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*Original Article*

# Identification of lncRNA-NR_104160 as a biomarker and construction of a lncRNA-related ceRNA network for essential hypertension

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**Abstract:** Objectives: To identify long noncoding RNAs (lncRNAs) and construct a competing endogenous RNA (ceRNA) network for essential hypertension. Methods: An RNA microarray and two-step quantitative real-time PCR were applied to identify differentially expressed RNAs (DE-RNAs), and a luciferase assay was performed to explore the binding relationship between RNAs. A generalized linear model and logistic regression model were used to analyze the associations between different RNAs and of RNAs with hypertension. Receiver operating characteristic curve analysis was executed to evaluate the diagnostic performance. Bioinformatics analysis was applied for network construction. Results: In total, 439 DE-RNAs (387 lncRNAs and 52 mRNAs) were identified in the microarray, and 71 'lncRNA-miRNA-mRNA' loops formed the ceRNA network. The first validation confirmed that five RNAs (NR_104160, lnc-GPR63-8:1, lnc-HPRT1-9:1, *ID1* and *RSL24D1*) were significantly upregulated in hypertensives ($P < 0.05$). NR_104160 was significantly associated with hypertension (OR = 2.863, 95% CI: 1.143-7.172; $P = 0.025$) after adjusting for confounding factors. NR_104160 was included in the hypertension diagnostic model, with an area under the curve of 0.852 (95% CI: 0.761-0.944). In the second validation, NR_104160 showed a constant significant difference ($P = 0.001$). An elevated expression level of NR_104160 was associated with the expression of *ID1* ($\beta = 0.2235$, $P = 0.005$). Luciferase assays showed hsa-miR-101-3p stimulation significantly inhibited the reporter gene activation ability of the NR_104160 wild-type plasmid ($P < 0.001$). Conclusions: Our study constructed a ceRNA network to provide hypotheses regarding the mechanism of hypertension development. lncRNA-NR_104160 was identified as a hub element that participates in hypertension transcriptional regulation and as a potential biomarker.

**Keywords:** lncRNA, hypertension, ceRNA, network, biomarker

## Introduction

Essential hypertension is a chronic noncommunicable disease caused by genetic and environmental factors [1]. The prevalence of hypertension in China is 39.7% [2]. As a major risk factor for stroke, myocardial infarction, heart failure and end-stage renal disease [3], hypertension has become a serious public health problem that needs to be addressed. This highlights the urgent need to identify biomarkers that predict the key factors of hypertension occurrence and therapy.

Several studies have confirmed that long noncoding RNAs (lncRNAs) participate in the development of hypertension, acting as biomarkers, potential therapeutic targets or strong indicators of prognosis [4]. Researchers have reported that microvascular dysfunction induced by hypertension is aggravated by knockdown of lncRNA GAS5 [5], and the expression of GAS5 in hypertensives was significantly reduced. LncRNA AK098656 is a human vascular smooth muscle cell (VSMC)-dominant lncRNA that is increased in hypertensive patients [6]. However, the underlying molecular mechanism related to

lncRNAs in the context of hypertension remains largely unknown.

Recently, an abundance of studies have focused on the competing endogenous RNA (ceRNA) hypothesis of diseases, which claimed that RNA transcripts (including mRNA, pseudogenes, lncRNA and circular RNA) can competitively combine with microRNAs (miRNAs) *via* miRNA response elements (MREs) [7]. According to the ceRNA mechanism, a new network-based regulatory pattern has been recognized, thus forming a 'ceRNA-miRNA-mRNA' network. Growing evidence has shown that this novel regulatory mechanism underlying the crosstalk among lncRNAs, miRNAs and mRNAs plays a pivotal role in the pathophysiological processes of cardiovascular diseases (CVDs) [8, 9]. However, few studies have reported on the ceRNA network in hypertension.

Therefore, this study aimed to identify differentially expressed lncRNAs (DE-lncRNAs) in the context of hypertension and systematically analyze the 'lncRNA-miRNA-mRNA' ceRNA network involved in hypertension.

## Materials and methods

### *Patients and samples for microarray and quantitative real-time PCR*

All participants were selected from the System Epidemiology Study on Salt Sensitivity of Blood Pressure (EpiSS) cohort study, which was set up by our research group, and details can be found in the previously published protocol [10]. In brief, 20 subjects (10 hypertensive and 10 normotensive individuals) were involved in creating the microarray, and two-step validation was conducted in 70 subjects (42 hypertensive and 28 normotensive individuals) and 56 subjects (35 hypertensive and 21 normotensive individuals) by quantitative real-time PCR (*q*RT-PCR). All participants were 35-70 years old. Primary hypertensive patients with systolic blood pressure (SBP) in the range of 140-159 mmHg or diastolic blood pressure (DBP) 90-99 mmHg were enrolled in this study. In addition, individuals with CVDs, kidney disease, liver disease, malignant tumor or pregnancy or who had used antihypertensive drugs in the past month were excluded. This study was approved by the ethics committee of Capital Medical University, and all subjects provided written informed consent.

Blood samples were collected in the early morning after the participants had fasted for eight hours. Serum samples were isolated and used to perform biochemical examination, including the assessment of total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and fasting blood glucose (FBG). Blood samples (2.5 mL) were collected in a PAXgene Blood RNA Tube (PreAnalytiX GmbH, Hombrechtikon, Switzerland) where they were maintained until RNA extraction was performed.

### *RNA isolation and quality control assay*

Total RNA was extracted and purified using a PAXgene Blood RNA Kit (cat. no. 762174, QIAGEN GmbH, Hilden, Germany). The RNA integrity number (RIN) of each RNA was assessed to evaluate RNA integration using an Agilent Bioanalyzer 2100 (Agilent Technologies, Santa Clara, CA, USA). RNA quantity was measured using a NanoDrop ND-1000 UV-VIS spectrophotometer (Nanodrop, ND1000) and an Agilent Bioanalyzer 2100 (Agilent Technologies, Santa Clara, CA, USA). If the RIN was more than seven and the 28 s/18 s ratio was more than 0.7, the RNA extract was considered adequate and was used for further analysis.

### *Microarray of expression profiles*

The microarray used in the current study was SBC human (4*180K) ceRNA array v1.0, which contains 68,423 lncRNAs and 18,853 mRNAs. The microarray analysis was performed according to the standard procedure. First, cDNA was generated *via* reverse transcription of RNA obtained from samples using a Low-Input Quick Amp WT Labeling kit (One-Color, Agilent Technologies Santa Clara, USA). Then, the cDNA was hybridized to the SBC human (4*180K) ceRNA array v1.0. Finally, the hybridized arrays were washed, fixed and scanned with an Agilent Microarray Scanner (Agilent Technologies, Santa Clara, CA, USA).

### *Significant differential gene analysis*

Raw data were normalized using a quantile normalization algorithm, and differential gene expression analysis of the microarray data was conducted using the Empirical Bayes method; both analyses were run using the limma package [11] in R software (http://www.bio-

conductor.org/packages/release/bioc/html/limma.html). In our study, DE-lncRNAs were identified by the following criteria: (i) Foldchange > 2 or < 0.5; (ii) *P*-value < 0.05; and (iii) Filtering genes satisfying the following two conditions [12]: Genes with an expression variability among 20 samples lower than the median of all the expression differences calculated for each RNA, and genes with a mean expression signal among 20 samples lower than the median of all the expression signals calculated for each RNA. The screening criteria for differentially expressed mRNAs (DE-mRNAs) were as follows: (i) Foldchange > 2 or < 0.5; (ii) *P*-value < 0.05. The heatmap of the top 10 upregulated and downregulated DE-lncRNAs and DE-mRNAs was drawn by the pheatmap package in R software.

*Prediction of lncRNA target genes*

We selected genes regulated by cis-regulation that were 10 kb upstream and downstream from the lncRNA as the target genes [13]. Trans-regulation [14] is the lncRNA-mediated transcriptional activation and expression regulation of coding genes on other chromosomes. Generally, the gene sequence of the corresponding species (human) in the database is used. First, the complementary or similar sequence is selected by BLAST. Second, the complementary energy between the two sequences is calculated by RNAplex [15]. Third, we selected genes with energy ≤ -30 as the target genes regulated by trans-regulation.

*Functional annotation of targeted genes*

Gene Ontology (GO) enrichment and Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway enrichment analyses for genes targeted by DE-lncRNAs were performed using the Database for Annotation, Visualization and Integrated Discovery [16, 17] (DAVID, https://david.ncifcrf.gov/).

*Coexpression network construction*

The lncRNA-mRNA coexpression network was constructed based on DE-lncRNAs and DE-mRNAs. We paired all DE-lncRNAs and DE-mRNAs, calculated the Pearson's correlation coefficient (PCC) for each pair, and then chose the significantly related pairs (PCC > 0.95 or PCC < -0.95) to construct the coexpression network using Cytoscape software version 3.4.0 [18].

*CeRNA network construction*

All lncRNAs and mRNAs in the ceRNA network were from the lncRNA-mRNA coexpression network. Each 'lncRNA-miRNA-mRNA' loop was built using the following steps: (i) Predicting the target miRNAs of the lncRNA by miRDB (http://mirdb.org/miRDB/); (ii) Predicting the target mRNAs of the abovementioned miRNAs by miRDB, TarBase (http://diana.imis.athena-innovation.gr/) and TargetScan (http://www.targetscan.org/vert_71/); and (iii) Finding the intersection of the abovementioned targeted mRNAs and mRNAs that have a coexpression relationship with the lncRNA in step (i). Then, we combined these loops together and constructed a 'lncRNA-miRNA-mRNA' ceRNA network using Cytoscape software.

