strategies in an attempt to identify a potential crowd for forensic researchers to approach. There was found to be limited research into crowdfunding for scientific research that addressed the motivations of contributors or recruitment strategies used, and no conclusions could be made. With regard to crowd science, there are major challenges with low response rates to recruitment messages and high attrition which must be overcome. Over the lifetime of a crowd science project or crowdfunding appeal, it is necessary to target a large number of people who are interested in the subject being studied and who want to make a difference in some way and contribute to science. True crime podcast audiences are proposed as they present large numbers of listeners who are interested in forensics, crime or law enforcement. These audiences have already been targeted for successful fundraising efforts and invitations to get involved in crowd activities. This avenue could be considered by forensic researchers who are looking to venture into crowd science or to crowdfund research projects.

Keywords: Crowdsourcing, Crowdfunding, Scientific research, Citizen science, True crime podcasts

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List of Abbreviations

MS	Multiple Sclerosis
US	United States of America
US $	US Dollars

1. Introduction

For many years, 'success' in scientific research has largely been measured by achieving the goal of publication in a peer-reviewed journal (1-4). Combined with increased competition for funding (5-7), the pressure to be first to publish has created an environment where scientists must gather large amounts of data from a diverse range of subjects as quickly as possible (1) and at as low a cost as possible, all while maintaining required standards of rigorous empirical testing and validation that will stand up to the peer-review process (8). The secretive environment fostered by this competition is being discouraged by funding bodies, which increasingly require more transparency and visibility to data and for researchers to deliver education programs and participate in community outreach programs (1, 2, 9, 10). These challenges are not unique to forensic science, and a range of other scientific disciplines have already successfully turned to crowdsourcing and crowdfunding in order to address and overcome these issues.

1.1. Crowdsourcing

Early examples of *crowdsourcing* described the rise of internet organisations that provided individuals and companies with easy access to products, such as professional photographs, and skills, such as the ability to solve research and development challenges (11). Prior to this, there had been a reliance on paid outsourcing, but crowdsourcing presented a means of accessing large numbers of resources at a reduced cost, or to offer financial incentives for solutions, rather than paying for the time spent (11). *Crowd science* or *citizen science* is the extension of this approach into the field of scientific research, and is commonly defined as the intentional involvement (12-19) of volunteer contributors (9,

10, 20-22) to scientific research. Contributors have been described as non-experts (22), non-professionals (12, 18) or non-scientists (4, 18, 23, 24), but some researchers have acknowledged that, like other types of crowdsourcing, crowd science projects can benefit from contributors who have specific skills or expertise that scientists do not have (1, 10, 16). Other benefits of crowd science include the ability to gather large volumes of data (4, 16) over a more extended period of time (2, 9, 18, 25-28) at much lower cost (4, 10, 16). A 2015 study estimated that the contributions made to seven online projects during the first six months after initiation was worth US $1,500,000 (16), while a similar study of study of 388 hands-on biodiversity projects estimated the ongoing contributions to those projects at up to US $2.5 billion each year (4). Wildlife monitoring, ecology and environmental projects benefit from being able to gather data from a larger geographical area (4, 9, 10, 27, 29-31), including from areas that are privately owned (12, 25, 26).

Effective project design is essential for successful crowd science, including defined goals or hypotheses (10, 27, 30, 32), clear experimental protocols (9, 10, 32), instruction or training for contributors (9, 27, 32, 33), user-friendly tools and interfaces (22, 27) and effective methods of validating data (9, 10, 27, 33). Ongoing communication is essential to provide feedback to contributors (10, 26, 34) and information on results and progress, even after a contributor's direct involvement has ended (32).

Forensic science has so far taken the approach of bringing the science to the crowd. The Netherlands' Lowlands Music and Performing Arts Festival is an annual event that runs over three days, attracting a crowd of around 50,000 visitors each year (35). Since 2015, *New Scientist* has partnered with the festival to run the Lowlands Science Program, with a range of projects being selected from proposal submissions from interested researchers

(36). The program invites festival visitors to volunteer to participate in the experiments and researchers are able to gather their data (36). The Netherlands Forensic Institute and the Police Academy were involved with studies conducted at the festival in 2015 and 2016, which have culminated in three publications in peer-reviewed journals (35, 37, 38). The benefits of this approach included the ability to collect a relatively large amount of data in a short period of time (37, 38); across the three projects, an average of 195 usable sets of data were collected. Volunteers showed a wide range of ages and educational backgrounds (35, 37), and one of the studies noted this as a particular benefit because scenario-based studies are often dominated by university undergraduates (35). Two of the studies described the process used to brief volunteers and obtain signed consent forms prior to their participation (35, 37), a necessary requirement to ensure adherence to high research standards and compliance with ethical considerations.

