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A randomized study of contingency management and spirometric lung age for motivating smoking cessation among injection drug users

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Abstract

Background: Even after quitting illicit drugs, tobacco abuse remains a major cause of morbidity and mortality in former injection drug users. An important unmet need in this population is to have effective interventions that can be used in the context of community based care. Contingency management, where a patient receives a monetary incentive for healthy behavior choices, and incorporation of individual counseling regarding spirometric “lung age” (the age of an average healthy individual with similar spirometry) have been shown to improve cessation rates in some populations. The efficacy of these interventions on improving smoking cessation rates has not been studied among current and former injection drug users.

Methods: In a randomized, factorial design study, we recruited 100 active smokers from an ongoing cohort study of current and former injection drug users to assess the impact of contingency management and spirometric lung age on smoking cessation. The primary outcome was 6-month biologically-confirmed smoking cessation comparing contingency management, spirometric lung age or both to usual care. Secondary outcomes included differences in self-reported and biologically-confirmed cessation at interim visits, number of visits attended and quit attempts, smoking rates at interim visits, and changes in Fagerstrom score and self-efficacy.

Results: Six-month biologically-confirmed smoking cessation rates were 4% usual care, 0% lung age, 14% contingency management and 0% for combined lung age and contingency management ($p = 0.13$). There were no differences in secondary endpoints comparing the four interventions or when pooling the lung age groups. Comparing contingency management to non-contingency management, 6-month cessation rates were not different (7% vs. 2%; $p = 0.36$), but total number of visits with exhaled carbon monoxide-confirmed abstinence were higher for contingency management than non-contingency management participants (0.38 vs. 0.06; $p = 0.03$), and more contingency management participants showed reduction in their Fagerstrom score from baseline to follow-up (39% vs. 18%; $p = 0.03$).

Conclusions: While lung age appeared ineffective, contingency management was associated with more short-term abstinence and lowered nicotine addiction. Contingency management may be a useful tool in development of effective tobacco cessation strategies among current and former injection drug users.

Trial registration: Clinicaltrials.gov NCT01334736 (April 12, 2011).

Keywords: Contingency management, Spirometry, Lung age, Smoking cessation

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Background

Injection drug users (IDUs) have among the highest prevalence of tobacco dependence, yet represent an understudied population in terms of smoking cessation strategies [1-4]. IDUs report smoking prevalence four times that of the general US population [5]. Low socioeconomic status, low educational achievement and poly-substance abuse are prevalent among IDUs and each is independently associated with increased tobacco dependence [6-8]. At the individual level, factors in each of the five psychosocial domains (personality, drug use behavior, family, peer and environment) have been shown to be independently associated with nicotine dependence in an urban cohort [9,10].

Studies have consistently demonstrated that the majority of illicit drug users are interested in quitting smoking [3,11]. As many as 61% of IDUs in substance abuse treatment programs report a desire to quit tobacco use, with an average of five prior quit attempts per person [12,13]. Designing effective and feasible smoking cessation programs tailored for this population may substantially improve cessation. Contingency management is an approach which provides a structured incentive contingent upon changes in a participant's behavior [14,15]. Typically, these incentives are in the form of a voucher or monetary reward for achieving a pre-specified therapeutic target. Initially employed as a motivation for illicit drug use cessation [16-19], several studies have demonstrated moderate efficacy in improving tobacco cessation rates [20-24]. A second novel approach to smoking cessation uses the concept of "lung age" as a motivational tool for smoking cessation [25]. Spirometric measurements of lung function are typically reported in absolute terms or percentage of predicted values based upon a referent population. Lung age reports spirometry results using the age of an average healthy individual with similar spirometry results (i.e., "You are 50 years old, but you have the lungs of a 70 year old"). The use of lung age as a motivational tool has been shown to improve biologically-confirmed smoking cessation endpoints in community-based clinic populations [25] and perceived smoking-related risks, worries and desire to quit in college smokers [26]. To date, no study has evaluated the efficacy of the positive reinforcement associated with contingency management and negative reinforcement of lung age-based counseling for improving smoking cessation among IDUs.

