A Phased Social Experiment Plan for Public-Oriented PAPRs in Cebu City — Toward Social Implementation of PAPR for Everyone and Field Evaluation During Influenza Seasons —

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Abstract. During the COVID-19 pandemic, physical distancing, facility closures, stay-at-home restrictions, and lockdowns were widely used to suppress transmission, but these measures also had major effects on daily life, economic activity, education, and social participation. The author has proposed "PAPR for Everyone," an approach that uses positive-pressure powered air-purifying respirators (PAPRs) designed for the general public to reduce inhalation exposure directly through engineering means. Previous work has addressed the required population use rate, low-cost prototypes, measurement of respiratory state and leakage, time-managed use, a wear-rate management network, and privacy protection. This paper connects these accumulated results to a research plan that can be tested in real-world settings. The Cebu region of the Philippines is envisaged as the field site. Research collaboration with the region originated in international cooperation in precision measurement and later developed into joint work on low-cost PAPRs. Cebu also experienced prolonged and stringent mobility restrictions during COVID-19, providing a practical context in which alternatives that reduce infection risk while maintaining social activity are worth examining. The proposed Cebu Social Experiment Program consists of Phase 1 (preliminary evaluation of donning and operability), Phase 2 (evaluation of use in everyday environments), Phase 3 (a small-scale social experiment including networked monitoring), and Phase 4 (a prospective field study during seasonal influenza or other respiratory-infection periods). In the final phase, actual PAPR wearing time, rather than a simple user/non-user classification, is treated as a principal exposure variable in exploring its association with infection incidence. A preceding Viewpoint in JMIR Public Health and Surveillance argued why positive-pressure exposure control should be positioned as a subject of formal public health evaluation. The present paper instead specifies how such evaluation could be conducted, in what sequence, and with which research outcomes. The social experiments proposed here have not yet been conducted; this paper does not report experimental results.

1. Introduction

The COVID-19 pandemic revealed the limited range of policy options available to modern societies for controlling large-scale respiratory infectious disease. Nonpharmaceutical interventions such as masking, physical distancing, facility closures, and stay-at-home restrictions helped suppress transmission but also imposed substantial costs on education, economic activity, and daily life [1–3]. Immediately after the emergence of an unknown respiratory pathogen, pathogen-specific vaccines and therapeutics are not yet available. It is therefore worthwhile, during nonemergency periods, to examine

engineering interventions that can complement existing measures, do not necessarily depend on pathogen type, and can be used while maintaining social activity.

For diseases in which airborne transmission is a major route, inhalation of infectious aerosols plays an important role in establishing infection [4]. The probability of infection is related to the quantity of viable pathogens reaching the respiratory tract—the infectious dose [5]. Accordingly, if inhalation exposure itself can be sufficiently reduced, a third option becomes conceivable: lowering infection risk without stopping social activity itself.

The specific means examined by the author is a positive-pressure PAPR for use by the general public. A PAPR actively supplies filtered air to the breathing zone with a blower and, under appropriate conditions, maintains positive pressure inside a hood or helmet, thereby limiting inward leakage of unfiltered ambient air through gaps. Conventional PAPR research has focused primarily on protecting health care workers in high-risk environments [6].

The author has defined the concept of allowing members of the general public to use PAPRs at the times and places they consider necessary to control their own inhalation exposure as "PAPR for Everyone," and since 2020 has progressively developed its engineering and theoretical foundations [7–14]. The objective is not to require universal continuous wearing. Rather, it is to provide each citizen, during periods of heightened transmission, with an additional option for protecting themselves while continuing social activity, thereby seeking to reconcile infection control with individual freedom.

A Viewpoint accepted by JMIR Public Health and Surveillance in 2026 [12] argued that positive-pressure exposure control should not be introduced immediately but should first be positioned as a formal subject of integrated engineering, medical, and public health evaluation. The role of the present paper is the next step: to specify how such evaluation could begin. Figure 1 presents the overall structure of the phased social experiment program envisaged for Cebu.

Fig. 1. Phased structure of the Cebu Social Experiment Program. Results from each phase are fed into the design of the next phase, progressing from engineering and human-factors evaluation to prospective public-health field evaluation.

2. Technical and Social Foundations of PAPR for Everyone

2.1 Population-Level Infection-Control Principle

When PAPR for Everyone is extended to the population level, the PAPR is no longer merely an item of personal protective equipment; the population wearing rate becomes a controllable variable in a sociotechnical system. The author has proposed models linking PAPR protection performance and population wearing rate to the effective reproduction number, Rt [7,8]. For example, theoretical analysis showed that, if the initial Rt is 2.0, continuous use of sufficiently protective PAPRs by approximately 55% of the population could reduce Rt to below 0.9 [8].

