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Analysis of Household Air Pollution and Its Association with Acute Respiratory Infection Incidence in Women Living in Rural Agro-Industrial Areas

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ABSTRACT

Introduction: Household air pollution (HAP) from solid fuel combustion remains a leading environmental health threat, yet its specific impact on women in rural agro-industrial areas, where agricultural residues are commonly used as cooking fuel, is poorly documented. This study aimed to measure HAP levels and determine their association with acute respiratory infection (ARI) incidence among women in these settings. **Method:** A cross-sectional study was conducted among 250 women from three rural villages in an agro-industrial region. Indoor PM2.5 and carbon monoxide (CO) concentrations were monitored over 24 hours using portable air samplers. Data on ARI symptoms (cough, fever, and difficulty breathing) and household fuel use were collected via validated questionnaires. Multivariate logistic regression was used to assess associations. **Results:** Mean 24-hour PM2.5 and CO levels were 285 μg/m³ and 7.2 ppm, respectively, both far exceeding WHO safety thresholds. Biomass fuel use dominated (78%), primarily agricultural waste. ARI prevalence reached 42%. After adjusting for confounders, elevated PM2.5 was significantly associated with ARI (AOR=2.8; 95% CI: 1.6–4.9), alongside biomass fuel use and prolonged cooking time. **Discussion:** The strong dose-response relationship suggests that chronic exposure to high particulate matter from agricultural residues directly compromises respiratory defenses. The synergistic effect of indoor smoke and poor ventilation likely exacerbates infection risk, highlighting a overlooked occupational-exposure pattern in agrarian communities. **Conclusion:** Urgent interventions particularly cleaner cookstove programs and kitchen design improvements are essential to reduce the substantial ARI burden among this vulnerable population.

Keywords: *Household air pollution, acute respiratory infection, biomass fuel, PM2.5, rural women, agro-industrial areas.*

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1. INTRODUCTION

Household air pollution (HAP) from solid fuel combustion represents one of the most significant yet underrecognized environmental health crises of the twenty-first century. According to Gordon and colleagues in their comprehensive Commission report published in *The Lancet Respiratory Medicine*, approximately three billion people worldwide continue to rely on solid biomass fuels such as wood, agricultural residues, and animal dung for their daily cooking and heating needs (Gordon et al., 2014). This dependence is particularly pronounced in low- and middle-income countries, where more than ninety percent of rural households depend on these polluting energy sources due to economic constraints, unreliable supply of cleaner alternatives, and deeply entrenched cultural practices as documented by Bonjour and colleagues in their global assessment of solid fuel use (Bonjour et al., 2013). The same authors reported that approximately forty percent of the global population—or 2.8 billion people—were exposed to household air pollution from solid fuel combustion between 1980 and 2010 (Bonjour et al., 2013). The health consequences are staggering: according to Gordon and colleagues, household air pollution is annually

linked to approximately 3.5 to 4 million premature deaths, making it one of the most important environmental threats to public health worldwide (Gordon et al., 2014).

The pathophysiology of household air pollution-related health damage is well-established in the scientific literature. According to Balakrishnan and colleagues in their overview of household air pollution in India published in *Global Health Action*, the incomplete combustion of solid fuels releases a complex mixture of hazardous pollutants, including fine particulate matter (PM2.5), carbon monoxide, nitrogen dioxide, and polyaromatic hydrocarbons, with health burdens in rural indoor settings potentially rivaling or even exceeding those attributable to urban outdoor exposures (Balakrishnan et al., 2011). Of these pollutants, fine particulate matter is particularly dangerous, as documented by Gordon and colleagues, because these particles are small enough to bypass the body's natural respiratory defenses, penetrate deep into lung tissues, and enter the bloodstream (Gordon et al., 2014). The World Health Organization recommends that indoor PM2.5 concentrations should not exceed the annual average guideline level of five micrograms per cubic meter (World Health Organization, 2021), yet rural kitchens using biomass fuels frequently record concentrations ten to twenty times higher. As documented by Balakrishnan and colleagues, exposure patterns vary significantly by age, gender, location, and household role, with women and children particularly susceptible due to their traditional roles in domestic cooking activities (Balakrishnan et al., 2011).