The AIDS Linked to the Intravenous Experience (ALIVE) study, a prospective, longitudinal cohort of persons with a history of injecting drugs followed in Baltimore, Maryland since 1988, represents an ideal population to explore novel smoking cessation interventions [27]. This cohort has nearly ubiquitous cigarette smoking [28,29] and recently instituted serial spirometric measures

into the existing data collection protocol. In this study, we assess the impact of contingency management and spirometric lung age as motivational tools to improve 6-month biologically confirmed smoking cessation rates in a cohort of 100 current smokers in a randomized, factorial design study. We hypothesized that the individuals who receive smoking cessation counseling including contingency management or spirometric lung age or both would be more likely to achieve tobacco cessation and have greater change in self-efficacy and intention to quit at 6 months compared to usual care.

Methods

Participant recruitment and eligibility

As described previously [27,30], ALIVE has recruited residents of Baltimore, MD since 1988 who were ≥ 18 years of age and had a history of injecting drugs. Bi-annual study visits include standardized questionnaires, a clinical examination, and biospecimen collection. Since 2007, pre-bronchodilator spirometry testing has been performed at each study visit. From March 16, 2011 to February 3, 2012, ALIVE participants presenting for a scheduled lung sub-study visit were screened for inclusion in this trial. Eligibility requirements included current cigarette smoking (defined as a history of smoking at least 100 cigarettes in their lifetime as well as reporting any cigarette smoking in the last month), no current involvement in a smoking cessation program, no current use of nicotine replacement therapy or other smoking cessation pharmacological treatments (bupropion, varenicline), interested in involvement in a smoking cessation trial and the ability to perform spirometry. After screening, the study was described to participants, and if interested, written informed consent was obtained. The study was approved by the IRB of Johns Hopkins University.

Randomization and study design

Prior to study initiation, 120 sequentially numbered opaque sealed envelopes were externally prepared that included random assignment to one of four interventions. Randomization sequence was computer-generated using a block randomization approach with randomly ordered four and eight sample blocks. After informed consent was obtained and baseline data including smoking-related questionnaires, assessment of self-efficacy and intention to quit smoking, exhaled carbon monoxide (eCO) level and spirometry were completed, study staff was provided the next sequential envelope which assigned the intervention.

Study visit protocol

The overall design of the study included one baseline visit and six follow-up visits over six months. All visits occurred at the ALIVE research clinic site. Assessment

of eligibility, informed consent, randomization and spirometry measurement occurred at the baseline visit. Follow-up visits occurred at one, two and four weeks, then two, three and six months from baseline visit. An increased frequency of visits early in the study was included to enhance protocol compliance.

Study procedures

At baseline and follow-up visits, all participants completed smoking-related questionnaires, assessment of self-efficacy and intention to quit smoking and eCO measurement. At all visits, participants also received a brief standardized counseling session on the harms of smoking and were offered information on smoking cessation resources available in the community. If the participant inquired about nicotine replacement therapy, he or she was advised to contact their primary care provider to discuss potential therapeutic options. Blood was obtained for serum cotinine analysis at six month visits.

Usual care

At baseline and follow-up visits, the usual care group reviewed baseline spirometry results of their lung function reported as a percentage of predicted values, communicated in a standardized written format. Lung function was first described as the numerical percent predicted value, and defined as normal if the forced expiratory volume in one second (FEV1) was equal or greater to 80% of predicted value. If normal, the report stated "Even though your lung function is normal, it is still important to quit smoking to prevent future damage to the lungs." If the results were abnormal, the report stated "This suggests that your lungs may already be damaged by smoking. Quitting smoking now can slow the rate of damage of the lungs."

Contingency management

Individuals randomized to contingency management received similar interventions as the usual care group. Additionally, it was explained to participants that they would receive monetary compensation for biological confirmation of tobacco cessation. At each visit, exhaled carbon monoxide levels were checked, and if eCO was <7 ppm, participants received compensation in a manner modified from the methodology of Shoptaw [31]. The first negative eCO resulted in \$25 payment, with subsequent negative eCO visits increasing \$5 in payment to a maximum of \$50. If the participant had an eCO consistent with recent tobacco use, they received no payment and the payment structure reset to the starting amount.