1.2. Crowdfunding

Crowdfunding emerged as an alternative means of raising money for a range of activities, predominantly business development (39-42), creative and artistic ventures (43) and charitable fundraising (39). A basic definition describes crowdfunding as an open call for financial resources (40, 44, 45), a call which is commonly made over the internet, with funds collected via a crowdfunding platform (39, 41, 44, 45). Crowdfunding reduces the reliance on a single source of finance by connecting a research team with multiple financial contributors, who are able to donate an amount of their own choosing (39, 46). For scientific researchers, the primary benefit of crowdfunding is the ability to supplement

existing funding or provide an alternative source of funding (5, 46, 47) outside traditional public and private funding networks (48).

Reward-based crowdfunding is perhaps the most common type of crowdfunding (45). In return for financial support, contributors usually receive a tangible reward (49-51). The movie *Veronica Mars* was funded in this way (43), raising over US $5.7 million and with individual contributors eligible for tiered rewards ranging from an electronic copy of the script for a US $10 contribution to a speaking role in the movie and invitation to the premiere, which was limited to one reward for a contribution of US $10,000 (52). *Donation-based* or *charity* crowdfunding seeks financial support for a specific cause or benevolent organisation, and tangible rewards are not usually offered, although acknowledgement or recognition may be provided (49). There is usually no set target or time limit to the appeal for charity funding (48). *Crowdlending*, *equity-based* and *royalty-based* crowdfunding represent more business-like arrangements, where contributors are financially rewarded for their investment by either the return of their funds with interest, or by becoming financial stakeholders or beneficiaries (49), and are not discussed any further in this review.

Crowdfunding platforms for scientific research follow two main models for the collection and disbursement of funds. Similar to the approach taken for reward-based crowdfunding, in an *all-or-nothing* model, fundraisers set a financial target and a limited timeframe for achievement of the goal, but receive no funding if the goal is not met (44, 53). This is a low risk approach for contributors (53, 54), who make their contribution as a pledge, but retain their funds if the project does not achieve the target goal (44). However, it can be frustrating to spend valuable time preparing a campaign and promoting a project only to have the funding appeal fail (54). In a *donation* or *keep-it-all approach*, a financial

goal is set and there may be a defined period of time for fundraising, but contributed funds are disbursed regardless of whether the goal is achieved (53). This approach is used by the DNA Doe Project, a non-profit organisation that was set up in 2017 (55) and uses genetic genealogy to identify unknown human remains and reunite them with their families (56). The DNA Doe Project is funded entirely by donation and staffed by volunteers (56). In the past, law enforcement has worked closely with the DNA Doe Project and the organisation has so far achieved success in the identification of 14 people, which includes ten confirmed or suspected victims of crime (57, 58).

There are a number of specific research-focussed crowdfunding platforms , such as Experiment (http://www.experiment.com), which is based in the United States of America (USA) and Italy's Consano (http://www.consano.org), but other platforms such as German Startnext (https://www.startnext.com/pages/sciencestarter) and USA-based Kickstarter (https://www.kickstarter.com) also host research projects. Scientific research has also successfully received crowdfunding via organisational websites, such as the Dutch Heart Foundation (59). Standard features of crowdfunding platforms include a description of the project and its goals , the target funding amount , a payment processing system and indicators of the number of contributors and fundraising progress (60). To date, forensic science has made limited use of crowdfunding for research. A search for the term 'forensic' on research crowdfunding platforms generated three results on *Experiment*, all successfully funded (61-63), one digital forensics project on *Startnext*, which achieved just 5% of its funding goal (64) and *Consano* has no forensic projects listed at all.

Research into scientific crowdfunding has largely focussed on projects that have successfully raised their target amount and analysis of common aspects of the campaigns.

Platform selection (5, 46), offering of rewards (48, 59), endorsements by third parties or organisations (5, 48, 59), communication styles (48, 59), use of video to promote projects (48) and social networks (48, 59) are all factors that contribute to successful crowdfunding for scientific research. All types of crowdfunded projects show a characteristic donation pattern, characterised by rapid achievement of around 20% of the funding goal, followed by a period of slower growth until about 80% is reached, then the final 20% is achieved more quickly again (40, 42, 44, 48, 50, 65). Studies into contributor motivations have tended to examine what causes this pattern (40, 42, 44, 50, 65), rather than analysing underlying motivations for choosing specific crowdfunding projects.