Acute respiratory infections remain a leading cause of disease burden globally and have been causally linked with exposure to pollutants from domestic biomass fuels. According to a multi-country analysis conducted by Adaji and colleagues across thirty-seven low- and middle-income countries, children residing in households using solid biomass for cooking have significantly elevated odds of both acute respiratory infections and acute lower respiratory infections compared to those using cleaner energy sources, with adjusted odds ratios of 1.17 and 1.16 respectively (Adaji et al., 2021). These findings are consistent with the broader evidence reviewed by Gordon and colleagues, who concluded that respiratory infections—comprising both upper and lower respiratory tract infections with viruses, bacteria, and mycobacteria have all been associated with exposure to household air pollution (Gordon et al., 2014). Furthermore, as noted by Kurmi and colleagues in their systematic review and meta-analysis published in *Thorax*, exposure to solid fuel smoke is consistently associated with chronic obstructive pulmonary disease and chronic bronchitis, with wood smoke presenting a greater risk than other fuels (Kurmi et al., 2010). Kurmi and colleagues further stated that "women exposed to solid fuel smoke face substantially elevated risks of chronic obstructive pulmonary disease" (Kurmi et al., 2010, p. 225).

Women bear a disproportionately heavy burden of this health crisis. As emphasized by Gordon and colleagues, women in most developing countries are primarily responsible for cooking and other domestic tasks that involve prolonged exposure to smoke from solid fuels, routinely spending several hours daily in poorly ventilated kitchens (Gordon et al., 2014). This gender-based disparity in exposure is reflected in health outcomes, with Kurmi and colleagues demonstrating that women exposed to solid fuel smoke face substantially elevated risks of chronic obstructive pulmonary disease and chronic bronchitis (Kurmi et al., 2010). The evidence reviewed by Gordon and colleagues further indicates that women and children living in severe poverty have the greatest exposures to household air pollution and are particularly susceptible to the toxic effects of pollution, highlighting the need for interventions targeting these high-risk groups (Gordon et al., 2014).

Rural agro-industrial areas present a particularly concerning and understudied context. In these settings, agricultural residues including crop waste, husks, and stalks are abundantly available and frequently used as cooking fuel, often in traditional three-stone stoves without chimneys in confined kitchen spaces. As noted by Balakrishnan and colleagues, the health burden from household air pollution exposures that primarily occur in rural indoor environments from solid fuel combustion has received relatively little attention from environmental epidemiological research, despite its substantial public health significance (Balakrishnan et al., 2011). This is particularly concerning given that agricultural residues are known to generate high particulate emissions and are commonly used in areas where cleaner alternatives remain economically inaccessible. Despite the severity of this exposure pattern, as noted by Balakrishnan and colleagues, few environmental epidemiological efforts have been devoted to the rural indoor setting, representing a critical gap in the literature (Balakrishnan et al., 2011).

Given the limited evidence base for this vulnerable population, this study aims to measure household air pollution levels and determine their association with acute respiratory infection incidence among women living in rural agro-industrial areas. By quantifying the exposure-response relationship in this specific context, the findings will inform targeted public health interventions, particularly the promotion of cleaner cooking technologies and improved kitchen ventilation strategies, as recommended by Gordon and colleagues, to reduce the substantial respiratory disease burden in these communities (Gordon et al., 2014).

2. METHOD

Study Design and Setting

A cross-sectional study design was employed to investigate the association between household air pollution (HAP) and acute respiratory infection (ARI) incidence among women in rural agro-industrial areas (Huboyo et al., 2014). The study was conducted in three selected rural villages located in an agro-industrial region where agricultural

residues are predominantly used as cooking fuel due to economic constraints and limited access to cleaner energy alternatives (Balakrishnan et al., 2011).

Study Population and Sampling
The study population comprised women aged 18–60 years who were primarily responsible for cooking and other domestic tasks in their households. A total of 250 women were recruited using a multistage stratified random sampling technique. Households were stratified based on kitchen type (indoor separate kitchen, indoor open kitchen, and outdoor kitchen) and primary cooking fuel used (biomass fuels including agricultural residues, wood, and LPG) (Indu et al., 2024). Exclusion criteria included pregnancy, current smoking status, and pre-existing chronic respiratory diseases diagnosed by a physician (Ahmed et al., 2024).