Lung age intervention

For individuals randomized to lung age intervention, spirometric results were reviewed in the context of lung

age [25]. Visual graphs were used to explain how the lung function normally reduces with age and that smoking can damage lung in a manner similar to more rapid aging. The written report included their chronological age and lung age. A similar description of normal or abnormal results was provided as in the usual care intervention, although the threshold to define abnormal was lung age exceeding chronological age.

Combined contingency management and lung age

Individuals randomized to this intervention received a combination of the lung age and contingency management protocols described above.

Study measures

Pre-bronchodilator spirometry FEV1 and forced vital capacity (FVC) was measured using KOKO® pneumotachometers (nSpire Health Inc, Longmont, CO) in accordance with American Thoracic Society guidelines [32]. Percent predicted values and lung age were calculated using standard formulas [33]. eCO measurements were performed with portable CO monitor (Breath CO, Clement Clarke Intl., Essex UK) with active smoking defined as an exhaled CO >7 ppm [34]. Self-efficacy and intention to quit smoking was assessed using a modified version of the Prochaska stages of change questionnaire [35]. Nicotine addiction was assessed with the Fagerstrom score [36]. Serum cotinine was measured via radioimmunoassay ELISA (Calbiotech, Spring Valley CA), with a threshold of ≥ 6 ng/mL indicative of active smoking [37].

Outcome measure and statistical analysis

The primary outcome of this study was the difference between interventions in six-month biologically-confirmed smoking cessation, defined as self-report of non-smoking in the last seven days combined with negative eCO and serum cotinine at final study visit. Secondary outcomes included differences by intervention in number of visits attended, smoking rates at interim visits (self-report and eCO), number of quit attempts, change in Fagerstrom score, and alterations in self-efficacy. All analyses were based on intention-to-treat. Comparison of outcomes across intervention was performed using chi2 test with Fisher's exact p-value for small samples of categorical outcomes and t-test or kruskal-wallis for continuous values as appropriate. A p-value of <0.05 was used to define statistical significance. It was determined a priori that if no interaction between lung age and contingency management was observed, individual interventions would be pooled for analysis (i.e., usual care and lung age versus contingency management and contingency management with lung age).

Results

Baseline characteristics

A total of 265 ALIVE participants were screened to identify 100 eligible and interested participants for this study (Figure 1). After randomization, 26 participants were enrolled in each of the usual care and contingency management interventions while 24 were enrolled in each of the lung age and lung age combined with contingency management interventions. The median age of the study cohort was 50 (IQR, 45–56) with 47% female participants. The median pack-years smoked was 19 (IQR, 12.5–31), with a median Fagerstrom score of 4 (IQR, 2–5). While all participants had a history of IDU, only 21% reported active injection in the last six months. However, there remained substantial involvement with consumption of other illicit drugs and alcohol, with 32% reporting use of non-intravenous drugs and 51% reporting alcohol use in the last six months. For participants in lung age interventions, the lung age was on average 12 years older than chronological age (median 12; IQR –1 to 23 years older), with 54% of lung age participants having a lung age at least ten years older than chronological age. Randomization resulted in similar baseline characteristics of the four intervention groups (Table 1). There was a higher proportion of non-African Americans in the lung age group when compared to the other interventions.

Outcomes across all interventions

The six month biologically-confirmed smoking cessation rate was 4% for usual care, 0% for lung age, 14%

for contingency management and 0% for combined lung age and contingency management. While higher cessation rates were observed in the contingency management intervention, this did not achieve statistical significance ($p = 0.13$). Using less stringent criteria for smoking cessation (self-report alone or self-report combined with negative eCO) also did not yield differential six month cessation rates across all four interventions. There were no substantial differences in the secondary endpoints of change in smoking rates (self-report and eCO) at interim visits, change in Fagerstrom score, total number of visits attended, alterations in self-efficacy and number of quit attempts comparing the four interventions.