In order for forensic scientists to successfully leverage the power of crowdsourcing and/or crowdfunding for their research, it is necessary to gain a better understanding of why people choose to contribute to crowdsourced or crowdfunded projects and what types of recruitment strategies are effective. There appears to have been no research investigating whether there are common motivations driving contributors to crowd science and crowdfunding for scientific research. The aim of this literature review was to identify common motivations for contribution to crowdsourced and crowdfunded scientific research projects across a range of different fields and investigate the different recruitment methods being used. Based on the findings, a target crowd is proposed, along with a method of promotion and recruitment to maximise success.

2. Materials and Methods

Automatic searches were used to identify relevant literature for review, using databases that included ProQuest, PubMed, Sage Journals, Science Direct, Scopus, Web of Science Core Collection and the Wiley Online Library. Keywords used for the search included crowdsourc*, 'crowd sourc*', 'crowd science', 'citizen science', crowdfund*, 'crowd fund*', 'scientific research', motiv*, engage, engagement, engag*, recruit* and 'recruit* strategy*'. Searches were limited to English language from peer-reviewed journal articles. Initially, the first 50 search results, sorted by relevance, were judged on the content of the title and abstract. Literature that was marked for inclusion based on this preliminary search was read in its entirety to determine relevance for inclusion in the review. References cited in articles selected for inclusion were sought by manual search and analysed for inclusion based on the same criteria.

To investigate contributor motivations, literature was restricted to articles that focused on initial motivations driving individuals to contribute to crowdsourced or crowdfunded scientific research projects as opposed to changing motivations over time. Studies into other types of crowdsourcing or crowdfunding were excluded, as were studies that investigated motivations of other parties, such as project creators or community groups. Literature was included only if there was certainty that the results weren't duplicated across multiple studies, which meant that the reported motivations or recruitment strategies were mostly related to a single project, clearly identified separate projects or similar projects where studies had been conducted in different countries. Literature was also excluded If contributors participated as part of an in-school project or if it was a compulsory requirement of a course of higher education.

Predominantly, literature that was included in the review of recruitment strategies was restricted to literature that provided specific details of recruitment strategies used. Articles were sought which provided detailed information on the number of contacts invited to projects, specific numbers of contributors, methods of promotion of projects, selection criteria for contributors and the duration of the recruitment campaign.

3. Results and Discussion

3.1. Motivations

3.1.1. Crowdfunding

Research into contributor motivations for crowdfunding of scientific research was extremely limited (48, 66) and research into other types of crowdfunding was found to be not completely applicable. A recent study that examined factors that contribute to success in research crowdfunding identified that projects offering rewards are more likely to succeed (48), however rewards are not always offered in return for contributing to scientific research projects. Another finding of the same study was that junior and unestablished researchers are more likely to be successful in crowdfunding for research (48), a finding that was in direct contrast with research into reward-based crowdfunding for business and creative ventures, which favours project creators who can demonstrate prior experience or success in their field (67). These findings suggest that motivations for reward-based crowdfunding don't apply to crowdfunding for scientific research. A speculative study to determine what types of medical treatment research projects would be more likely to succeed found that potential contributors expressed that they considered

research into treatments for diseases that afflict children and common diseases to be the most important (68), suggesting that there is a value judgement involved in the decision to contribute that is more akin to charity crowdfunding. However, a more recent analysis found that actual crowdfunding patterns did not support these results (69). Both studies noted that contributors to crowdfunded research are likely to already have some form of relationship with the researcher that influences the decision to contribute, with the earlier study reporting that prospective donors actually expressed a preference for appeals to come from friends, family or organisations with which they were already involved (5). The dominance of family and friends as contributors has been consistently observed in other studies into crowdfunding for scientific research (48, 70), however, if the relationship is more important than the funding purpose, then this finding contradicts the suggestion that the reliance on these relationships is linked to the higher success rate for junior and less established researchers (45, 48). This presents a challenge for researchers considering crowdfunding as family and friends, and their finances, are a limited resource, and to be successful in ongoing crowdfunding efforts or to achieve higher financial targets, researchers must reach a much broader audience (70, 71), possibly by partnering with a third party who can promote the research project to a wider network of contacts.