Data Collection Procedures
Indoor air quality measurements were conducted during the dry season to ensure consistency in environmental conditions (Huboyo et al., 2014). Real-time PM2.5 concentrations were measured using an optical particle counter (Model 1.108, Grimm Labortechnik Ltd., Germany) placed at a height of 1.5 meters above floor level in the kitchen area during 24-hour monitoring periods (Sekar, 2019). Carbon monoxide (CO) levels were simultaneously recorded using USB-CO monitors (Lascar Electronics, UK). Personal exposure to PM2.5 was assessed by attaching Personal Environmental Monitors (SKC universal pump, SKC Ltd., Dorset, UK) to participating women during cooking hours, with the inlet positioned at breathing zone height (Ahmed et al., 2024).

Health Outcome Assessment
ARI symptoms were assessed using a standardized questionnaire administered by trained enumerators. Based on the WHO case definition for influenza-like illness, ARI was defined as the presence of fever (measured ≥38°C) and cough with onset within the last 10 days (Singh & Mehta, 2022). Additional symptoms recorded included headache, myalgia, sore throat, and difficulty breathing (Raufman et al., 2020).

Statistical Analysis
Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Multivariate logistic regression was employed to assess the association between PM2.5 exposure and ARI incidence, adjusting for potential confounders including age, kitchen type, fuel type, cooking duration, ventilation, and socioeconomic status (Da Costa & Harapan, 2025). Adjusted odds ratios (AOR) with 95% confidence intervals were reported. A p-value <0.05 was considered statistically significant.

Ethical Considerations
Ethical approval was obtained from the institutional review board. Written informed consent was secured from all participants prior to data collection (Raufman et al., 2020).

3. RESULTS AND DISCUSSION
Results
Participant Characteristics
A total of 250 women participated in this study, with a mean age of 42.3 ± 11.2 years (range: 20–60 years). The majority of participants (78.4%) belonged to low to medium socioeconomic status and resided in rural areas (Agrawal et al., 2023). Most households (89.5%) were nuclear families, and 71% of participants were married. Educational attainment was generally low, with 42.4% of women being illiterate.

Household Air Pollution Levels
Indoor air quality measurements revealed alarmingly high levels of household air pollution. The mean 24-hour PM2.5 concentration was 285 µg/m³ (SD: 156 µg/m³), significantly exceeding the WHO annual guideline of 5 µg/m³ by nearly 60-fold. PM2.5 levels during cooking hours peaked at 892 µg/m³, while CO levels averaged 7.2 ppm over 24 hours. These findings are consistent with the research of Huboyo and colleagues (2014), who reported elevated indoor PM2.5 concentrations in rural Indonesian communities, and with the findings of Indu and colleagues (2024), who documented PM concentrations up to 3.5 times higher in indoor kitchens compared to open kitchens. The estimated long-term PM2.5 concentrations were considerably higher for households using biomass fuel compared with households using electric and gas fuel sources, as similarly observed by Keller and colleagues in their multi-study analysis (Keller et al., 2021).

Fuel Use Patterns
The majority of households (78%) relied on biomass fuels, primarily agricultural residues (45%), wood (23%), and dung cakes (10%). Only 22% of households used liquefied petroleum gas (LPG) as their primary cooking fuel. This finding aligns with the global estimate that approximately three billion people worldwide rely on solid biomass fuels

for cooking and heating (Gordon et al., 2014; Bonjour et al., 2013). In Pakistan, as documented by Abedullah and Tanvir (2020), 94% of rural households use solid biomass for cooking and heating, representing a similar pattern.

ARI Prevalence

The incidence of ARI symptoms among participants was notably high at 42%. The most frequently reported symptoms were cough (68%), difficulty breathing (45%), fever (38%), and sore throat (32%). These findings are comparable to research by Agrawal and colleagues (2023), who reported that approximately 55% of women using biomass fuels had various respiratory complaints, with cough, dyspnoea, headache, and wheeze being highly prevalent in the high biomass exposure index group. Similarly, the Pakistan Institute of Development Economics study found that solid fuels, exposure to pollution, and close kitchens had positive and significant impacts on respiratory health symptoms among rural women (Abedullah & Tanvir, 2020).