Outcomes comparing contingency management to non-contingency management

Because there was neither an effect of lung age on outcomes nor an interaction between contingency management and lung age, we compared outcomes of the contingency management interventions to non-contingency management interventions (usual care combined with lung age alone) (Table 2, Figures 2 and 3). Comparing contingency management interventions (with and without lung age) to non-contingency management interventions (usual care and lung age alone), at six months more individuals self-reported smoking cessation in the prior seven days (18% vs. 4%; $p = 0.05$). There was no statistically significant difference in biologically-confirmed six month smoking cessation rates between contingency management and non-contingency management interventions (7% vs. 2%; $p = 0.36$). Contingency management was not

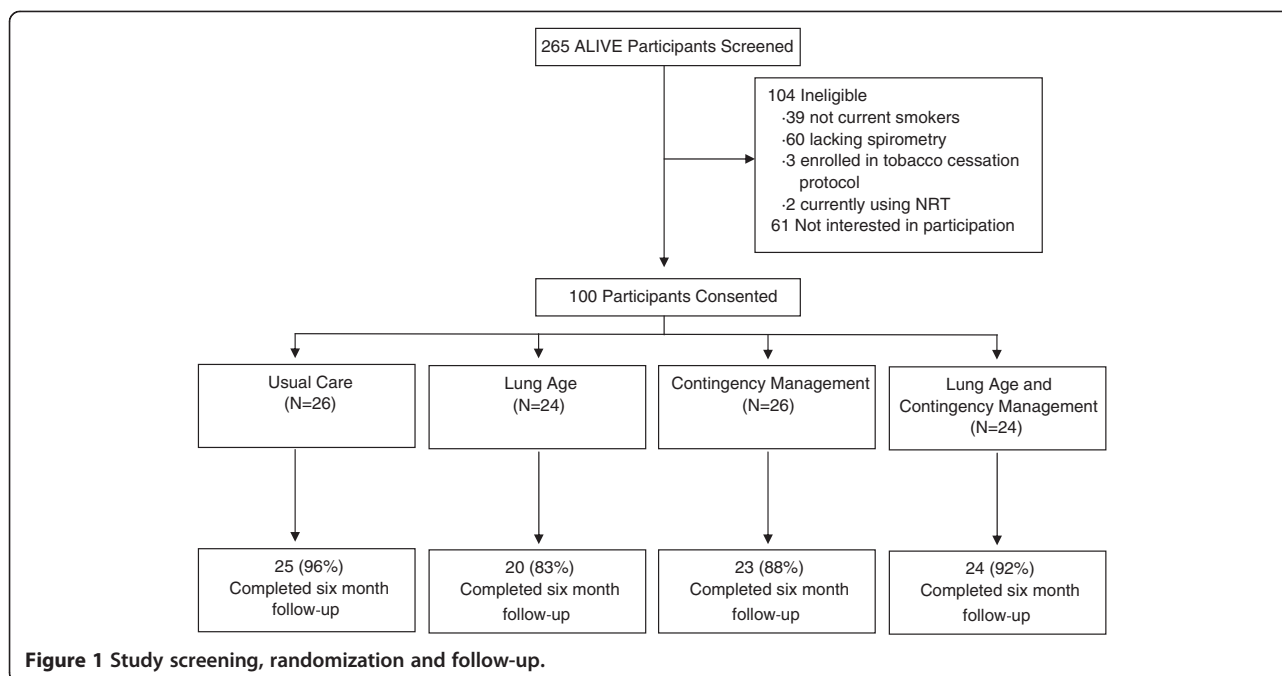


Table 1 Baseline characteristics at randomization

| | Usual care | Lung age | Contingency management | Lung age + contingency management | p-value |
|------------------------------------------------------|----------------|--------------------|------------------------|-----------------------------------|---------|
| N | 26 | 24 | 26 | 24 | |
| Age, years | 52.3 (7.2) | 46.1 (8.9) | 51.2 (7.5) | 49.2 (8.7) | 0.09 |
| Female, n (%) | 11 (42) | 10 (42) | 17 (65) | 9 (38) | 0.18 |
| African American race, n (%) | 24 (92) | 18 (75) | 26 (100) | 21 (88) | 0.03 |
| Current IDU, n (%) | 3 (12) | 8 (33) | 6 (23) | 4 (17) | 0.27 |
| Current non-IDU, n (%) | 7 (27) | 8 (33) | 7 (27) | 10 (42) | 0.64 |
| Current alcohol use, n (%) | 15 (58) | 12 (50) | 12 (46) | 12 (50) | 0.87 |
| More than 1 drink a day per week, n (%) | 15 (58) | 12 (50) | 12 (46) | 12 (50) | 0.37 |
| Alcohol or drug treatment in last 6 months, n (%) | 9 (35) | 10 (42) | 4 (15) | 9 (38) | 0.19 |
| HIV infected, n (%) | 6 (23) | 4 (17) | 4 (15) | 6 (25) | 0.83 |
| Age first smoked | 16.2 (5.0) | 16.1 (5.4) | 17.1 (5.8) | 14.9 (4.4) | 0.79 |
| Pack-years, med (IQR) | 19.1 (13.7-32) | 18.4 (14.1-22.8) | 17.8 (11.5-31.0) | 20.3 (11.0-35.5) | 0.74 |