3.1.2. Crowdsourcing

The literature searches generated a range of different project types, including wildlife monitoring (birds, mammals, insects and invasive species), environmental monitoring (air quality, water quality and pollution), mapping/geography, disease research and online projects in the fields of astronomy, biological sciences and technology

development. Comparison of the results was complicated by the use of different types of surveys and different reporting methods. In order to produce a generalised summary of the motivations that might be used to inform the selection of an appropriate target for recruitment to forensic research studies, results were grouped into five broad categories, personal factors, contributing to science, making a difference, a desire to learn and social factors. Apart from personal factors, the selection of these categories was guided by a 2018 study which used the same categories to promote a research project to prospective contributors (72). The study investigated the differences in response rate of contributors based on the motivational message used for recruitment by inviting contributors but promoting their involvement as an opportunity to either contribute to scientific knowledge, make a difference by helping scientists, acquire new knowledge or participate in social activities by joining a community (72). In the three weeks after the invitations were emailed, researchers tracked the number of respondents who followed the link in the email to the website as well as the number who ultimately signed up as contributors (72). A comparison of their results with the results of this review is provided later in the discussion.

Personal Factors

Personal factors included interest in the subject of study (73-80), participating in an activity that was fun (73, 75, 77, 78, 80-84) and a desire to spend more time in nature (75, 81, 85). These types of motivations were consistently stated as a primary motivations across all of the categories of projects. Interestingly, it seemed that personal interest and fun were particularly highly rated in projects that required specialised skills, for example, personal interest was the highest rated motivator for a project that recruited scuba divers

(76). In a study involving the transcription of historical maps, more than 96% of contributors Agreed with the statement 'I liked looking at the old maps', with the next highest rated motivations reflecting that they enjoyed the task (88%) involved and found it satisfying (82.9%) (82). It has been noted that crowd science projects in ornithology recruit avid birdwatchers who are drawn by their interest in the birds (86, 87) and this was demonstrated by contributors to the Manitoban Nocturnal Owl Survey, who rated personal motivations as their main reason to contribute (88), although some of the reasons listed in that study would be better categorised as social factors in this review and it wasn't possible to re-categorise the data with the way that it was reported.

Make a Difference

The desire to make a difference encompassed a range of factors, and commonly included wanting to make a difference to the environment (79, 81, 83, 89, 90), to the community (75, 81, 89-91), for the future (82, 89) or to the specific field (76, 77, 80). In medical studies, there was the potential to make a difference by finding a cure (84). One specific response that potentially ties in with the idea of crowdfunding and crowdsourcing for a research project was the expressed desire to make a difference by helping the organisation do more at a lower cost (81). This particular statement was made in relation to an environmental project involving the monitoring of water quality, and also found that contributors placed a high value on ongoing communication from researchers regarding progress and, more importantly, results (81).

Contribute to Science

A desire to make a contribution to science or to scientific knowledge was another key factor driving individuals to contribute to crowd science projects across all types of projects. Notably, it was reported as a motivating factor in all of the online projects that were reviewed, which included projects in the fields of astronomy (77, 78) and biological sciences (74, 80). Additionally, although changing motivations was not a focus of this review, it was noted in one study into invasive species monitoring that contributing to science emerged as an important reason for contributors to continue their involvement in the crowd science project (89).

Learning

The findings in relation to learning were inconsistent. Just over one third of the reviewed projects, reported contributors' desire to learn as one of the top three motivating factors in joining research projects (75, 78, 79, 85, 92, 93). However, other studies didn't rate learning highly. Other studies rated learning lower in the motivational list (73, 74, 81, 84, 88, 91) or didn't provide a ranking (77), and some didn't include learning as a motivational factor being assessed or reported on (76, 77, 80, 82, 90). Specific statements included learning about the subject (81, 88), and learning new skills (81). In a medical research project learning translated to a desire to learn how to manage the disease (84).

Social Factors

Only about half of the reviewed studies had social factors listed as a key motivator, and these included general development of social relationships with people with similar

interests and/or scientists (74, 75, 79, 81, 83, 85, 92), competition with other contributors (74, 75, 80, 92), factors relating to career progression (81, 92) and enhancement of reputation (81, 92). While social factors were not the highest rated motivational factors for contributors to join a project, over time, they were seen to be important in promoting continued participation (92) and researchers emphasised the importance of developing ongoing relationships and communication with contributors (82). Additionally, a 1-month study that used internet analytics to analyse the results of a marketing campaign for an online crowd science found that promotion through social networks also resulted in renewed participation in the project by previously dormant contributors (94).