*Quantitative real-time PCR*

The expression of RNAs was detected by an ABI 7900HT Real-Time PCR System (Applied Biosystem, Foster City, CA, USA) using SYBR Green PCR Master Mix (ABI, 4368708), and glyceraldehyde 3-phosphate dehydrogenase (GAPDH) was used as the internal control. The relative expression level was determined with the $2^{-\Delta\Delta ct}$ method [19]. Each sample was performed in triplicate, and the average value was calculated. The primer sequences for *q*RT-PCR are summarized in Table S1.

*Luciferase reporter assay*

HEK 293T cells were seeded into 24-well plates and cotransfected with plasmids (GV272-NR_104160-WT, GV272-NR_104160-Mut, GV-272-ID1-3UTR-WT, GV272-ID1-3UTR-Mut) and miRNA mimics (hsa-miR-101-3p) using X-tremeGENE HP (cat. no. 06366236001, Roche, Basel, Switzerland). Luciferase activity was measured using the Dual-Luciferase® Reporter Assay System (cat. no. E2910, Promega, Madison, WI, USA) after 48 h of incubation according to the manufacturer's instructions. Independent experiments were performed in triplicate, and the average value was calculated. Relative luciferase activity was normalized to the Renilla luciferase internal control.

*Statistical analysis*

All statistical analyses were performed using SPSS 20.0 (SPSS, Inc., Chicago, IL, USA), R software (version 3.4.4) and SAS (version 9.4). A *P*-value < 0.05 indicated a statistically significant difference, and all *P*-values were two-sided. Measurement data are presented as the mean ± standard deviation. Normally distributed data were analyzed using Student's *t*-tests. Nonnormally distributed data were analyzed using a Wilcoxon rank sum test. Enumeration data were compared using a Pearson $\chi^2$ test. The differentially expressed RNAs in the microarray data were tested by the Bayesian adjusted *t*-statistics from the linear models for Microarray data (limma) package, and multiple testing correction based on the false discovery rate was performed. PCC between RNAs was calculated in the correlation analysis. Differential expression levels of RNAs between groups in *q*RT-PCR validation were analyzed using an independent two-sample *t*-test. The association between RNAs and hypertension was analyzed using an unconditional logistic regression model and adjusted for age, sex, TC, TG, BMI, HDL-C, LDL-C, FBG, smoking, family history of hypertension, and the consumption of sauce and poultry. Odds ratios (ORs) represent the risk of developing hypertension. Receiver operating characteristic (ROC) curve analysis was performed to determine the differences in the area under the curve (AUC). A generalized linear model (GLM) was conducted to explore the associations between the mRNA and lncRNA expression levels.

## Results

*Characteristics of subjects*

We enrolled ten paired hypertensive patients and healthy control individuals for the microarray analysis and 70 (42 hypertensive and 28 normotensive individuals) and 56 subjects (35 hypertensive and 21 normotensive individuals) for separate *q*RT-PCR analyses. The characteristics of the subjects are summarized in **Tables 1** and S2. Variables in the microarray test were balanced between the two groups except for SBP (*P* = 0.030) and TC (*P* = 0.037). Among the samples in the *q*RT-PCR test, SBP, DBP, HDL-C, LDL-C and sauce consumption per month differed between the two groups in the first validation group (*P* < 0.05), while SBP, TC, TG and HDL-C showed significant differences in the second validation group (*P* < 0.05).

*Overview of lncRNA and mRNA expression profiles*

In total, 387 DE-lncRNAs and 52 DE-mRNAs were identified (**Figure 1A** and **1D**; Table S3). Of these, 355 DE-lncRNAs and 39 DE-mRNAs were upregulated, while 32 DE-lncRNAs and 13 DE-mRNAs were downregulated. The DE-lncRNAs were found to be widely distributed among all chromosomes, and chromosome (chr) 1 and chr3 were the top two chromosomes (**Figure 1B**). Among the 387 DE-lncRNAs, 170, 77, 59, 55, 14 and 12 DE-lncRNAs belong to the intergenic, exonic sense, intronic antisense, intronic sense, exonic antisense and bidirectional groups, respectively. For DE-mRNAs, there was no distribution on chr14, chr16, or chr21, with chr12 and chr19 being the top two chromosomes (**Figure 1E**). **Table 2** shows the information of the top 20 DE-lncRNAs and DE-mRNAs, and their heatmap results are shown in **Figure 1C** and **1F**.

*Functional annotation of targeted genes of DE-lncRNAs*

A total of 311 target genes of DE-lncRNAs were identified by cis-regulation and 671 genes by trans-regulation (Table S4). Only 38 DE-lncRNAs are associated with trans-regulated genes, suggesting that one lncRNA is associated with many target genes *via* a trans-regulatory mechanism. The GO and KEGG pathway enrichment analyses suggested that these genes might play roles in some important GO terms ('response to estrogen', 'endothelial cell proliferation', etc.) and KEGG pathways ('HIF-1 signaling pathway', etc.) (**Figure 2**).

*Construction of the lncRNA-mRNA coexpression network*

A total of 102 DE-lncRNAs, 12 DE-mRNAs (*ID1*, *CD69*, *SNRPF*, *GZF1*, *EGR3*, *PTS*, *RSL24D1*, *ERMN*, *CDADC1*, *SFN*, *C12orf79* and *RPL17*) and 195 pairs formed the coexpression network (**Figure 3** and Table S5). All the DE-lncRNAs and DE-mRNAs were upregulated in the hypertensive group compared to the control group, and each lncRNA-mRNA pair was positively correlated in the expression profile. The *RSL24D1* and *RPL17* genes were associated

**Table 1.** Clinical characteristics of study participants in the hypertensive and normotensive groups of microarray test

| Variables | Hypertensive (*N* = 10) | Normotensive (*N* = 10) | Total (*N* = 20) | *P*-value |
|---|---|---|---|---|
| Gender (female, n (%)) | 6 (60) | 6 (60) | 12 (60) | 1.000‡ |
| Age (years) | 64.20 ± 1.55 | 64.90 ± 2.77 | 64.55 ± 2.21 | 0.494* |
| SBP (mmHg) | 143.30 ± 13.96 | 129.20 ± 12.69 | 136.25 ± 14.86 | 0.030* |
| DBP (mmHg) | 79.80 ± 7.001 | 74.10 ± 7.676 | 76.95 ± 7.72 | 0.100* |
| BMI (kg/m$^2$) | 24.88 ± 2.70 | 24.19 ± 1.98 | 24.54 ± 2.33 | 0.523* |
| TC (mmol/L) | 3.45 ± 2.02 | 5.21 ± 1.38 | 4.33 ± 1.91 | 0.037* |
| TG (mmol/L) | 2.83 ± 1.99 | 1.48 ± 0.64 | 2.15 ± 1.60 | 0.067* |
| HDL-C (mmol/L) | 2.18 ± 1.38 | 2.77 ± 0.98 | 2.48 ± 1.20 | 0.218† |
| LDL-C (mmol/L) | 2.17 ± 1.11 | 1.95 ± 1.10 | 2.06 ± 1.08 | 0.326† |
| FBG (mmol/L) | 6.01 ± 1.17 | 5.70 ± 0.74 | 5.85 ± 0.97 | 0.545† |
| Heart rate | 73.60 ± 6.15 | 74.90 ± 7.37 | 74.25 ± 6.64 | 0.674* |
| Smoke (yes, n (%)) | 5 (50) | 3 (30) | 8 (80) | 0.650‡ |
| Family history of hypertension (yes, n (%)) | 6 (60) | 4 (40) | 10 (50) | 0.656‡ |
| Salt consumption per month | | | | 1.000‡ |
| ≤ 500 gram | 5 (50) | 4 (40) | 9 (45) | |
| > 500 gram | 5 (50) | 6 (60) | 11 (55) | |
| Pickle consumption per month | | | | 0.650‡ |
| ≤ 250 gram | 7 (70) | 5 (50) | 12 (60) | |
| > 250 gram | 3 (30) | 5 (50) | 8 (40) | |
| Sauce consumption per month | | | | 1.000‡ |
| ≤ 150 gram | 7 (70) | 7 (70) | 14 (70) | |
| > 150 gram | 3 (30) | 3 (30) | 6 (30) | |
| Poultry consumption per week | | | | 0.656‡ |
| ≤ 3 times | 6 (60) | 4 (40) | 10 (50) | |
| > 3 times | 4 (40) | 6 (60) | 10 (50) | |

BMI, body mass index; TC, total cholesterol; TG, triglycerides; HDL-C, high-density-lipoprotein-cholesterol; LDL-C, low-density-lipoprotein-cholesterol; FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure. $P < 0.05$ was considered statistically significant. *, Statistical testing by independent-samples *t* test. †, Statistical testing by Wilcoxon rank sum test. ‡, Statistical testing by $\chi^2$ test.

with 64 and 86 DE-lncRNAs, respectively, and could be the central nodes in the coexpression network.

*Construction of the ceRNA network*

In total, 485 lncRNA-miRNA interactions (62 lncRNAs and 381 miRNAs) were identified in miRDB (Table S6), and 54 miRNAs of the above pairs were associated with the aforementioned 12 DE-mRNAs in the coexpression network, thus forming the ceRNA network, which was composed of 10 mRNAs, 30 lncRNAs, and 54 target miRNAs, including 71 'lncRNA-miRNA-mRNA' ceRNA circular pathways (**Figure 4** and Table S7). In the ceRNA network, NR_104160 was associated with seven ceRNA circular pathways, making it the top lncRNA. *RSL24D1* was involved with 44 ceRNA loops, making it the top mRNA. Furthermore, five miRNAs (hsa-miR-4426, hsa-miR-335-3p, hsa-miR-4662b, hsa-miR-4647 and hsa-miR-103a-2-5p) were related to three ceRNA pathways, making them the top miRNAs.