| Smoking >1 pack per day, n (%) | 5 (19) | 4 (17) | 3 (12) | 5 (21) | 0.68 |
| Smokers in home, n (%) | 18 (69) | 20 (83) | 15 (58) | 19 (79) | 0.18 |
| Fagerstrom score, med (IQR) | 4 (2-5) | 3.5 (2-4) | 3.5 (2-5) | 4 (3-5.5) | 0.54 |
| Pulmonary diagnoses | | | | | |
| Asthma, n (%) | 6 (23) | 5 (21) | 8 (31) | 5 (22) | 0.84 |
| COPD, n (%) | 3 (12) | 4 (17) | 2 (8) | 2 (9) | 0.79 |
| Both, n (%) | 7 (27) | 7 (29) | 9 (35) | 5 (22) | 0.79 |
| FEV1 | | | | | |
| Absolute (L) | 2.58 (0.88) | 2.58 (0.78) | 2.42 (0.62) | 2.72 (0.94) | 0.74 |
| % predicted | 87.2 (20) | 84.1 (19) | 86.5 (14) | 93.7 (21) | 0.42 |
| FVC, (L) | | | | | |
| Absolute (L) | 3.58 (1.27) | 3.45 (0.96) | 3.18 (0.73) | 3.62 (1.13) | 0.57 |
| % predicted | 96.2 (17) | 90.8 (14) | 91.4 (12) | 99.5 (16) | 0.14 |
| FEV1/FVC ratio | 0.72 (0.11) | 0.74 (0.10) | 0.76 (0.06) | 0.75 (0.09) | 0.62 |
| Lung age | - | 60.7 (16) | - | 54.2 (19.8) | 0.31 |
| Difference btw lung age and actual age, median (IQR) | - | 12.5 (5.5 to 28.5) | - | 11.0 (-10 to 18.5) | 0.12 |

Table 2 Impact of contingency management on smoking habits and nicotine addiction

| | Non-contingency management | Contingency management | p-value |
|--------------------------------------------------------------------------|----------------------------|------------------------|---------|
| 6 month cotinine confirmed cessation, n (%) | 1 (2) | 3 (7) | 0.36 |
| 6 month eCO confirmed cessation, n (%) | 2 (4) | 5 (11) | 0.27 |
| 6 month self-reported cessation, n (%) | 2 (4) | 8 (18) | 0.05 |
| Use of nicotine replacement at 6 month visit, n (%) | 2 (4) | 7 (16) | 0.16 |
| Decreased Fagerstrom from 1 st visit, n (%) | 8 (18) | 17 (39) | 0.03 |
| Total number of visits ^a , mean (SD) | 5.34 (1.83) | 5.14 (1.84) | 0.59 |
| No. of visits reporting wanting to quit smoking ^a , mean (SD) | 5.12 (1.85) | 5.02 (1.83) | 0.79 |
| No. of visits reporting trying to quit smoking ^a , mean (SD) | 1.94 (1.92) | 2.42 (2.20) | 0.25 |
| No. of visits reporting cessation ^a , mean (SD) | 0.10 (0.30) | 0.58 (1.28) | 0.01 |
| No. of visits with eCO-confirmed cessation ^a , mean (SD) | 0.06 (0.24) | 0.38 (0.99) | 0.03 |

^aNumber of visits is out of 6 possible.