The results of the 2018 study into recruitment patterns based on the motivation expressed in the recruitment messages found that the desire to make a difference had the lowest rate of recipients following the email link, but at 52% conversion, this group represented the highest rate of conversion and overall the highest number of contributors recruited (72). An interest in learning attracted the highest number of people to follow the link from the email to the project website, but the conversion rate was only 37% (72). Contributing to scientific knowledge also garnered a very high rate of recipient interest based on the number of people who followed the email link, and had the second highest rate of conversion and number of contributors while social aspects attracted the least number of recipients to the website as well as the lowest conversion rate (72). The findings of this review support the findings of the earlier study and this information can be used to aid scientific researchers in choosing the most effective way to promote the value of a study when marketing a project to potential contributors.

3.2. Recruitment Strategies

Again crowdfunding was under-represented in the literature, with few articles providing detailed information about how projects were promoted or how many people were contacted compared with the number who actually contributed. Articles which did specifically address the promotional strategies of crowdfunding campaigns were based on other types of crowdfunding, particularly for business and equity investment crowdfunding (41). A number of studies emphasised the importance of building or developing social networks in advance of launching crowdfunding campaigns (70, 71).

Three broad categories of recruitment strategies for crowd science projects were identified. Targeted recruitment campaigns identified a specific audience based on geographical location (73, 85, 88, 95-99), interest (88, 99, 100),skillsets or qualifications (89, 101-103), affiliations with specific organisations (102-104), age (105), disease affliction (106) or availability of specific data (107). Ideally this approach used direct methods, such as email or letters to promote their research studies, allowing for accurate determination of response rates. Generic recruitment campaigns broadcast research projects via less specific means including press releases (108), coverage online and on television (108) , public outreach and media campaigns (89) and social media (108). In some cases, a specific target audience was identified, but the generic nature of recruitment campaigns meant that it wasn't possible to quantify the number of people who were contacted. Combination recruitment campaigns tended to identify characteristics of the desired contributor, such as those used in the targeted campaigns, and used both direct contact methods such as personally promoting with target audiences (109) and email (110, 111), as well as more generalised approaches such as social media (104, 105, 109, 110, 112), press releases, print

and online articles (93, 109), radio interviews (93), pamphlets and flyers (93, 111) and public outreach events (93, 111).

One of the most important findings across all types of projects and regardless of the strategy used was that the response rate is typically low. In the projects that used targeted recruitment strategies and provided figures for the number of people contacted as well as the number who participated, the highest response rate reported was 19.5% in a project to monitor invasive insect species on privately-owned land (95). A total of 6,966 potential contributors were contacted either by letter or by invitation to an information session where project organisers outlined the project requirements, which required participation from contributors over a 14-week period (95). For this study, contributors were encouraged to invite friends to participate, and while there was no significant difference in the initial response rate based on the contact method, only contributors who attended the information sessions recruited additional participants (95). The project also had highest participation rate across all of the literature that was reviewed, with over 99% of registered contributors completing the project activities in each of the three years of the project (95). Additionally, this project had a high retention rate with 45% of contributors from the first year returning for the second year and 91% of contributors from the second year participating in the third year (95). This level of commitment was not seen in any other project that was reviewed.

Response rates of under 10% were more typical, as demonstrated by three separate water monitoring projects that directly contacted customers of the water company (73). The response rate for each of the projects was reported as 6.5%, 8.5% and 8.9%, although there was no indication of whether any of the potential contributors were invited to

participate in more than one of the projects (73). With generic and combination campaigns it was difficult to quantify the exact number of people reached during recruitment campaigns, and one project that reported using radio interviews noted that while the listener numbers were provided, there was no way of determining if any were duplicated (93) .However, where target contacts were estimated, generic and combination recruitment methods showed even lower response rates. A conservation study that estimated to have reached more than 290,000 through their recruitment campaigns managed to recruit only 2,070 actual contributors (104). A project that aimed to recruit hikers from the estimated 500,000 per year who were visiting the target region managed to recruit only 1,775 contributors over a five-year period (98). It is clear that in order to successfully recruit contributors for a crowd science project, it is important to promote to a large number of people.

Additional recruitment by contributors was also noted as an important factor for many projects, whether it be through word of mouth (88, 95, 111, 112), interactions on social media (93, 104) or inviting others to accompany contributors during project activities (99). A recent study which mapped the social networks that formed between contributors to a bird conservation project focussed in the northwest of North America commented on the value of contributors continuing to recruit while they were participating, and noted that in their study, these individual influencers recruited an average of nine additional participants, with the highest recruiting individual bringing an additional 30 contributors (86). Similar results have been noted in crowdfunding as well with researchers noting that successful campaigns are associated with high interaction on social media, including comments and sharing of posts (113) and that success is driven by building social networks

and promoting projects in advance of launching recruitment campaigns (48, 70) and by the ongoing promotion of projects by contributors and other interested parties outside the research team (69, 71).