The key idea is to treat the required population wearing rate as a target while preserving, as far as possible, individual choice over when and where to wear the device. The subsequently proposed time-managed PAPR concept and PWS-NET provide a framework for reconciling such individual choice with population-level wear-rate management [11].

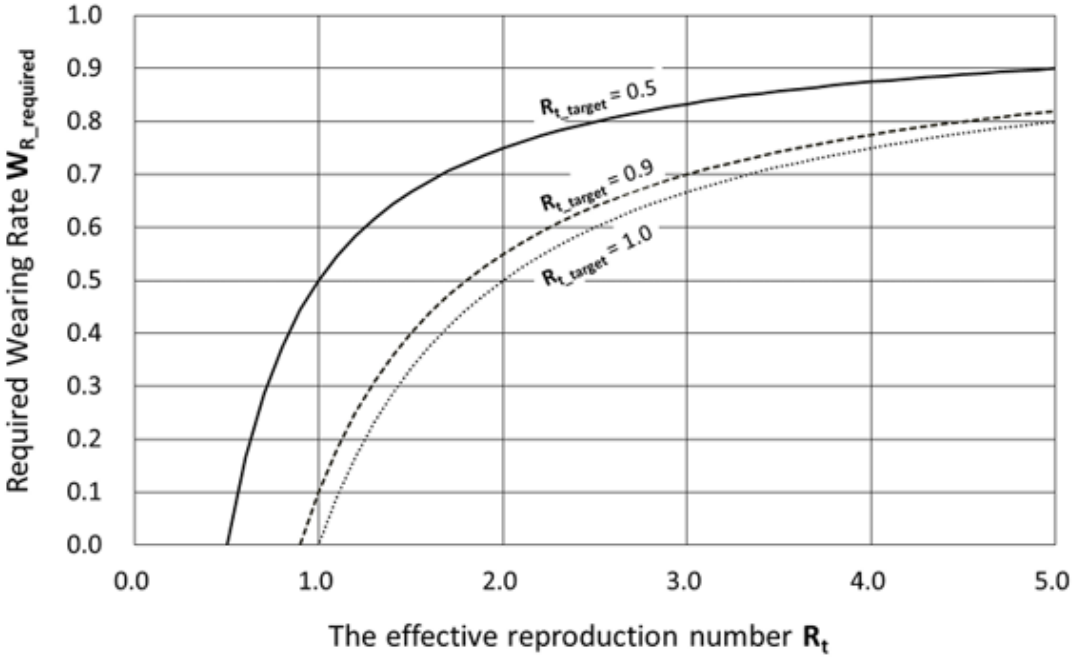


Fig. 2. Theoretical example of the PAPR wearing rate required to reduce the effective reproduction number Rt to specified target values [7,8].

2.2 Public-Oriented PAPRs and Measurement/Control Technologies

For daily use by the general public, a PAPR must be evaluated not only for protection performance but also for affordability, low weight, breathing comfort, CO_2 accumulation, noise, heat, visibility, communication, and maintainability. The feasibility of low-cost PAPRs has been demonstrated in prototypes developed by the author and collaborators [13,14] and by other research groups [15]. Usability, including communication while wearing a PAPR, is also an important evaluation outcome [16].

The author and collaborators developed a fluid-flow model that estimates respiratory state from differential pressure and PWM blower-control signals [9], as well as a method for real-time estimation of respiratory flow and leakage using a single differential-pressure sensor and a microcontroller [10]. Technology for changing supply flow and internal pressure in accordance with respiratory state is

protected by Japanese Patent No. 7653735 [17], and technology for coordinated control of supply and exhaust to manage helmet airflow and pressure is protected by Japanese Patent No. 7616624 [18].

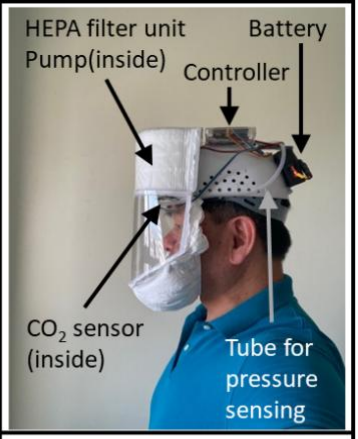
Model	[A] Versaflo TR-300+ (3M)	[B] Simple model (prototype)	[C] Controller model (prototype)
Photo			
Filter	Non-woven filter	HEPA filter	HEPA filter
Internal Pressure	positive	positive	positive (controllable)
Flow rate [L/min]	180 (Low) or 200 (High)	400	300-400
Computer			Board computer
Sensor			2 CO_2 & 1 pressure sensors
Cost	Price: 1,000USD	Parts cost: 40USD	Parts cost: 300USD

Fig. 3. Comparison of a commercial medical PAPR with simplified and measurement/control PAPR prototypes developed by the author and collaborators.