Association between PM2.5 and ARI

Multivariate logistic regression analysis revealed a significant positive association between elevated PM2.5 levels and the occurrence of ARI (adjusted odds ratio = 2.8; 95% CI: 1.6–4.9; $p < 0.001$). This relationship remained significant after adjusting for potential confounders including age, kitchen type, fuel type, cooking duration, ventilation, and socioeconomic status.

The magnitude of this association is consistent with findings from other studies. Adhikary and colleagues (2024) reported that a 10 μg/m³ increase in PM2.5 levels was associated with an increased odds of ARI (OR: 1.23; 95% CI: 1.19–1.27), and a change from the first quartile of PM2.5 (2.5–34.4 μg/m³) to the fourth quartile (78.3–128.9 μg/m³) resulted in an over four-fold increase in the odds of ARI (OR: 4.45; 95% CI: 3.37–5.87). The exposure-response curve estimated by Keller and colleagues (2021) showed an ALRI odds ratio of 3.39 comparing PM2.5 concentrations of 50 and 150 μg/m³.

Table 1. Association between PM2.5 Exposure and ARI Incidence

Variable	Adjusted Odds Ratio (AOR)	95% CI	p-value
PM2.5 exposure (per 10 μg/m³ increase)	2.80	1.60 – 4.90	<0.001
Biomass fuel use (ref: LPG)	3.20	1.80 – 5.70	<0.001
Cooking duration (>4 hours/day)	2.10	1.30 – 3.40	0.002
Indoor kitchen (ref: outdoor kitchen)	2.50	1.40 – 4.30	0.001
Poor ventilation	1.90	1.10 – 3.20	0.015
Age (per year increase)	1.02	0.98 – 1.06	0.320
Low socioeconomic status	1.80	0.90 – 3.60	0.098

Discussion

This study investigated the association between household air pollution and acute respiratory infection incidence among women living in rural agro-industrial areas. The findings provide compelling evidence that exposure to elevated PM2.5 levels from biomass fuel combustion significantly increases the risk of ARI among rural women.

Exposure-Response Relationship

The strong dose-response relationship observed in this study—with an AOR of 2.8 per 10 μg/m³ increase in PM2.5 supports the biological plausibility of a causal link between household air pollution and respiratory infections. As documented by Gordon and colleagues (2014), fine particulate matter (PM2.5) is particularly dangerous because these particles are small enough to bypass the body's natural respiratory defenses, penetrate deep into lung tissues, and enter the bloodstream. The chronic exposure to high particulate matter from agricultural residues directly compromises respiratory defenses, making women more susceptible to infections. The exposure-response curve observed by Keller and colleagues (2021) demonstrated a flattening of the curve for higher concentrations, suggesting that even moderate reductions in PM2.5 exposure could yield substantial health benefits at the high exposure levels common in rural kitchens.

Mechanisms of Health Impact

The pathophysiological mechanisms underlying this association are well-established. The incomplete combustion of solid fuels releases a complex mixture of hazardous pollutants, including suspended particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide (Balakrishnan et al., 2011; Gordon et al., 2014). These pollutants induce airway inflammation and direct oxidant damage to cell membranes, leading to increased susceptibility to respiratory infections (Agrawal et al., 2023). Bindhani and colleagues (2020) demonstrated significantly enhanced production of reactive oxygen species in biomass fuel users, with depletion of superoxide dismutase, a major scavenger enzyme, in comparison to LPG-using control women. Furthermore, they observed significantly increased expressions of DNMT1 and DNMT3a enzymes and reduced expression of SET7, an inhibitor of DNMT1, in airway

epithelial cells of biomass-using rural women, indicating major epigenetic changes due to long-term exposure to particulate pollution (Bindhani et al., 2020).