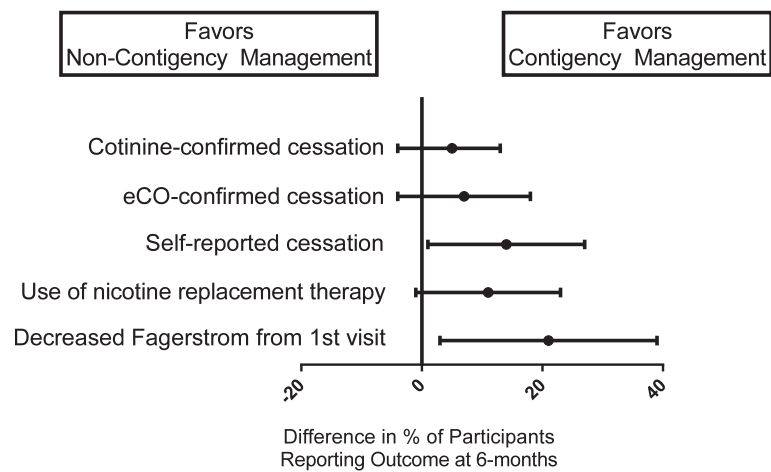


Figure 2 Relative effect of contingency management on six-month study outcomes. The figure displays the difference in the percent of participants reporting 6-month outcomes comparing contingency management to non-contingency management interventions. Center points represent the estimated difference in proportions with bars showing 95% confidence intervals. Vertical line represents no difference in proportion between interventions.

associated with higher cumulative study visit attendance (5.14 vs. 5.34 visits; $p = 0.59$) nor with more visits expressing desire to quit smoking (5.02 vs. 5.12 visits; $p = 0.72$). However, participants randomized to contingency management interventions had more visits reporting not smoking in the prior seven days confirmed with negative eCO (0.38 vs. 0.06 visits; $p = 0.03$) and more visits reporting not smoking in the prior seven days (0.58 vs. 0.10 visits; $p = 0.01$). As well, more participants in the contingency management interventions had a decrease in Fagerstrom score from baseline to six month visit (39% vs. 18%; $p = 0.03$). The range in decrease of Fagerstrom score was -1 to -2 points for both interventions. There was no difference in measures of self-efficacy between contingency management and non-contingency interventions. Over

the study period, in the contingency management interventions a total of 25 participants were reimbursed for an initial negative eCO, 11 for a second negative eCO, four for third negative eCO and one individual achieved four consecutive eCO measurements. The total reimbursement over the six month study period for the 50 eligible participants was \$1135 (average of \$22.70 per participant).

Discussion

In this study, we examined the impact of contingency management and the use of spirometric lung age as motivational tools to improve smoking cessation rates among IDUs. While neither intervention, when compared to usual care, was associated with a statistical change in six-month biologically-confirmed cessation

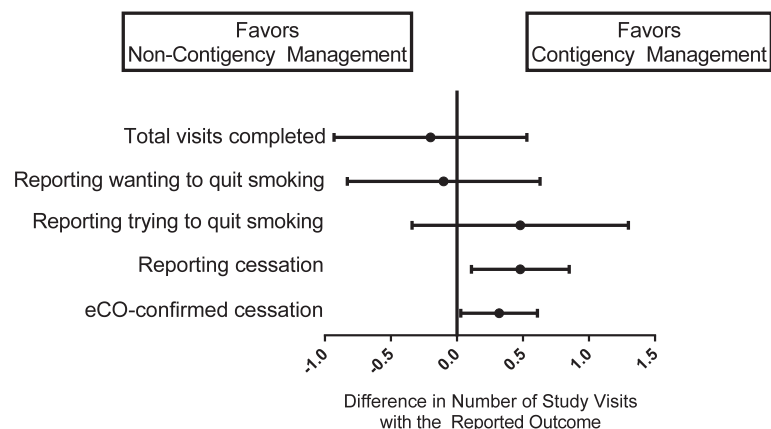


Figure 3 Relative effect of contingency management on cumulative study outcomes. Number of Study Visits. The displays the difference in number of cumulative study visits for the stated outcome, comparing contingency management to non-contingency management interventions. Center points represent the estimated mean difference in study visits with bars showing 95% confidence intervals. Vertical line represents no difference in number of visits between interventions.