Perhaps the most effective means of targeted recruitment was seen in projects that partnered with a third party for promotional purposes. A medical disease study partnered with genealogy testing company 23andMe, offering a hefty discount on the testing to those who were willing to donate their genetic data to a study into Parkinson's disease (107). With the cost of testing reduced from $399 to $25, a total of 2000 contributors had donated their data within the first seven weeks of recruitment (107). A Swiss research team investigated the efficacy of partnering with the Swiss Multiple Sclerosis Society (Swiss MS Society) to recruit people with multiple sclerosis (MS) to a longitudinal study, launching their recruitment campaign in conjunction with the first ever Swiss MS Day (106). Their stated goal was to recruit 400 contributors within the first year, yet even with a four-stage eligibility process, this goal was achieved within just 20 days, and a total of 1700 contributors had enrolled to participate by the end of 18 months (106). The Swiss MS Society continued to promote the project in their quarterly newsletter, and after each newsletter was published, a renewed interest in the project was demonstrated by short periods of increased enrolments in the project (106), again demonstrating the importance of continuing to promote and recruit throughout the life of the project.

3.3. Who to target for forensic research?

It is clear that in order to succeed in crowdsourcing or crowdfunding forensic research, it is necessary to identify the appropriate crowd to target and the best means of promoting the study to that crowd. Based on the findings of this review, the target crowd is large in numbers, has an interest in forensics, crime or law enforcement and has a desire to either contribute to forensic scientific advances and/or make a difference to the community, perhaps in the form of improving law enforcement. They may be interested in learning more through the experience or in building social relationships through their participation. Importantly, the development of ongoing relationships between researchers and the crowd is essential to successful recruitment and ongoing contribution.

True crime as a genre has been popular for many years (114), and with the release of *Serial* in 2014, the genre exploded into the medium of podcasting (115, 116). The first season of *Serial* consisted of 12 weekly episodes and through the series, host, Sarah Koenig, presented an in-depth investigative presentation of the story of Adnan Syed, who had been convicted in 2000 of the murder of his high school ex-girlfriend the previous year (116). At the time of its release, *Serial* was the fastest podcast ever to reach five million downloads (117, 118), earning the ranking of most popular podcast to that date (116). The investigative approach has been used by other true crime podcasts, but an alternative popular format used by other true crime podcasts is a regular release format where new episodes are distributed on a regular basis, and the individual episodes are, for the most part, independent of each other.

In 2018, five true crime podcasts, including *Serial*, ranked in the Australian iTunes top 25 by downloads (119). The five titles are shown in Table 1 in order of their Australian ranking, along with the country of origin, a brief description of the format of the podcast and the date of commencement of the title.

Table 1 True Crime Podcasts that ranked in the Apple iTunes Top 25 in 2018

Chart Ranking	Podcast Title	Country of Origin	Format
5	*Casefile True Crime*	Australia	Regular release Commenced 2016 (120)
6	*The Teacher's Pet**	Australia	Investigative 1 season 2018 (121)
11	*Australian True Crime*	Australia	Regular release Commenced 2017 (122)
12	*My Favorite Murder*	USA	Regular release Commenced 2016 (123)
20	*Serial*	USA	Investigative 3 seasons 2014-2018 (124)
** The Teacher's Pet has been withdrawn in Australia pending legal action (121).*			

Social media platforms provide additional means for listeners to interact with their favourite podcasts and with other listeners through official accounts and through fan pages and discussion pages that are independent of the creators. Listeners are able to 'like' and/or 'follow' podcasts' official accounts on Facebook and to 'follow' official accounts on Instagram and Twitter. Figure 1, below, shows the numbers of followers of the official accounts for these titles on Facebook, Twitter and Instagram at the time of writing. Followers was chosen for measurement because on each of these social media platforms, a follower of an account is notified of activity from the podcast, but on Facebook, it is

possible to 'like' a Facebook account but opt out of 'following' it. Having been withdrawn, *The Teacher's Pet* has no official social media accounts, so it has not been included.