2.3 Measurement of Actual Wearing Time, Networking, and Privacy Protection

For social implementation, the key issue is not whether a person owns a PAPR but whether it is actually used at the necessary times and places. Technology for estimating wearing status from supply/exhaust airflow and recording it with time information is included in Japanese Patent No. 7515044 [19]. Accordingly, this study treats actual wearing time, rather than only a binary PAPR/non-PAPR classification, as a principal exposure variable.

Networking wearing histories, location information, and proximity/contact information can improve infection-control capability, but it can also create the ability to infer citizens' daily behavior in detail. The author has proposed governance frameworks including VRAIO that make information use and system outputs retrospectively verifiable in public-space AI cameras [20], autonomous driving [21], smartphone sensing [22,23], and AI platforms [24]. The need for Trust Infrastructure has also been derived from the Extended Kelvin Principle [25].

The technical background includes Japanese Patent No. 6671627 on encrypted storage and access control [26] and patent applications concerning storage of viewing and utilization histories [27–29]. For a PAPR wear-rate management network, collecting information is not an end in itself. A design requirement is that what was measured, why it was measured, who used it, under what rules it was used, and how it was actually used can be verified afterward.

2.4 Positioning as Measurement Engineering

This research is grounded in measurement engineering. Respiratory state and leakage inside a PAPR are not always directly measurable and must be inferred from limited sensor information [9,10]. In other measurement studies, the author and collaborators have addressed self-error correction using the

dynamic characteristics of sensor output [30] and robust frequency estimation under noisy conditions [31]. Although these studies are not direct applications to PAPRs, they share the same methodological foundation: making a quantity measurable in order to enable understanding and control.

PAPR for Everyone also seeks to expand citizens' options through technology rather than restrict freedom through technology. In this respect, it is connected to the author's broader concern with how human agency and democratic choice may be preserved as AI and automation advance [32].

3. Why Cebu? Background for Selecting the Field Site

3.1 Existing International Research Collaboration

The first reason for considering Cebu as a candidate field site is the pre-existing research collaboration. The author's collaboration with researchers at Cebu Technological University (CTU) and elsewhere in the Cebu region was not established specifically for PAPR research; it originated in joint work in precision measurement and related measurement engineering and subsequently developed, during COVID-19, into collaborative research on public-oriented, low-cost PAPRs.

Within this collaboration, a very-low-cost PAPR intended for industrial use (DFM-I) [14] and a low-cost PAPR intended for operational testing in hospitals in Cebu City (DFM-F) [13] were proposed. These studies do not represent completed social implementation, but they demonstrate that a basis already exists in Cebu for prototype development, operational planning, and researcher-to-researcher cooperation.

3.2 A Region That Experienced Prolonged and Stringent COVID-19 Restrictions

The second reason is that Cebu experienced prolonged and stringent mobility restrictions during COVID-19. An analysis of local-government responses in the Philippines reported that Cebu remained under stricter community quarantine even after other areas of the country had moved to less restrictive regimes [33]. Residents of the region therefore have direct experience of an extended period during which everyday social and economic activity was curtailed. This provides a practical context in which the value of preparing, during nonemergency periods, alternatives to stopping social activity during future outbreaks may be readily understood.

3.3 Potential for Prospective Evaluation During Influenza Seasons

The third reason is the possibility of conducting repeated field studies using seasonal influenza without waiting for a pandemic. National surveillance in the Philippines has reported that influenza positivity generally rises from approximately June to November, overlapping with the rainy season and the start of the school year, with multiple peaks observed in some years [34]. Because these are national rather than Cebu-specific data, the latest local surveillance information should be reviewed when Phase 4 is designed. Nevertheless, the findings suggest that a comparatively long observation window may be available in the Philippines.

4. Cebu Social Experiment Program

The program is not intended as a single linear sequence that must be completed from Phase 1 through Phase 4 without interruption. Each phase can begin as an independent demonstration opportunity, and findings can be fed back into device design, evaluation metrics, ethics procedures, participant recruitment, data management, and medical collaboration before proceeding to the next phase.