*The results of selected RNA relative expression levels in the first qRT-PCR*

To analyze the association between hypertension and ceRNA pathways, we decided to validate NR_104160 and *ID1* by *q*RT-PCR, which both interacted with hsa-miR-101-3p. Moreover, we reviewed the literature on the aforementioned five miRNAs and decided to identify RNAs (lnc-GPR63-8:1, lnc-HPRT1-9:1, lnc-MDC1-1:1 and *RSL24D1*) that all interacted with hsa-miR-103a-2-5p. The results showed that RNA expression was upregulated in hypertensive patients compared with that in normotensive patients, which was in line with the microarray analysis. Furthermore, NR_104160, lnc-GPR63-8:1, lnc-HPRT1-9:1, *ID1* and

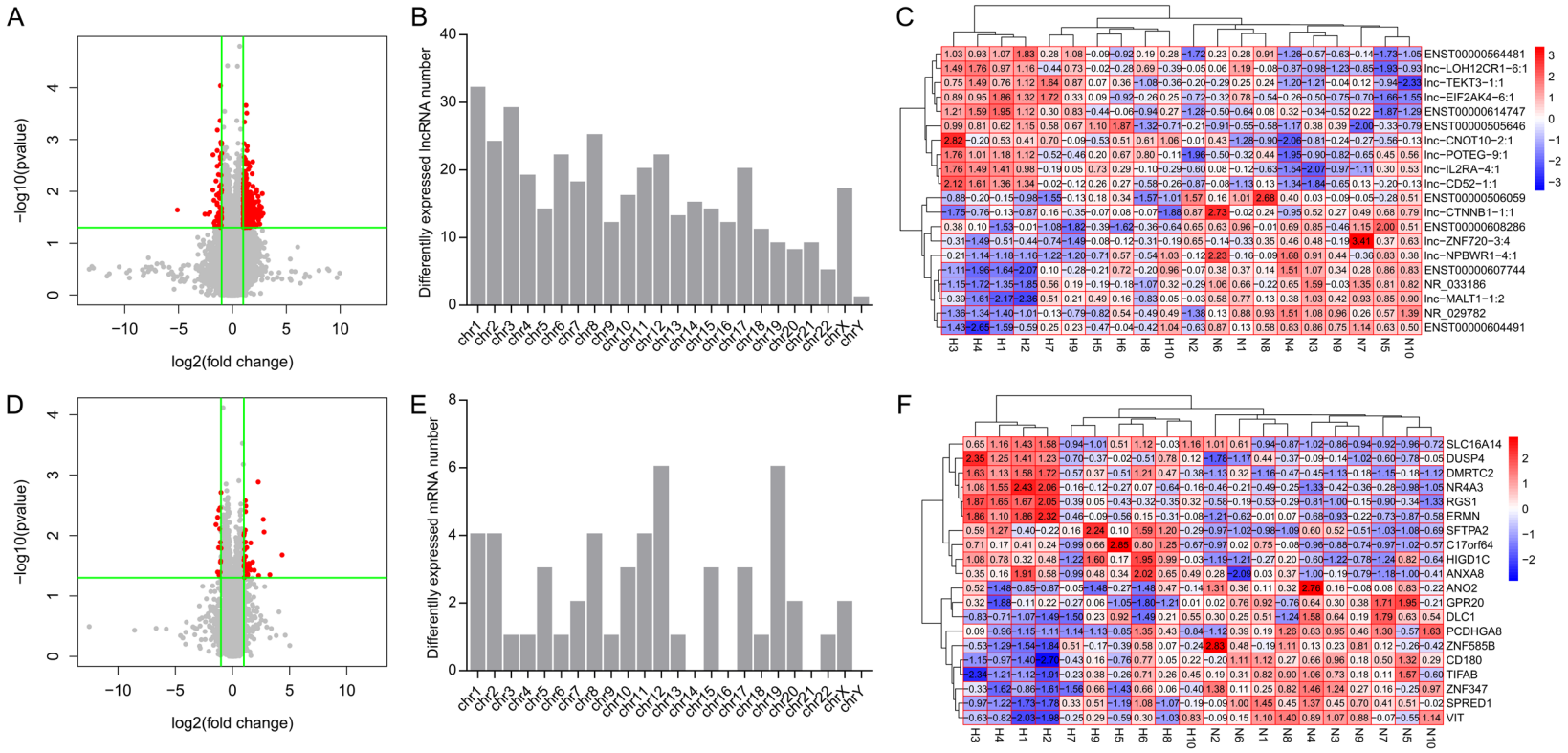


**Figure 1.** Overview of lncRNA and mRNA expression profiles. A. Volcano plot of differentially expressed lncRNAs. The vertical green lines correspond to twofold increased and decreased expression, and the horizontal green line represents $P = 0.05$. The red points represent differentially expressed lncRNAs between hypertensive and normotensive individuals. B. Chromosomal distribution of differentially expressed lncRNAs. C. Heatmap of the top 20 differentially expressed lncRNAs. The red and blue colors indicate high and low expression of the 20 dysregulated RNAs among samples, respectively. The values in the heatmap represent the levels of RNAs in each group. H: hypertensive samples; N: normal samples. D. Volcano plot of differentially expressed mRNAs. The vertical green lines correspond to twofold increased and decreased expression, and the horizontal green line represents $P = 0.05$. The red points represent differentially expressed mRNAs between hypertensive and normotensive individuals. E. Chromosomal distribution of differentially expressed mRNAs. F. Heatmap of the top 20 differentially expressed mRNAs. The red and blue colors indicate high and low expression, respectively, of the 20 dysregulated RNAs among samples. The values in the heatmap represent the levels of RNAs in each group. H: hypertensive samples; N: normal samples.

**Table 2.** Top 10 dysregulated lncRNAs and mRNAs

| | lncRNA | *P*-value | Fold change | mRNA | *P*-value | Fold change |
|---|---|---|---|---|---|---|
| Upregulated | lnc-EIF2AK4-6:1 | 0.00269 | 3.66 | *DMRTC2* | 0.00130 | 4.78 |
| | lnc-IL2RA-4:1 | 0.00300 | 2.43 | *SFTPA2* | 0.00265 | 2.28 |
| | lnc-CD52-1:1 | 0.00457 | 3.55 | *HIGD1C* | 0.00325 | 2.24 |
| | ENST00000614747 | 0.00556 | 2.47 | *ANXA8* | 0.00402 | 2.21 |
| | lnc-CNOT10-2:1 | 0.00558 | 2.16 | *RGS1* | 0.00541 | 6.49 |
| | ENST00000505646 | 0.00638 | 2.16 | *SLC16A14* | 0.00816 | 2.17 |
| | ENST00000564481 | 0.00718 | 2.84 | *NR4A3* | 0.00875 | 6.80 |
| | lnc-LOH12CR1-6:1 | 0.00723 | 2.20 | *ERMN* | 0.00918 | 2.04 |
| | lnc-POTEG-9:1 | 0.00751 | 2.68 | *DUSP4* | 0.00982 | 2.01 |
| | lnc-TEKT3-1:1 | 0.00779 | 2.20 | *C17orf64* | 0.01282 | 2.20 |
| Downregulated | ENST00000608286 | 0.00043 | 0.45 | *ZNF347* | 0.00194 | 0.50 |
| | NR_033186 | 0.00184 | 0.50 | *SPRED1* | 0.00350 | 0.47 |
| | NR_029782 | 0.00197 | 0.29 | *CD180* | 0.00379 | 0.44 |
| | ENST00000506059 | 0.00475 | 0.41 | *VIT* | 0.00501 | 0.41 |
| | lnc-NPBWR1-4:1 | 0.00631 | 0.35 | *GPR20* | 0.00661 | 0.37 |
| | lnc-MALT1-1:2 | 0.00751 | 0.48 | *ANO2* | 0.00777 | 0.46 |
| | lnc-CTNNB1-1:1 | 0.00800 | 0.44 | *PCDHGA8* | 0.01295 | 0.48 |
| | lnc-ZNF720-3:4 | 0.00944 | 0.28 | *DLC1* | 0.01589 | 0.43 |
| | ENST00000607744 | 0.00957 | 0.50 | *TIFAB* | 0.01628 | 0.50 |
| | ENST00000604491 | 0.00987 | 0.48 | *ZNF585B* | 0.02631 | 0.49 |