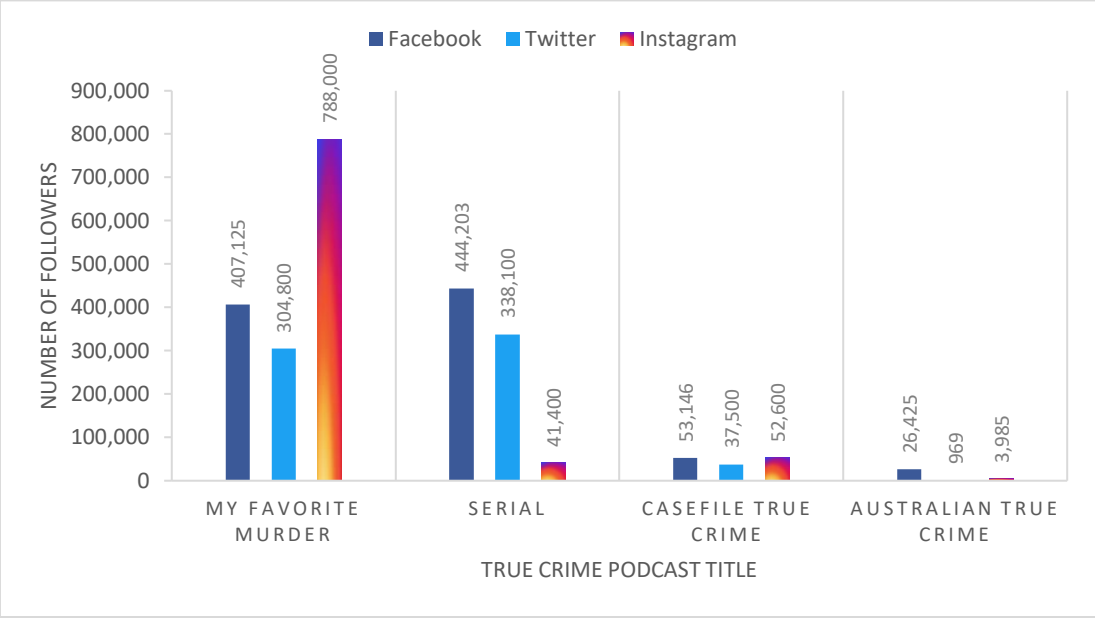

Figure 1 Followers of True Crime Podcast Official Social Media

With the exception of Facebook and Twitter accounts for *Serial*, the number of followers was observed to have increased by an average of 7% over a 9-week period from August to October 2019. However, it is important to note that this represents a relatively small fraction of total listeners. In an email dated September 16, 2019, *Casefile True Crime* (contact@casefilepodcast.com) reported a total of 1.26 million downloads of the episode titled *Case 123: Mark Kilroy* in the nine days since its release. The following summary figures were also provided:

Table 2 Download Numbers for *Casefile True Crime*

Time	Number of Downloads
7 days – Full catalogue of 123 cases	2.9 million
30 days – full catalogue of 123 cases	12 million
1 year – full catalogue of 123 cases	134 million

These numbers, as well as the increasing numbers of followers on social media, demonstrate a growing audience, and also that new listeners don't just listen to new episodes – they go back and listen to old episodes as well, which is supported by anecdotal evidence drawn from social media comments. Financially, the podcasts benefit from paid advertising, but it is worth noting that *My Favorite Murder*, *Casefile* and *Australian True Crime* are also sponsored by listeners through Patreon (https://www.patreon.com/) (125-127). Patreon operates with a monthly payment commitment (128), and in return for sponsorship, contributors gain access to early release episodes (125), advertisement-free episodes (125, 126) and exclusive content (125-127).

The regular release podcast format provides an opportunity to encourage listener contributions by linking a fundraising drive or research project with a particular theme or case as it is presented. Over time, this format also provides an avenue to acknowledge listener contributions and to provide ongoing updates on progress or results. This has already been demonstrated as a successful approach by *Crime Junkie*, an independently produced weekly release true crime podcast that is regularly ranked in the weekly top 10 podcasts by download for the USA (129). On July 1, 2019, *Crime Junkie* released an episode titled *Unidentified: Sumter County Does*, which told the story of two sets of unidentified remains found in South Carolina in 1976, which were awaiting funding for genetic analysis by the DNA Doe Project (130). During the episode, the host launched and promoted a limited edition range of merchandise with proceeds going to the DNA Doe Project to assist with funding the identification of the Sumter County Does. In an episode released two weeks later (and recorded earlier than this), the host reported that listeners had raised over US $17,500 (131). Subsequently, the status of all outstanding cases was updated to

'funded' and the DNA Doe Project currently has more than 45 cases in the process of DNA extraction, sequencing or genealogical analysis (58).