4.1 Phase 1: Preliminary Evaluation of Donning and Operability

A small number of participants will be used to determine whether members of the general public can safely and practically don, remove, and operate a PAPR. The initial phase will not evaluate infection-prevention effectiveness; its purpose is to identify device-related and human-factors problems. A scale of approximately several dozen participants in CTU laboratories or similar settings is envisaged.

- Ease of donning and doffing; weight; balance; visibility; ease of communication
- Heat, noise, effects on walking and light work, and tolerable wearing duration
- Engineering measures including hood CO_2 concentration, maintenance of positive pressure, and leakage indicators
- Subjective acceptability, willingness to reuse, and suggestions for improvement

4.2 Phase 2: Evaluation of Use in Everyday Environments

There is an important difference between a device being "usable" in a laboratory and people actually choosing to use it in daily life. In Phase 2, participants will use PAPRs during activities such as movement around campus, lectures, office work, commuting, and shopping, and actual wearing time and reasons for discontinuing use will be evaluated.

- Actual wearing time per day and situations in which the PAPR is used
- Reasons for discontinuation, situations in which participants prefer not to use it, and reactions from others
- Intention to continue use, perceived social awkwardness, and comfort
- Whether participants voluntarily use the PAPR at times and places they perceive as high exposure risk

4.3 Phase 3: Small-Scale Social Experiment Including Networked Monitoring

In Phase 3, the PAPR will be connected to a smartphone or similar device to automatically record wearing status, wearing time, and necessary operating information. The program may be expanded to several dozen or up to approximately one hundred participants to evaluate the extent to which an actual wear rate can be achieved.

The effects of networking will be evaluated separately from those of the PAPR itself. In addition to any additional infection-control benefit, the effects of collecting location, proximity, and biometric information on privacy and citizens' rights will be treated as independent outcomes. Rather than directly using detailed individual-level information for policy decisions, statistically aggregated indicators such as population wearing rate will be used wherever possible.

4.4 Phase 4: Prospective Field Study During Influenza Seasons

After Phases 1–3 have established a sufficient basis in technical practicality, usability in everyday life, social acceptability, and measurement of wearing time, a prospective study will be conducted during a period of seasonal influenza or other respiratory infectious disease activity. The first objective is not to establish definitive preventive effectiveness immediately, but to determine whether the relationship between actual PAPR use and respiratory-infection incidence can be measured prospectively in a real community.

Participation will be voluntary, and PAPRs will be lent to participants who wish to use them. Participants will not be required to remain unprotected for research purposes. Wearing histories will be recorded automatically where feasible. Candidate outcomes include influenza-like illness, clinically diagnosed influenza, COVID-19, and other acute respiratory infections.

A simple comparison of "PAPR users" and "non-users" would place a participant who uses the device eight hours per day in the same category as one who uses it only one hour per week. Actual

wearing time will therefore be treated as a principal exposure variable, and future studies may also estimate the proportion of time in higher-risk settings during which participants were protected by the PAPR. This would directly evaluate the time-managed PAPR concept [11] under real-world conditions.

The first influenza-season study will be positioned as a pilot study rather than as a confirmatory trial of effectiveness. It will evaluate participant recruitment, sustained use, measurement of wearing time, follow-up of infection outcomes, attrition, and the information needed to estimate future sample sizes. The results will provide design data for subsequent prospective cohort studies, cluster studies, or, where appropriate, intervention studies.

5. Data Governance, Social Acceptance, and Ethics

5.1 Separating Measurement Capability from Surveillance Capability

For PAPR for Everyone to be socially acceptable, protection performance is not sufficient; mechanisms are needed to prevent measurement capability from automatically becoming surveillance capability. The more accurately a system measures wearing rate, location, proximity, and respiratory state, the more it may infer about an individual's daily life. Data-acquisition purposes, scope, access rights, use histories, and retention periods should therefore be limited in advance and made retrospectively verifiable.

Drawing on VRAIO and related concepts [20–25] and the relevant patents and patent applications [26–29], the system should at minimum make it possible to verify what was measured, why it was measured, who was permitted to use it, under what rules it was used, and how it was actually used.

5.2 Research Ethics

Before human-subject wearing experiments, questionnaire surveys, or collection of health information begin, the required institutional ethics review will be obtained and informed consent will be secured. Participation will be voluntary, withdrawal will be permitted at any time, and neither wearing nor non-wearing of the PAPR will be compelled. In Phase 4 in particular, a core principle is that participants will not be intentionally exposed to additional infection risk by being required to remain without a PAPR for research purposes.