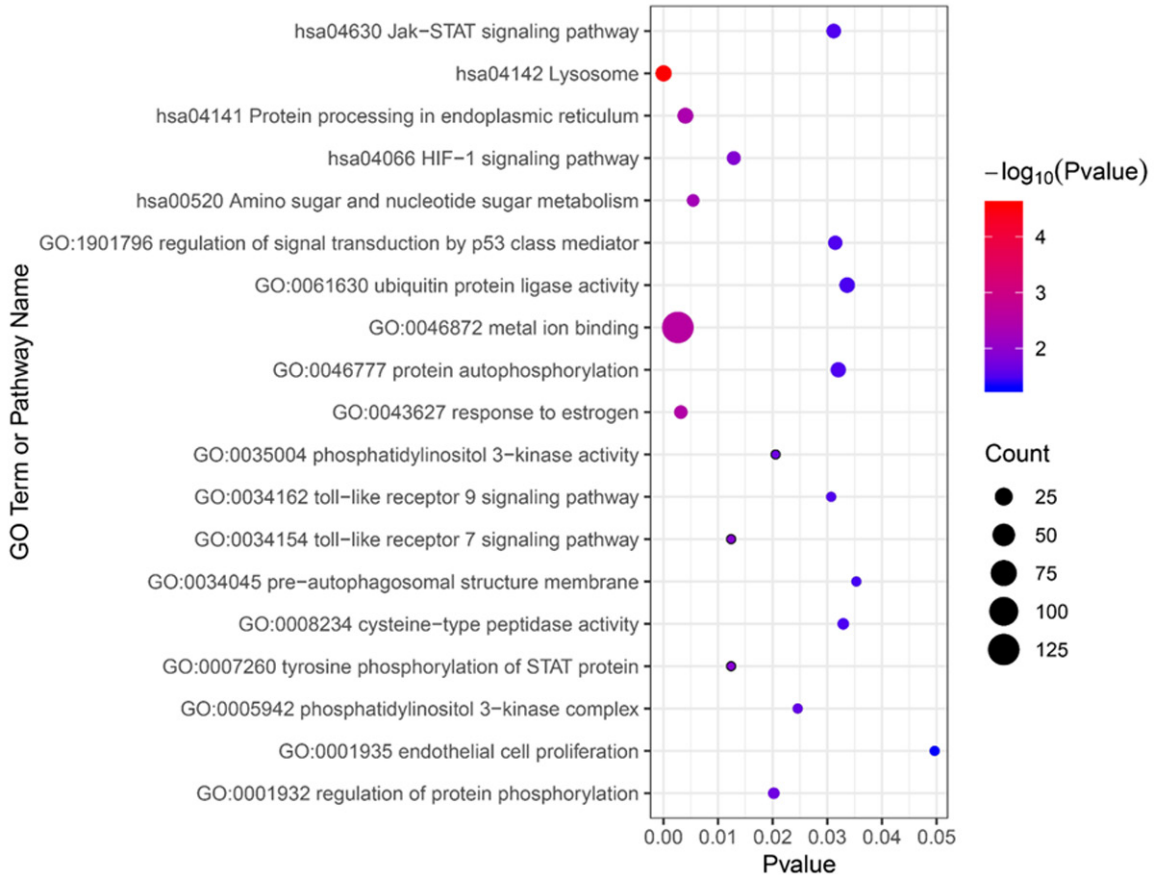


**Figure 2.** The GO Term and KEGG Pathway enrichment analyses of genes targeted by differentially expressed lncRNAs. Count represents the gene number in the GO term or KEGG pathway.

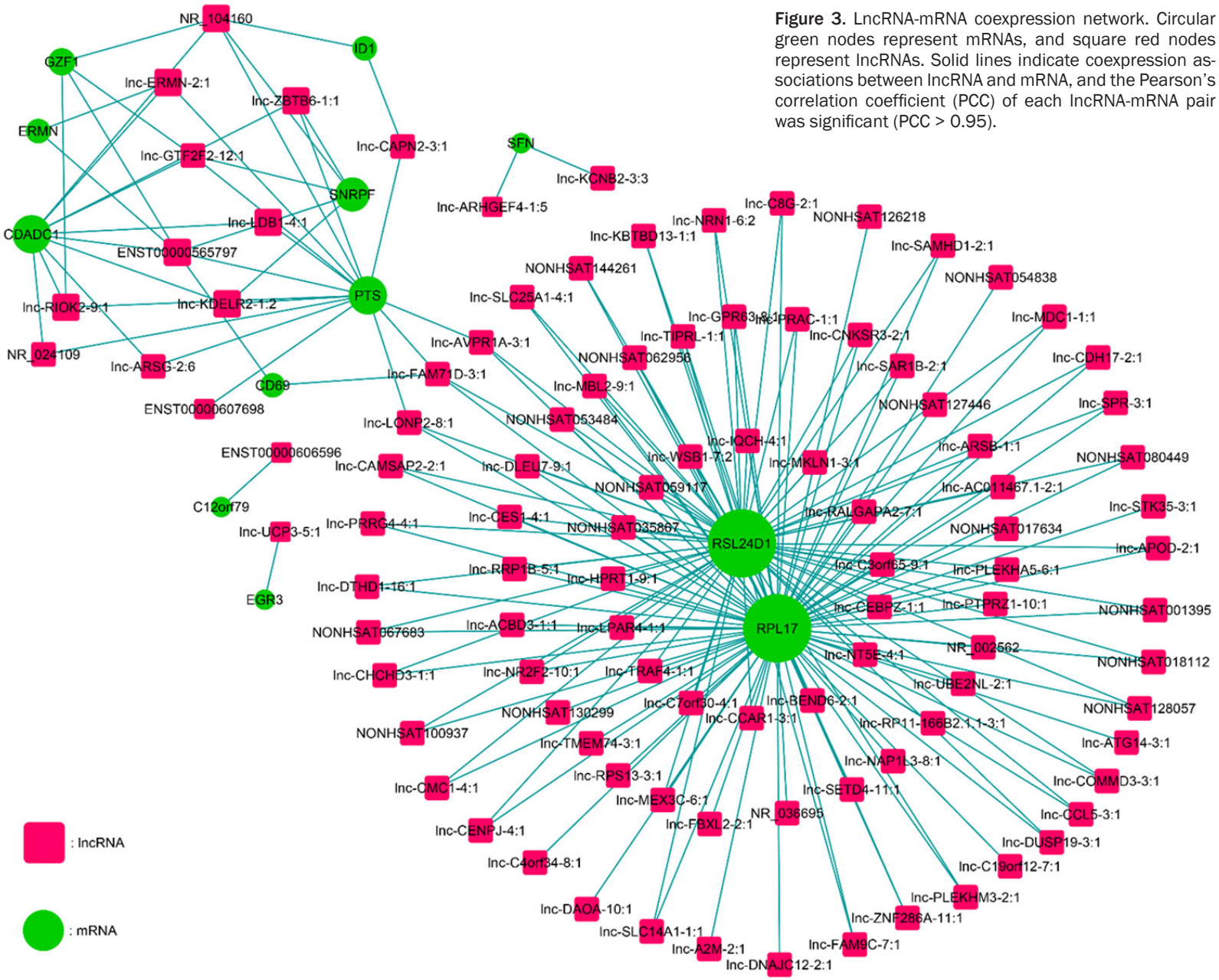


**Figure 3.** LncRNA-mRNA coexpression network. Circular green nodes represent mRNAs, and square red nodes represent lncRNAs. Solid lines indicate coexpression associations between lncRNA and mRNA, and the Pearson's correlation coefficient (PCC) of each lncRNA-mRNA pair was significant (PCC > 0.95).

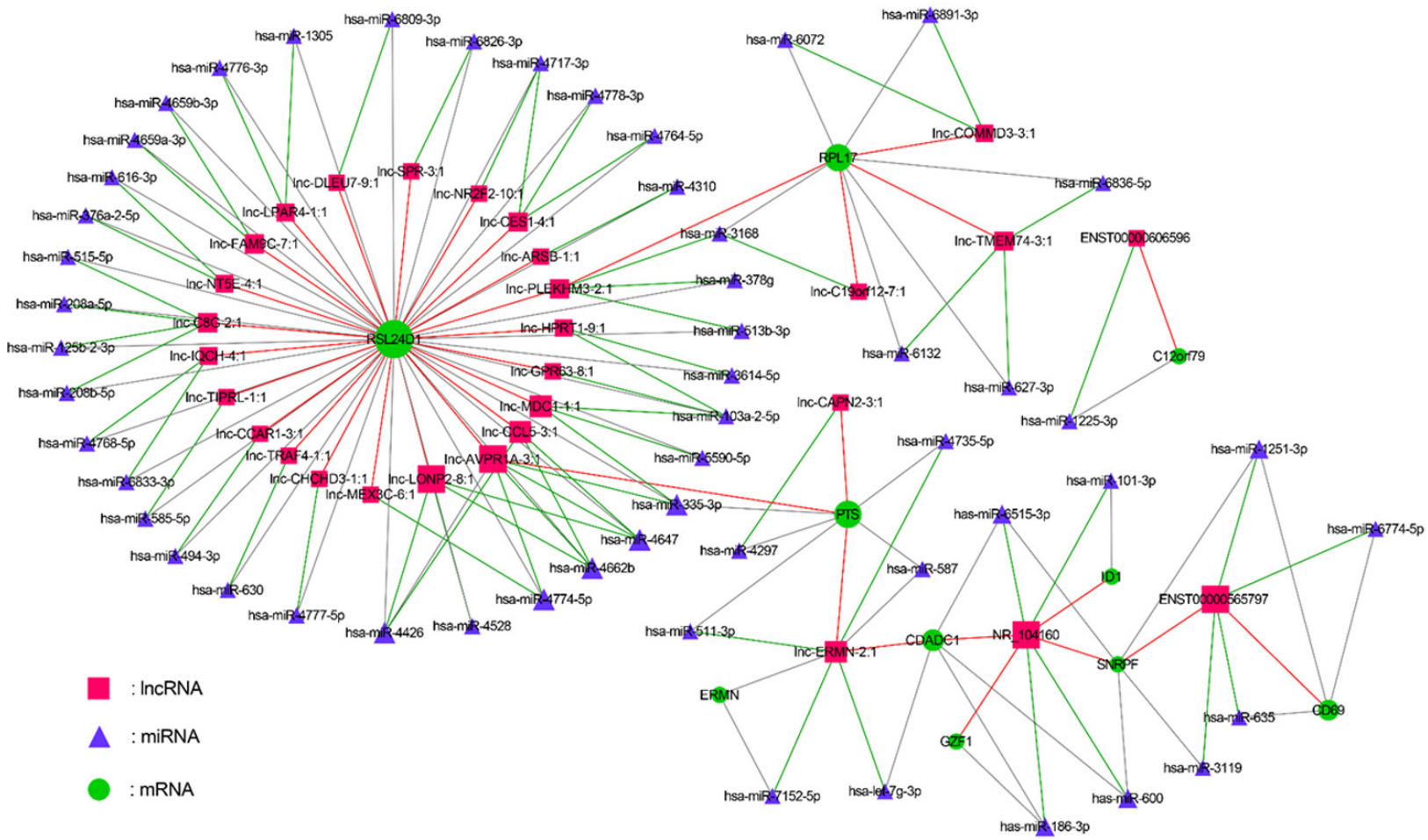


**Figure 4.** LncRNA-miRNA-mRNA ceRNA network. In this network, the triangle, square and circular nodes represent miRNA, lncRNAs and mRNAs, respectively. Red edges indicate the coexpression relationship between a lncRNA and mRNA, and the Pearson's correlation coefficient of each lncRNA-mRNA pair was > 0.95. The green and gray edges represent predicted lncRNA-miRNA and miRNA-mRNA associations, respectively, predicted by bioinformatic software.