rates, we did observe that contingency management interventions were associated with more short-term abstinence as measured by exhaled CO and with lower nicotine addiction as assessed by Fagerstrom score. We did not observe any effect of using spirometric lung age as tool to change smoking behavior or nicotine addiction in this population, and in fact observed that spirometric lung age may have attenuated the effect of contingency management when these interventions were combined.

Contingency management has been reported to enhance smoking cessation rates in opioid-maintained patients [20-22]. Most of these studies were of short duration, and carried out in the context of an existing drug rehabilitation program. Our study extends these findings by testing this intervention outside of a methadone clinic, for a longer duration of follow-up and with rigorous biological confirmation of smoking status. In the setting of a multinational company based in the United States, a longer duration study of more substantial financial incentives (\$750 per person over one year) for smoking cessation in a non-substance abusing employee population achieved 15% biologically-confirmed cessation rates at 9-month follow-up compared to 5% in an information-only comparator group [24]. We observed a lower proportion of cessation at the final visit, highlighting the challenges of durable cessation in a substance abusing population. While a statistical difference in 6-month cessation rates was not observed in this study, meaningful differences were observed regarding the beneficial impact of contingency management on outcomes indicative of smoking cessation initiation, suggesting potential efficacy of this intervention in IDUs. These results highlight the potential value in integration of contingency management programs into existing smoking cessation programs for substance abusers.

Contingency management for drug abuse treatment has been extensively evaluated, with consistent data from high-quality studies demonstrating benefit for abuse of varied substances (opiates, stimulants, alcohol, marijuana, tobacco) in different settings (inpatient, outpatient, community-based) [38-44]. Similar to our study, contingencies in studies of drug-users have generally been vouchers or cash-equivalents of modest amount, delivered for providing biological samples which confirm abstinence. Modest incentives (\$10) improve attendance at weekly clinic visits among drug users [45] while free methadone vouchers linked 90% of hospitalized drug users to outpatient treatment by 3 months (8 times better than standard referral) [46]. In addition to drug use, modest incentives have been shown to improve participation in HIV counseling and testing, returning to receive HIV test results, and attendance at referral HIV clinic visits [47-49]. Contingency management interventions have demonstrated reductions in HIV-related risk

behavior [50,51], increased compliance with tuberculosis screening [52] and improvements in ART adherence [53-56]. In our population, we have previously observed no difference in smoking behaviors or tobacco-cessation rates by HIV status [28]. Our findings demonstrate that this intervention may be beneficial in changing early smoking habits in a challenging population of current and former drug users, and justify a larger study to explore this intervention further.

While contingency management did impact some outcomes of this study, we did not observe any differential changes in smoking behaviors or perceptions associated with the use of spirometric lung age as a motivational tool. This differs from several prior reports in varied study populations. Parkes and colleagues conducted a randomized controlled trial of smoking cessation incorporating lung age-based counseling in 561 smokers from United Kingdom outpatient practices [57]. At 12 month follow-up, verified quit rates (self-report, carbon monoxide and salivary cotinine) were 6.4% in the control group and 13.6% in the intervention arm ($p = 0.005$). Average consumption of cigarettes was also lower in the intervention group. The authors conclude that the use of individualized lung age feedback is effective at improving smoking cessation. Lipkus and Prokhorov examined the effect of providing lung age on college smokers' perceived smoking-related risks, worries and desire to quit [26]. Smokers with a lung age that exceeded their chronological age tended to have greater perceptions of absolute and comparative risk, short- but not long-term worries and expressed a stronger desire to quit. The lung age of this cohort was over a decade older than physiological age. It is unclear what magnitude of discrepancy between measured and actual age can motivate behavioral changes in this population. While lung age may be beneficial in other populations, the lack of an observed effect in IDUs highlights the need to study specific cessation interventions in unique populations of smokers.