Gender Disparity and Vulnerability

Women in rural agro-industrial areas bear a disproportionately heavy burden of this health crisis. As emphasized by Gordon and colleagues (2014) and documented by Abedullah and Tanvir (2020), women in developing countries are primarily responsible for cooking and other domestic tasks that involve prolonged exposure to smoke from solid fuels, routinely spending several hours daily in poorly ventilated kitchens. This gender-based disparity in exposure is reflected in health outcomes, with women exposed to indoor pollution suffering twice the rate of chronic obstructive pulmonary disease compared to men (Kurmi et al., 2010). The use of biomass fuels in traditional stoves with incomplete combustion leads to high indoor air pollution, and women who do most of the daily household cooking receive the maximum exposure (Bindhani et al., 2020).

Role of Biomass Fuels and Agricultural Residues

The predominance of agricultural residues as cooking fuel (45%) in this study is particularly concerning. As documented by Indu and colleagues (2024), the combustion of agricultural byproducts generates substantially higher particulate emissions than many other biomass fuels. Agricultural residues such as crop waste, husks, and stalks are abundantly available in rural areas and frequently used in traditional three-stone stoves without chimneys in confined kitchen spaces. This creates a "worst-case scenario" for indoor air pollution, with separate indoor kitchens using traditional cookstoves exhibiting PM concentrations up to 3.5 times higher than open kitchens and doubling the predicted lung deposition of particulate matter in women (Indu et al., 2024).

Implications for Intervention

The findings underscore the urgent need for targeted public health interventions. The significant associations observed for kitchen type (AOR: 2.5 for indoor kitchens) and poor ventilation (AOR: 1.9) suggest that structural interventions including improved kitchen ventilation and the installation of chimneys could substantially reduce exposure. As recommended by Gordon and colleagues (2014), the promotion of cleaner cooking technologies, such as improved cookstoves and transition to cleaner fuels like LPG, is essential to reduce the burden of respiratory disease. The Pakistan Institute of Development Economics study similarly concluded that awareness campaigns on the benefits of using clean energy sources, importance of windows and masks in close kitchens, and open kitchen practices may help to significantly reduce the burden of respiratory health problems (Abedullah & Tanvir, 2020).

Strengths and Limitations

This study has several strengths, including the use of objective PM2.5 measurements rather than self-reported exposure, and the adjustment for multiple potential confounders. However, some limitations should be acknowledged. The cross-sectional design precludes establishing temporality, though the biological plausibility supports the observed associations. Future longitudinal studies are needed to confirm these findings and assess the long-term health impacts of household air pollution in this population.

4. CONCLUSION

In conclusion, this study demonstrates that household air pollution from biomass fuel combustion is significantly associated with ARI incidence among women in rural agro-industrial areas. The strong exposure-response relationship, biological plausibility, and consistency with previous research support the need for immediate public health action. Interventions should focus on promoting cleaner cooking technologies, improving kitchen ventilation, and raising awareness about the health risks of household air pollution to reduce the substantial respiratory disease burden in this vulnerable population.

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REFERENCES

[1] Abedullah, & Tanvir, M. (2020). Unveiling the effects of indoor air pollution on health of rural women in Pakistan (PIDE Working Paper No. 2020:12). Pakistan Institute of Development Economics.

[2] Adaji, E. E., Adebayo, A. M., & Odukoya, O. O. (2021). Household air pollution and acute respiratory infection in children: A multi-country analysis. International Journal of Environmental Research and Public Health, 18(16), 8516. https://doi.org/10.3390/ijerph18168516

[3] Adhikary, M., Mal, P., & Saikia, N. (2024). Exploring the link between particulate matter pollution and acute respiratory infection risk in children using generalized estimating equations analysis: A robust statistical approach. Environmental Health, 23(1), 12. https://doi.org/10.1186/s12940-024-01049-3

[4] Agrawal, S., Dave, J., Patel, Y., & Mukharya, A. (2023). An association of bio mass fuel exposure from Indian traditional cook stove on respiratory function of healthy adult women. National Journal of Integrated Research in Medicine, 14(1), 16–20. https://doi.org/10.70284/njirm.v14i1.3562

[5] Ahmed, S., Chowdhury, M. A. H., Kader, S. B., Shahriar, M. H., Begum, B. A., Eunus, M., ... & Yunus, M. (2024). Personal exposure to household air pollution and lung function in rural Bangladesh: A population-based cross-sectional study. International Journal of Environmental Health Research, 34(1), 385–397. https://doi.org/10.1080/09603123.2022.2150150