*RSL24D1* were significantly upregulated in the hypertension group compared to their expression levels in the control group ($P$ = 0.012, 0.024, 0.035, 0.028 and 0.039, respectively), but the $P$-value of lnc-MDC1-1:1 was 0.074. **Figure 5** illustrates the relative expression levels of five differentially expressed RNAs.

*The results of multiple logistic regression analysis*

The associations between hypertensive status and $\log_2$-transformed relative expression levels of RNAs (NR_104160, lnc-GPR63-8:1, lnc-HPRT1-9:1, *RSL24D1*, *ID1*) were assessed. After adjusting for confounding factors, including TG, HDL-C, and sauce and poultry consumption, only NR_104160 was significantly associated with the risk of hypertension (OR = 2.863, 95% CI: 1.143-7.172; $P$ = 0.025). The final model was logit ($P$ = hypertension) = 1.913 + 1.052 × NR_104160 + 1.415 × TG - 0.815 × HDL-C + 1.234 × poultry + 1.917 × sauce (**Table 3**).

*The diagnostic performance by ROC analysis*

Predicted probabilities based on a multiple logistic regression model were examined by ROC curve analysis. We evaluated the diagnostic value of NR_104160 and five RNA combinations in human peripheral blood samples for hypertension (**Figure 6**). After adjusting for TG, HDL-C, and sauce and poultry consumption, the AUCs of NR_104160 and the combination of five RNAs were 0.852 (95% CI: 0.761-0.944; $P$ < 0.001) and 0.821 (95% CI: 0.721-0.922; $P$ < 0.001), the sensitivity values were 73.8% (95% CI: 58.0%-86.1%) and 78.6% (95% CI: 63.2-89.7%), and the specificity values were 89.3% (95% CI: 71.8-97.7%) and 78.6% (95% CI: 59.1-91.7%), respectively.

*NR_104160 is a potential biomarker for hypertension*

NR_104160 was further tested by *q*RT-PCR on another 56 individuals and showed a significantly higher expression level in hypertensives than normotensives ($P$ = 0.001) (**Figure 7A**). The NR_104160-related diagnostic model was externally verified in these samples, and the predicted probabilities were used to perform ROC curve analysis (**Figure 7B**). The AUC was 0.769 (95% CI: 0.641-0.898; $P$ < 0.001), with sensitivity and specificity values of 68.6% (95% CI: 50.7%-83.2%) and 86.7% (95% CI: 63.7%-97.0%), respectively.

*NR_104160 serves as an miRNA sponge for hsa-miR-101-3p and the association between NR_104160 and ID1*

NR_104160 is located at 10p11.22 (chr10: 32345112-32347218), and its associated gene symbol is *EPC1*. Bioinformatics analysis revealed that hsa-miR-101-3p was targeted by both NR_104160 in miRDB and *ID1* in TarBase v8. Luciferase assays were applied to determine whether miR-101-3p directly targets NR_104160 and *ID1*. Potential binding sites of miR-101-3p were identified within the NR_104160 and *ID1* sequences (**Figure 8A**). The results illustrated that miR-101-3p mimics significantly inhibited the luciferase activity of GV272-NR_104160-WT ($P$ < 0.001) but did not affect the luciferase activity of GV272-NR_104160-Mut (**Figure 8B**). These data suggest that NR_104160 may serve as a sponge for miR-101-3p. However, *ID1* was not a binding target of miR-101-3p (**Figure 8C**).

According to the correlation analysis, the PCC of *ID1* and NR_104160 in the first *q*RT-PCR test was 0.565. **Table 4** illustrates the results of GLM after adjusting for age, sex, MAP, TC, TG, HDL-C, and LDL-C. The results showed that an elevated expression level of NR_104160 increased the expression of *ID1* ($\beta$ = 0.2235, $P$ = 0.005).

## Discussion

Our results identified 387 DE-lncRNAs and 52 DE-mRNAs by microarray and verified that five RNAs (lnc-GPR63-8:1, lnc-HPRT1-9:1, NR_104160, *ID1* and *RSL24D1*) were significantly upregulated in hypertensive patients compared with their expression levels in controls. NR_104160 was significantly associated with the risk of hypertension, and in the hypertension diagnostic model, the AUC was 0.852 (95% CI: 0.761-0.944). Luciferase assays indicated that NR_104160 serves as a sponge for miR-101-3p. Our study constructed a ceRNA network to provide a hypothesis for the understanding of the mechanism of hypertension. lncRNA-NR_104160 was identified as a hub element that participates in hypertension tran-

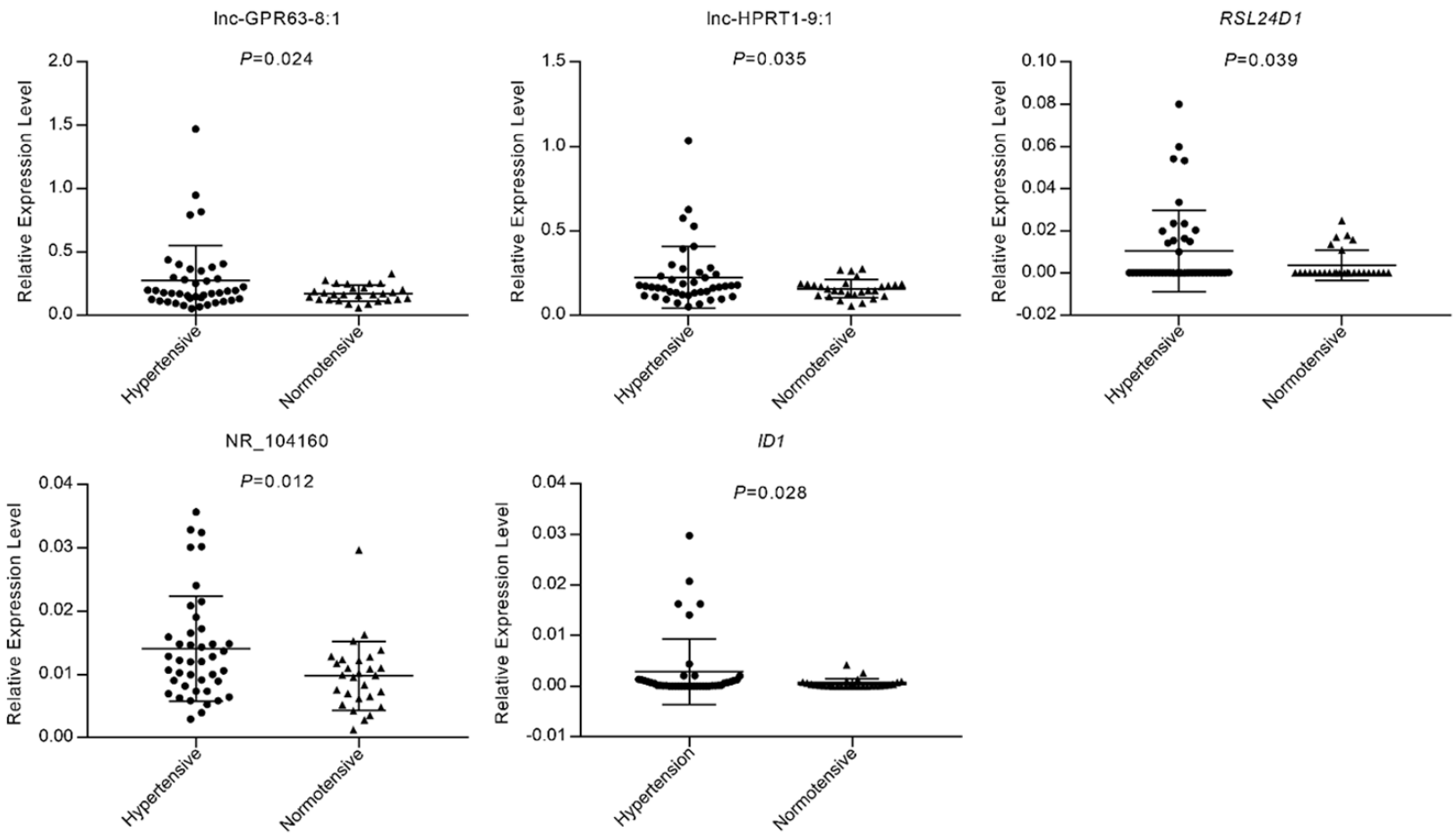


**Figure 5.** Relative expression levels of five RNAs according to *q*RT-PCR. Independent two-sample *t*-test was analyzed to compare the expression of RNAs (lnc-GPR63-8:1, lnc-HPRT1-9:1, *RSL24D1*, NR_104160 and *ID1*) between 42 hypertensives and 28 normotensives. The long and short lines represent the mean and standard deviation, respectively, of the RNA relative expression level.