Several theoretical models of health behavior change, including the health belief model, protection motivation theory and precaution adoption models, propose that perceptions of personal vulnerability to the harms of smoking are key to motivating smoking cessation [58-60]. Additionally, greater perceived risk has been associated with a greater desire to quit, more frequent quit attempts and sustained quitting [61-64]. In addition to a lack of impact of lung age as a motivational tool, the benefits of contingency management were not seen when combined with lung age intervention. Based on the null findings observed with lung age-based risk counseling, the relationships between perceived risk and motivation for cessation may be more complex among IDUs. Conceptual models of smoking cessation include reinforcement-based motivational therapy and augmentation of perceived personal risk.

Contingency management serves to motivate behavioral change through reinforcement while lung age serves to enhance perceived personal risk. Therefore, the lack of a lung age effect in the population studied here suggests that IDUs may be more responsive to incentives rather than perceived self-risk. Further, the attenuation of contingency management effects by the presence of lung age suggest that lung age may serve as a negative reinforcement of other cessation tools.

Unique strengths of this study include the focus on an under-studied population with high tobacco dependence, a study design permitting evaluation of the independent and synergistic effects of two interventions, and the near-complete 6-month follow-up. This study has some limitations. The small sample size of this study limits the ability to determine the efficacy or estimate the magnitude of the effect of contingency management or spirometric lung age on smoking cessation. The data from this study can be used to inform larger trials testing these interventions. The durability of benefits from contingency management after completion of the intervention is not known, but will be evaluated with on-going follow-up. While the overall rates of cessation were low, a six month 7-11% biological cessation rate is likely substantial in this challenging population of IDUs. Intentionally, this study lacks generalizability outside of urban, minority populations dealing with substance abuse. Our goal was to examine specific cessation interventions among drug users, as this population has high smoking prevalence, substantial tobacco-related disease burden, extremely low cessation rates, and has been greatly understudied in terms of cessation interventions. This study demonstrates that tobacco cessation interventions can be effectively implemented in this population. Novel cessation strategies, such as incorporating mobile health (mHealth) tools to improve smoking cessation among marginalized, underserved populations holds promise for improving access and efficiency to smoking cessation interventions and towards reducing the tobacco-related disparities that currently exist [65].

Conclusions

In summary, we have demonstrated that contingency management, but not spirometric lung age message, as a motivational tool for smoking cessation leads to more short-term abstinence and lower nicotine addiction over a 6-month period. While definitive benefit on biologically-confirmed smoking cessation at 6 months was not achieved in this study, our findings demonstrate that contingency management interventions are feasible among urban drug-using populations and leads to favorable modifications in smoking behavior, specifically cessation attempts and in reduced levels of nicotine addiction. Larger trials among drug-using populations are appropriate to

definitively establish if contingency management is of benefit in this population. Ultimately, contingency management may help decrease the substantial burden of tobacco dependence in similar underserved populations with excessive tobacco use.

Abbreviations

ALIVE: AIDS Linked to the Intravenous Experience; eCO: Exhaled carbon monoxide; FEV1: Forced expiratory volume in 1 second; FVC: Forced vital capacity; IDUs: Injection drug users.

Competing interests

All authors have no financial conflict of interest to disclose.

Authors' contributions

MD contributed to study design, analysis plan, interpretation and writing and editing of the report. JA contributed to the analysis plan, interpretation and was responsible for data analysis. AL contributed to study design, analysis plan, interpretation and editing of the report. SG contributed to data collection, interpretation of results, and editing of the report. MS contributed to data analysis, interpretation and editing of the report. CM contributed to study design, data analysis, interpretation and editing of the report. CR contributed to study design, interpretation and editing of the report. RW contributed to study design, analysis plan, interpretation and editing of the report. GK contributed to study design, analysis plan, interpretation and writing and editing of the report. All authors read and approved the final manuscript.

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