Personal data collection will be limited to what is necessary for the research purpose, using appropriate combinations of anonymization or pseudonymization, encryption, access control, and use-history logging. Aggregated information needed for population-level infection control will be separated from individual behavioral histories as far as practicable.

6. Implementation Structure and Phased Expansion in Cebu

In the initial phases, CTU is envisaged as the research base for PAPR usability evaluation, daily-use testing by students and staff, data collection, and questionnaire surveys. It is not necessary to establish every collaboration mechanism from the beginning; additional participating organizations can be added according to the research scale and objectives.

- Phases 1–2: engineering and human-factors evaluation centered at CTU
- Phase 3: small-scale social experiment with information-system, ethics, and data-management personnel
- Phase 4: confirmation of infection outcomes in collaboration with medical institutions
- Future stages: collaboration with local government, other universities, commercial facilities, public transport providers, and local communities

If collaboration with local government is obtained, the program can expand beyond recruitment and securing study sites to consideration of future procurement, stockpiling, distribution, consumable

supplies, cleaning, and disposal. The practical value of the present plan is that, when society and public authorities begin to treat PAPR for Everyone as a serious candidate intervention, a concrete research plan and phased implementation procedure will already exist.

7. Discussion

7.1 Positioning of the Present Plan

The contribution of this paper does not lie in proposing a new PAPR principle. Rather, it connects accumulated engineering and theoretical results, together with related intellectual property, to a sequence of research protocols that can be evaluated in a real community. By progressively linking PAPR performance, daily use, wear-rate measurement, and infection outcomes, the plan seeks to address the currently unevaluated space between engineering feasibility and public health effectiveness.

7.2 Why Publish the Plan During a Nonemergency Period?

If device design, performance evaluation, ethics review, mass production, and social-experiment methods are considered only after the next pandemic begins, the resulting countermeasure may not be ready when it is needed. The WHO PRET framework likewise emphasizes preparedness for respiratory-pathogen pandemics during nonemergency periods [35]. For PAPR for Everyone, developing and testing evaluation methods during seasonal influenza periods may enable more rapid decision-making in a future emergency.

7.3 Limitations

This is a planning paper, and the proposed social experiments have not yet been conducted. It therefore provides no data establishing individual-level preventive effectiveness, population-level infection-control effectiveness, long-term acceptability, cost-effectiveness, or equity. In addition, national influenza seasonality data for the Philippines [34] cannot be assumed to represent Cebu specifically; the latest local epidemiological information will be required when Phase 4 is initiated.

Furthermore, an observational design in which PAPRs are offered to volunteers may be affected by self-selection bias related to health awareness, occupation, exposure behavior, and other factors. The initial pilot should collect these variables, and subsequent larger studies should use appropriate comparator-group design and adjustment for confounding.

8. Conclusions

This paper presents a phased social experiment plan for Cebu City, Philippines, based on prior engineering research on positive-pressure PAPRs for the general public, wear-rate models, time-managed use, networked management, and privacy-protection technologies.

The plan consists of Phase 1, evaluating donning and operability; Phase 2, evaluating use in everyday environments; Phase 3, a small-scale social experiment including networked monitoring; and Phase 4, a prospective field study during periods of influenza or other respiratory infectious disease activity. In the final phase, actual wearing time rather than mere PAPR possession or nominal group assignment is treated as a principal exposure variable in exploring associations with infection incidence.

The purpose of this plan is not to treat the effectiveness of PAPR for Everyone as already established. Rather, it is to move an engineering candidate intervention into a form that can be tested by medicine and public health. By using the existing international research base in Cebu, the region's experience of prolonged and stringent COVID-19 restrictions, and the possibility of evaluation during seasonal respiratory-infection periods, we propose preparing during nonemergency periods a research plan that

universities, medical institutions, public authorities, and local communities can activate when conditions make implementation appropriate.

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Author Contributions

Conceptualization, methodology, writing—original draft preparation, writing—review and editing, visualization, project administration, and funding acquisition: Y.F. The author has read and agreed to the final version of the manuscript.

Ethics Statement

No human-participant experiment, intervention, survey, or analysis of identifiable personal data was conducted for this planning paper. All future human-subject studies described in the proposed program will require appropriate institutional ethics approval and informed consent before initiation.

Data Availability

Data sharing is not applicable to this article because no datasets were generated or analyzed in this planning paper.

Conflicts of Interest

The author is an inventor or co-inventor of patents and patent applications cited in this article concerning PAPR and privacy-protection technologies. No other competing interests are declared.

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