**Table 3.** Analysis of the association between RNAs and hypertension depending on unconditional logistic regression analysis

| Variables | *β* | *P*-value | OR | 95% CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| NR_104160 | 1.052 | 0.025 | 2.863 | 1.143 | 7.172 |
| TG | 1.415 | 0.018 | 4.118 | 1.272 | 13.326 |
| HDL-C | -0.815 | 0.009 | 0.443 | 0.240 | 0.815 |
| Poultry | 1.234 | 0.007 | 3.435 | 1.407 | 8.384 |
| Sauce | 1.917 | 0.044 | 6.799 | 1.049 | 44.055 |
| Constant | 1.913 | 0.519 | 6.775 | | |

TG, triglycerides; HDL-C, high-density-lipoprotein-cholesterol; Poultry, poultry consumption per week; Sauce, sauce consumption per month. Statistical testing by stepwise regression method. $P < 0.05$ was considered statistically significant.

scriptional regulation and acts as a potential biomarker.

Recently, an increasing number of functional lncRNAs have been reported in hypertension studies [20], such as lncRNA-Sone [21], lncAng362 [22], and CDKN2B-AS1 [23]. However, few studies using microarrays have focused on lncRNAs in the context of human hypertension. Cai J [6] explored the lncRNA expression profile using Human lncRNA Array v2.0 (8 × 60K, Arraystar) and demonstrated that lncRNA-AK098656 was strongly upregulated in the plasma of hypertensive patients. In the current study, lncRNA-NR_104160 was highly expressed in hypertensive individuals compared with its expression in normotensive individuals, and the risk of hypertension increased by 1.863 times. Furthermore, the ROC curve analysis revealed that the AUC of NR_104160 was equal to 0.852 and demonstrated 73.8% sensitivity and 89.3% specificity. This model was externally verified in 56 individuals in the second step of the validation, with an AUC of 0.769 (95% CI: 0.641-0.898). These results suggested that NR_104160 was significantly and independently associated with hypertension.

Our results revealed a relatively new biomarker of NR_104160 that was coexpressed with five DE-mRNAs (*ID1*, *PTS*, *SNRPF*, *GZF1*, *CDADC1*). In general, the high PCC between these RNAs represented the high possibility of similar functions. The gene *PTS* encodes the enzyme that is greatly associated with the biosynthesis of tetrahydrobiopterin (BH4). BH4 is the cofactor of nitric oxide synthase (eNOS), and many studies have focused on the mechanisms of eNOS dysfunction in hypertension because restoring eNOS function might be a potential novel therapeutic strategy to treat hypertension [24]. Researchers have found that the upregulation of the BH4 pathway might ameliorate the hypertension-related decline in the reendothelialization capacity of endothelial progenitor cells [25]. In addition, studies demonstrated that antihypertensive treatment can restore BH4, e.g., triple therapy with reserpine + hydrochlorothiazide + hydralazine or oral BH4 [26]. These data suggest that *PTS* might be related to hypertension. Few hypertension-related studies have assessed *SNRPF*, *GZF1*, and *CDADC1*. Researchers have found that *SNRPF* expression is downregulated by ubiquitin C-terminal hydrolase-L5, resulting in the inhibition of the migration and invasion of glioma cells [27]. *GZF1* mutations could cause the expansion of genetic heterogeneity in Larsen syndrome [28].

LncRNAs can regulate coding RNAs in the development of diseases, such as pulmonary hypertension [29], and the heart against myocardial I/R injury [30], by acting as miRNA sponges [31, 32]. In the novel regulatory mechanism, miRNAs are viewed as messengers and MREs as the letters of an 'RNA language'; thus, RNA-RNA crosstalk appears. We constructed a ceRNA network for hypertension that included 30 lncRNAs, 10 mRNAs, 54 miRNAs and 71 'lncRNA-miRNA-mRNA' loops. Strikingly, lncRNAs and mRNAs in each ceRNA loop interacted with the same miRNAs and had a coexpression relationship between themselves.

Within the ceRNA network, NR_104160 was involved in seven ceRNA pathways, and NR_104160→hsa-miR-101-3p→*ID1* was one of them. The gene symbol of NR_104160 is *EPC1*, and it might be named lncRNA-EPC1 according to the current default rules. Thus, we referred to the literature on *EPC1*, hsa-miR-101-3p and *ID1*. *EPC1* was reported to be associated with many biological functions and diseases, such as endometrial stromal sarcoma [33] and aberrant spermatid development [34]. A previous study revealed that *ID1* may be associated with familial pulmonary arterial hypertension [35] and is relevant to the proliferation of pulmonary artery smooth muscle

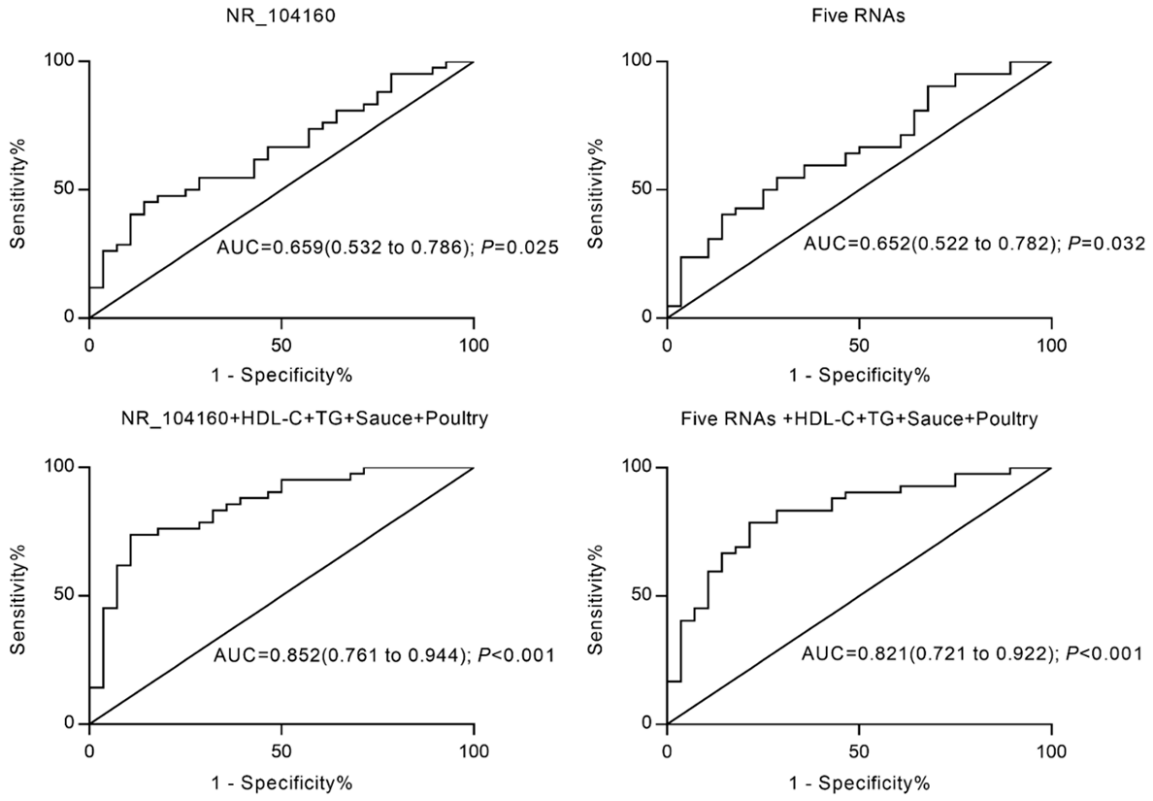


**Figure 6.** ROC analysis of NR_104160 and the combination model of five RNAs. AUC, area under the curve; HDL-C, high-density lipoprotein cholesterol; TG, triglycerides; Sauce, sauce consumption per month; Poultry, poultry consumption per week; Five RNAs, lnc-GPR63-8:1 + lnc-HPRT1-9:1 + NR_104160 + *ID1* + *RSL24D1*.

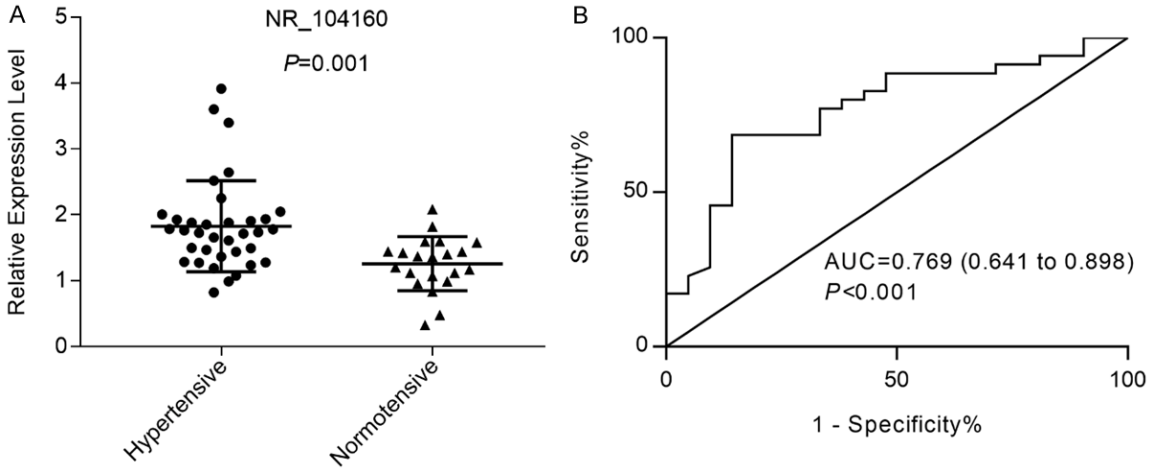


**Figure 7.** The second *q*RT-PCR validation of NR_104160. A. Relative expression levels of NR_104160. Independent two-sample *t*-tests were performed to compare the expression levels between 35 hypertensive patients and 21 normotensive patients. The long and short lines represent the mean and standard deviation, respectively. B. ROC analysis of the NR_104160-related model. AUC, area under the curve.