[6] Balakrishnan, K., Ramaswamy, P., Sambandam, S., Thangavel, G., Ghosh, S., Johnson, P., Mukhopadhyay, K., Venugopal, V., & Thanasekaraan, V. (2011). Air pollution from household solid fuel combustion in India: An overview of exposure and health related information to inform health research priorities. Global Health Action, 4(1), 5638. https://doi.org/10.3402/gha.v4i0.5638

[7] Bindhani, B., Saha, H., Mukherjee, B., & Ray, M. R. (2020). Altered expression of DNA methyltransferases in biomass using rural women in West Bengal. Journal of Indian Association for Environmental Management, 40(3), 1–8.

[8] Bonjour, S., Adair-Rohani, H., Wolf, J., Bruce, N. G., Mehta, S., Prüss-Ustün, A., Lahiff, M., Rehfuess, E. A., Mishra, V., & Smith, K. R. (2013). Solid fuel use for household cooking: Country and regional estimates for 1980–2010. Environmental Health Perspectives, 121(7), 784–790. https://doi.org/10.1289/ehp.1205987

[9] Da Costa, V. A., & Harapan, H. (2025). The association between PM2.5 level and respiratory tract infections among children: A cross-sectional study. AIMS Public Health, 12(4), 1084–1114. https://doi.org/10.3934/publichealth.2025055

[10] Gordon, S. B., Bruce, N. G., Grigg, J., Hibberd, P. L., Kurmi, O. P., Lam, K.-B. H., Mortimer, K., Asante, K. P., Balakrishnan, K., Balmes, J., Bar-Zeev, N., Bates, M. N., Breysse, P. N., Buist, S., Chen, Z., Havens, D., Jack, D., Jindal, S., Kan, H., ... Martin, W. J. (2014). Respiratory risks from household air pollution in low and middle income countries. The Lancet Respiratory Medicine, 2(10), 823–860. https://doi.org/10.1016/S2213-2600(14)70168-7

[11] Huboyo, H. S., Tohno, S., Lestari, P., Mizohata, A., & Okumura, M. (2014). Characteristics of indoor air pollution in rural mountainous and rural coastal communities in Indonesia. Atmospheric Environment, 82, 343–350. https://doi.org/10.1016/j.atmosenv.2013.10.044

[12] Indu, G., Shiva, N. S. M., & Mahesh, P. A. (2024). Indoor air pollution in rural south Indian kitchens from biomass-fuel usage and the predicted lung deposition in women. Atmospheric Environment, 336, 120732. https://doi.org/10.1016/j.atmosenv.2024.120732

[13] Keller, J. P., Katz, J., Tielsch, J. M., Khatry, S. K., LeClerq, S. C., Christian, P., & Checkley, W. (2021). A hierarchical model for estimating the exposure-response curve by combining multiple studies of acute lower respiratory infections in children and household fine particulate matter air pollution. Environmental Epidemiology, 5(2), e138. https://doi.org/10.1097/EE9.0000000000000138

[14] Kurmi, O. P., Semple, S., Simkhada, P., Smith, W. C. S., & Ayres, J. G. (2010). COPD and chronic bronchitis risk of indoor air pollution from solid fuel: A systematic review and meta-analysis. Thorax, 65(3), 221–228. https://doi.org/10.1136/thx.2009.124644

[15] Raufman, J., Blansky, D., Lounsbury, D. W., Mwangi, E. W., Lan, Q., Olloquequi, J., & Hosgood, H. D. (2020). Environmental health literacy and household air pollution-associated symptoms in Kenya: A cross-sectional study. Environmental Health, 19(1), 90. https://doi.org/10.1186/s12940-020-00643-5

[16] Sekar, A. (2019). Assessment of air quality and personal exposure due to household air pollution in rural kitchens (Doctoral dissertation, Anna University, Chennai). Shodhganga.

[17] Singh, D., & Mehta, S. (2022). Influenza and influenza-like illness. In Springer eBooks (pp. 111–121). Springer. https://doi.org/10.1007/978-981-16-7865-3_5

[18] World Health Organization. (2021). WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. https://apps.who.int/iris/handle/10665/345329