Some law enforcement agencies have already seen the value in podcasts and their audiences. In 2018, Newport Beach Police Department in California released their own podcast series, *Countdown to Capture* (132). The podcast detailed the alleged crimes of Peter Chadwick, who had been a fugitive since 2015, when he absconded while on bail awaiting trial for the 2012 murder of his wife (132, 133). Six short episodes were released over a period of just under two weeks in September 2018 and the podcast reached number 24 on the USA podcast charts (133). This was just one of the tools used by Newport Beach Police Department in their quest to locate Chadwick, who was ultimately taken into custody in August 2019 (132). Earlier this year, the Queensland Police Homicide Investigation Unit approached the creators of *Casefile True Crime* and proposed using the platform to promote awareness of domestic violence, stating that they were looking at other methods of disseminating information beyond traditional print media and local television and radio (134). The collaboration, which also included White Ribbon Australia, an advocacy group working to reduce violence against women, resulted in the release of *Case 122: Leeann Lapham*, which detailed the cycle of violence and progressively increasing violence through Leeann's relationship with her former partner, who was convicted in 2018 of Leeann's manslaughter in 2010 (135). In 2019, former cold case investigator Paul Holes joined with true crime journalist Billy Jensen to host *Jensen and Holes: The Murder Squad* (136). The premise of this podcast is to promote problematic cases and draw on the crowd to assist in solving them (137). They have received information from volunteers interested in transcribing old case notes and they have asked listeners to assist with identifying

women pictured in photographs found in the homes of more than one convicted serial killer and with filling in timelines of movements of known offenders (136). It may be inferred that the potential of these audiences could extend beyond simply contributing to research projects.

4. Limitations and Future Research Opportunities

Perhaps the biggest limitation associated with this review is that exclusion of literature that had surveyed contributors to multiple projects drastically reduced the number of papers that were reviewed. Additionally, the use of different survey methods and/or differences in the way that results were reported made comparison challenging for both motivations and recruitment strategies. An unintentional element of bias may have influenced the way that responses were allocated to the motivational categories.

Crowdfunding for scientific research has had limited study. Predictive surveys regarding priorities for funding do not match up with observed patterns of donation (81), and other than individual case studies (138), very little has been published relating to the promotion of crowdfunded projects other than in medical research (106, 107). There are many avenues for further research into this field. Similarly, the level of detail provided on how campaigns were launched and communicated for crowdsourcing for scientific research was inconsistent, and there is the opportunity for further research into this area as well.

In suggesting true crime podcast audiences as a potential target crowd, it is notable that podcasting as a whole has had little attention from researchers and it has generally been focussed on the medium rather than the content (115). There is scope to further analyse the motivations of the true crime audience as one study which did attempt to do found that the three highest-ranked reasons were entertainment, convenience and boredom (115). Entertainment and boredom could quite easily be applied to any subject or topic and don't begin to explain why an individual chooses to listen to true crime, while convenience is more indicative of the selection of the podcast medium. Additionally, podcast metrics are an emerging field. Until 2017, downloads were the only way to track podcasts, and while they remain a common measure of success, downloads alone don't accurately reflect listener behaviours (139). Newer metrics enable podcast creators to track how many unique devices were used to listen to an episode, geographical distribution of listeners and listener behaviours such as how much of an episode was listened to and where listeners started and stopped a podcast (139).

5. Conclusion

While it wasn't possible to link common motivations driving contributors' decisions to contribute to crowdsourced and crowdfunded scientific projects, key findings of this review have helped to identify a potential crowd for forensic researchers to target if they choose to draw on either of these options to assist in progressing research projects. The true crime podcast provides a medium for targeting a massive, growing crowd that is interested in forensic science, crime and/or policing. The podcast medium provides

opportunities for initial promotion of a project, to provide ongoing updates on project status and results and to continue recruiting and promoting opportunities throughout the life of a project. The willingness of audiences to contribute financially has been demonstrated by the ongoing sponsorship of the podcasts themselves as well as successful fundraising activities that have been conducted. This may be an untapped source of both financial support and resources on which to draw in the future.

Appendix 1 – Personal Communication

Casefile Podcast 16 September 2019 at 6:21 am

Re: Information request - Masters student research

To: Rebecca Parrick

Hi Rebecca,

Nice to meet you.

You are right, our social media following is a fraction of our audience.

The current download numbers for Case 123: Mark Kilroy, are currently 1.26 Million.

Across our entire episode list, Casefile has had 2.9 Million downloads in the past 7 days.
12 Million downloads in the past 30 days.
And 134 million downloads in the past year.

Let me know if there is anything else you need and best of luck with your research.

See More from Rebecca Parrick

--

Host & Creator

casefilepodcast.com
fromthefiles.com
casefilepresents.com

This message is intended solely for the addressee. If you have received this message by mistake, please reply to this email and delete it from your mailbox. Please think of the environment when considering printing this email. Thank you.

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