cells [36], endothelial proliferation and angiogenesis [37]. Hsa-miR-101-3p is involved in ceRNA pathways in various diseases, such as the PTAR/miR-101-3p/ZEB1 pathway in ovarian cancer [38], the SNHG12/miR-101-3p/FOXP1 axis in glioma [39], and the LINC00052/miR-

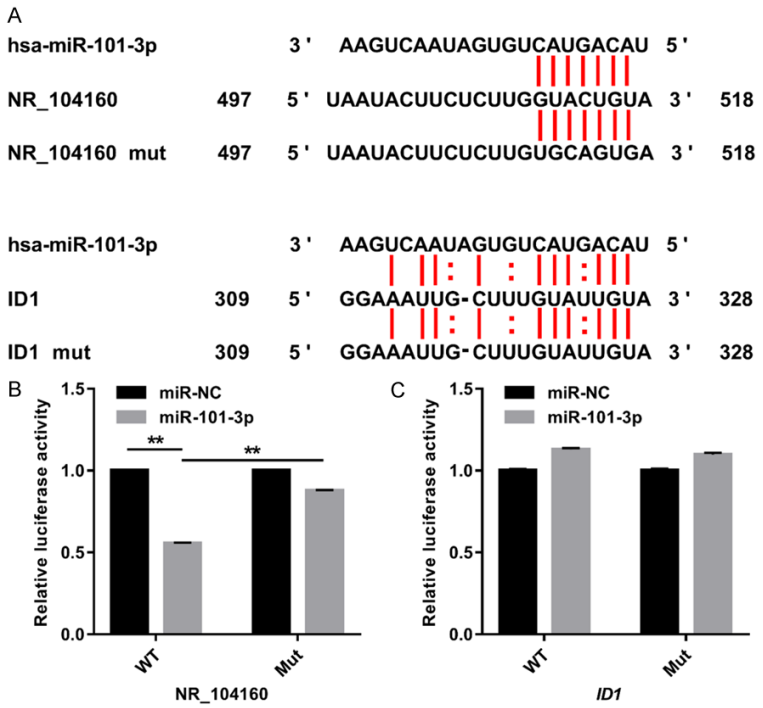


**Figure 8.** The potential relationships between lncRNA-NR_104160, hsa-miR-101-3p and ID1. A. Hsa-miR-101-3p binding sequences in lncRNA-NR_104160 or ID1 and mutant sites in lncRNA-NR_104160 or ID1. B. Luciferase assay showed that the luciferase activity of lncRNA-NR_104160-WT (wild type) was inhibited by hsa-miR-101-3p mimics but that the luciferase activity of lncRNA-NR_104160-mut (mutant) was not. **, $P < 0.001$. C. Luciferase assay showed that the luciferase activities of ID1-WT and ID1-mut were not inhibited by hsa-miR-101-3p mimics.

**Table 4.** Analysis of the influencing factors of mRNA expression depending on Generalized linear model

| Dependent | Variables | $\beta$ | 95% CI | | *P*-value |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| *ID1* | NR_104160 | 0.2235 | 0.0663 | 0.3806 | 0.005 |
| | Age | 0.0001 | -0.0002 | 0.0003 | 0.602 |
| | Gender | 0.0007 | -0.0012 | 0.0027 | 0.456 |
| | MAP | < 0.0001 | -0.0001 | 0.0001 | 0.376 |
| | TC | -0.0014 | -0.0029 | 0.0001 | 0.072 |
| | TG | 0.0014 | 0.0004 | 0.0025 | 0.009 |
| | HDL-C | 0.0016 | < -0.0001 | 0.0033 | 0.056 |
| | LDL-C | 0.0010 | -0.0007 | 0.0027 | 0.237 |
| | Constant | -0.0109 | -0.0288 | 0.0070 | 0.224 |

TC, total cholesterol; TG, triglycerides; HDL-C, high-density-lipoprotein-cholesterol; LDL-C, low-density-lipoprotein-cholesterol; MAP, mean arterial pressure.

101-3p/SOX9 axis in hepatocellular carcinoma [40]. Hence, we hypothesized that NR_104160 might regulate *ID1* by binding to hsa-miR-101-3p.

Therefore, luciferase reporter assays were applied to determine whether miR-101-3p directly targets NR_104160 and *ID1*. The results illustrated that NR_104160 may serve as a sponge for miR-101-3p. Although *ID1* was not a binding target of miR-101-3p, our GLM results revealed that the expression level of *ID1* was associated with NR_104160 ($\beta = 0.2235$, $P = 0.005$), which suggested that the relationship between NR_104160 and *ID1* may be very complicated.

Some strengths and limitations of the current study should be acknowledged. First, we performed two-step *q*RT-PCR validations for NR_104160, and the results showed consistent significantly higher expression in hypertensive individuals than in controls. Second, NR_104160 was found to be significantly and independently associated with the risk of hypertension, and the robustness of the diagnostic model was verified externally. Third, the construction of a ceRNA network might provide a potential basis for revealing the pathogenesis of hypertension, and we found that NR_104160 could serve as a sponge for miR-101-3p. Fourth, we used bioinformatics technology, which can aid in the understanding of the genes and networks that are responsible for diseases. The limitations are as follows: the number of samples limited the statistical power of the microarray analyses. This study only considered one lncRNA regulatory mechanism, but lncRNA-related regulation is very complicated. The result of the luciferase reporter assay suggested that *ID1* was not a

binding target of miR-101-3p, and the relationship between NR_104160 and *ID1* may be very complicated and require further exploration. However, this study aimed to identify lncRNAs as potential biomarkers and construct a ceRNA network for hypertension.

In conclusion, our study verified that NR_104160 was significantly upregulated in the human peripheral blood of hypertensive patients compared to its expression in normotensive patients. Moreover, NR_104160 was identified as a potential biomarker for hypertension. Our results suggest that systematically analyzing the 'lncRNA-miRNA-mRNA' ceRNA network could help to elucidate the pathogenesis of hypertension and the RNA-RNA crosstalk among lncRNAs, miRNAs and mRNAs.

## Acknowledgements

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## Disclosure of conflict of interest

None.

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**Table S1.** The primer sequences for *q*RT-PCR

| NO. | Gene | Primer sequence |
|---|---|---|
| 1 | lnc-TIPRL-1:1 | F: AGGCAGACTTTGAGGGGTTC |
| | lnc-TIPRL-1:1 | R: CCACCATATTCCCTGCTGAC |
| 2 | lnc-MDC1-1:1 | F: GAAGGAATTTCCCAGAGCTGAA |
| | lnc-MDC1-1:1 | R: TTGCCTTTTGAATCATCTTTTGG |
| 3 | lnc-GPR63-8:1 | F: GTTGGTAGTGGTCGGAAAGC |
| | lnc-GPR63-8:1 | R: GACAACATGCTTCCCACTGA |
| 4 | lnc-HPRT1-9:1 | F: GCGATCTTGAGGACTTGGTC |
| | lnc-HPRT1-9:1 | R: TGTTCTGCTGTGCTTTGTCC |
| 5 | NR_104160 | F: AAACAGGGTGCAGTGTATTGACA |
| | NR_104160 | R: CCACAACAAAATTGTAGCACACAA |
| 6 | *RSL24D1* | F: CTTTTCTAGCCCAGCATTGA |
| | *RSL24D1* | R: TTAAAAGGCGCTGGGATTC |
| 7 | *ID1* | F: TTTCTGAGGAAATTGCTTTGTATTGT |
| | *ID1* | R: CAGCCCCACAGAACTATTGTAAAA |
| 8 | GAPDH | F: TGACTTCAACAGCGACACCCA |
| | GAPDH | R: CACCCTGTTGCTGTAGCCAAA |

**Table S2.** Clinical characteristics of study participants in the hypertensive and normotensive groups of *q*RT-PCR

| Variables | First quantitative real-time PCR | | | | Second quantitative real-time PCR | | | |
|---|---|---|---|---|---|---|---|---|
| | Hypertensive (*N* = 42) | Normotensive (*N* = 28) | Total (*N* = 70) | *P*-value | Hypertensive (*N* = 35) | Normotensive (*N* = 21) | Total (*N* = 56) | *P*-value |
| Gender (female, n (%)) | 28 (66.67) | 18 (64.29) | 46 (65.71) | 0.837‡ | 25 (71.43) | 10 (47.62) | 35 (62.50) | 0.075‡ |
| Age (years) | 63.67 ± 4.14 | 63.18 ± 4.44 | 63.47 ± 4.24 | 0.640* | 63.06 ± 6.51 | 62.84 ± 6.23 | 63.11 ± 5.98 | 0.739* |
| SBP (mmHg) | 151.19 ± 16.83 | 127.5 ± 10.62 | 141.71 ± 18.68 | < 0.001* | 146.09 ± 17.88 | 129.38 ± 12.16 | 139.82 ± 17.83 | < 0.001* |
| DBP (mmHg) | 79.60 ± 8.64 | 74.21 ± 8.75 | 77.44 ± 9.02 | 0.013* | 78.17 ± 14.58 | 76.07 ± 8.66 | 77.38 ± 12.64 | 0.552* |
| BMI (kg/m$^2$) | 25.49 ± 3.24 | 23.92 ± 3.37 | 24.87 ± 3.36 | 0.054* | 26.03 ± 3.54 | 24.15 ± 3.43 | 25.32 ± 3.59 | 0.057* |
| TC (mmol/L) | 4.64 ± 1.53 | 4.93 ± 0.97 | 4.76 ± 1.33 | 0.476† | 3.37 ± 1.80 | 4.42 ± 1.31 | 3.76 ± 1.70 | 0.049† |
| TG (mmol/L) | 1.85 ± 1.25 | 1.38 ± 0.57 | 1.66 ± 1.05 | 0.275† | 3.44 ± 1.93 | 1.97 ± 1.68 | 2.90 ± 1.96 | 0.011† |
| HDL-C (mmol/L) | 2.14 ± 1.09 | 2.91 ± 0.81 | 2.45 ± 1.05 | 0.001† | 2.09 ± 1.00 | 2.75 ± 0.85 | 2.34 ± 0.99 | 0.012† |
| LDL-C (mmol/L) | 2.23 ± 1.18 | 1.61 ± 0.73 | 1.98 ± 1.06 | < 0.001† | 1.78 ± 1.07 | 1.62 ± 1.08 | 1.72 ± 1.07 | 0.741† |
| FBG (mmol/L) | 5.78 ± 1.15 | 5.63 ± 0.88 | 5.72 ± 1.04 | 0.806† | 5.97 ± 1.54 | 5.50 ± 0.89 | 5.80 ± 1.34 | 0.397† |
| Heart rate | 76.29 ± 10.09 | 72.96 ± 9.83 | 74.96 ± 10.05 | 0.177* | 73.54 ± 10.94 | 72.38 ± 10.93 | 73.11 ± 10.85 | 0.702* |
| Smoke (yes, n (%)) | 10 (23.81) | 6 (21.43) | 16 (22.86) | 0.816‡ | 4 (11.43) | 6 (28.57) | 10 (17.86) | 0.105‡ |
| Family history of hypertension (yes, n (%)) | 30 (71.43) | 15 (53.57) | 45 (64.29) | 0.127‡ | 26 (74.29) | 11 (52.38) | 37 (66.07) | 0.094‡ |
| Salt consumption per month | | | | 0.762‡ | | | | 0.213‡ |
| ≤ 500 gram | 15 (35.71) | 11 (39.29) | 26 (37.14) | | 14 (40.00) | 12 (57.14) | 26 (46.43) | |
| > 500 gram | 27 (64.29) | 17 (60.71) | 44 (62.86) | | 21 (60.00) | 9 (42.86) | 30 (53.57) | |
| Pickle consumption per month | | | | 0.917‡ | | | | 0.068‡ |
| ≤ 250 gram | 28 (66.67) | 19 (67.86) | 47 (67.14) | | 20 (57.14) | 17 (80.95) | 37 (66.07) | |
| > 250 gram | 14 (33.33) | 9 (32.14) | 23 (32.86) | | 15 (42.86) | 4 (19.05) | 19 (33.93) | |
| Sauce consumption per month | | | | 0.048‡ | | | | 0.215‡ |
| ≤ 150 gram | 27 (64.28) | 24 (85.71) | 51 (72.86) | | 21 (60.00) | 16 (76.19) | 37 (66.07) | |
| > 150 gram | 15 (35.71) | 4 (14.29) | 19 (27.14) | | 14 (40.00) | 5 (23.81) | 19 (33.93) | |
| Poultry consumption per week | | | | 0.202‡ | | | | 0.183‡ |
| ≤ 3 times | 16 (38.10) | 15 (53.57) | 31 (44.29) | | 23 (65.71) | 10 (57.62) | 34 (60.71) | |
| > 3 times | 26 (61.90) | 13 (46.43) | 39 (55.71) | | 12 (34.29) | 11 (52.38) | 22 (39.21) | |

BMI, body mass index; TC, total cholesterol; TG, triglycerides; HDL-C, high-density-lipoprotein-cholesterol; LDL-C, low-density-lipoprotein-cholesterol; FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure. $P < 0.05$ was considered statistically significant. *, Statistical testing by independent-samples *t* test. †, Statistical testing by Wilcoxon rank sum test. ‡, Statistical testing by $\chi^2$ test.

**Table S3-1.** All DE-lncRNAs between hypertensive and normotensive groups

| DE-lncRNA | *P*-value | Fold Changes | DE-lncRNA | *P*-value | Fold Changes |
|---|---|---|---|---|---|
| ENST00000608286 | 0.000431 | 0.451954 | lnc-SPR-3:1 | 0.029937 | 2.149257 |
| NR_033186 | 0.001842 | 0.499125 | lnc-CHCHD3-1:1 | 0.029962 | 2.241278 |
| NR_029782 | 0.001968 | 0.286406 | lnc-IRAK1BP1-6:1 | 0.029968 | 3.191759 |
| lnc-EIF2AK4-6:1 | 0.002691 | 3.656553 | lnc-UNC5C-2:1 | 0.029976 | 2.492030 |
| lnc-IL2RA-4:1 | 0.003001 | 2.427779 | lnc-RCSD1-2:1 | 0.029980 | 2.461092 |
| lnc-CD52-1:1 | 0.004570 | 3.553413 | lnc-WDR36-1:1 | 0.029981 | 0.490155 |
| ENST00000506059 | 0.004747 | 0.406730 | lnc-BMP2K-4:1 | 0.030193 | 2.161710 |
| ENST00000614747 | 0.005561 | 2.468473 | lnc-NR4A2-8:1 | 0.030258 | 2.232988 |
| lnc-CNOT10-2:1 | 0.005582 | 2.164794 | lnc-KDELR2-1:2 | 0.030267 | 2.570226 |
| lnc-NPBWR1-4:1 | 0.006309 | 0.347671 | lnc-UBE2NL-2:1 | 0.030268 | 3.054562 |
| ENST00000505646 | 0.006378 | 2.161718 | lnc-PLIN1-1:1 | 0.030318 | 4.660597 |
| ENST00000564481 | 0.007182 | 2.844158 | lnc-MEX3C-6:1 | 0.030330 | 2.263003 |
| lnc-LOH12CR1-6:1 | 0.007230 | 2.199606 | lnc-C4orf34-8:1 | 0.030545 | 3.133566 |
| lnc-POTEG-9:1 | 0.007507 | 2.683584 | lnc-TRAPPC8-4:1 | 0.030573 | 3.099935 |
| lnc-MALT1-1:2 | 0.007510 | 0.476829 | lnc-CNKSR3-2:1 | 0.030724 | 3.241606 |
| lnc-TEKT3-1:1 | 0.007793 | 2.199088 | lnc-PSEN2-3:1 | 0.030799 | 3.969550 |
| NR_024109 | 0.007942 | 2.033839 | lnc-NDUFS8-6:1 | 0.030854 | 3.317164 |
| lnc-CTNNB1-1:1 | 0.008001 | 0.441364 | lnc-TMEM185B-7:1 | 0.030934 | 3.235290 |
| lnc-FKBP1C-2:1 | 0.008001 | 3.720573 | NONHSAT083013 | 0.031080 | 2.519326 |
| NR_027064 | 0.008194 | 2.413124 | lnc-DPYSL2-1:2 | 0.031187 | 0.369112 |
| lnc-SLITRK2-2:1 | 0.008466 | 2.135440 | lnc-TRAF4-1:1 | 0.031297 | 2.922623 |
| lnc-ACTR8-2:2 | 0.008950 | 2.010220 | lnc-HSP90AA1-12:1 | 0.031488 | 2.965284 |
| lnc-GPR125-5:1 | 0.009259 | 2.249563 | lnc-DPY19L4-2:1 | 0.031507 | 3.277730 |
| lnc-GLI2-8:1 | 0.009269 | 4.732693 | lnc-INSM2-3:1 | 0.031540 | 4.369118 |
| lnc-ZNF720-3:4 | 0.009444 | 0.284125 | lnc-GJA1-5:1 | 0.031616 | 4.414721 |
| ENST00000607744 | 0.009565 | 0.498854 | lnc-C21orf91-7:1 | 0.031910 | 2.057613 |
| ENST00000604491 | 0.009868 | 0.483914 | lnc-HNRPDL-1:1 | 0.032011 | 2.246524 |
| lnc-XRCC2-11:1 | 0.010028 | 4.751639 | lnc-SLC36A4-4:1 | 0.032026 | 5.435425 |
| lnc-KCNB2-3:3 | 0.010433 | 3.170159 | lnc-AF165138.7.1-6:1 | 0.032115 | 3.129283 |
| lnc-ARHGEF4-1:5 | 0.010667 | 2.284153 | lnc-UCP3-5:1 | 0.032162 | 2.459402 |
| lnc-WDR60-10:1 | 0.010714 | 4.353585 | ENST00000418620 | 0.032233 | 2.865087 |
| lnc-ITPR1-1:1 | 0.010979 | 2.810121 | lnc-MKLN1-3:1 | 0.032452 | 3.154286 |
| lnc-MTFR1-4:1 | 0.011047 | 6.836786 | lnc-SEMA6A-9:1 | 0.032508 | 2.967021 |
| ENST00000562459 | 0.011098 | 0.413284 | lnc-RRP1B-5:1 | 0.032558 | 2.988848 |
| lnc-ABCC11-2:1 | 0.011194 | 2.555013 | lnc-FAM133A-1:1 | 0.032572 | 2.822855 |
| lnc-PSMB4-2:1 | 0.011320 | 2.635221 | lnc-RUNX1T1-8:1 | 0.032599 | 5.508733 |
| lnc-NCDN-4:1 | 0.011472 | 3.118238 | lnc-SAMHD1-2:1 | 0.032674 | 2.944065 |
| lnc-FAM150A-4:1 | 0.011629 | 3.014977 | lnc-HAS2-4:1 | 0.033028 | 3.272611 |
| lnc-TMEM14C-3:1 | 0.011791 | 0.363498 | lnc-TAAR8-2:1 | 0.033103 | 3.198109 |
| lnc-HELT-4:1 | 0.012120 | 3.399447 | NONHSAT035867 | 0.033243 | 2.275326 |
| lnc-EREG-1:1 | 0.012501 | 5.222298 | lnc-SLAIN1-10:1 | 0.033278 | 2.633741 |
| lnc-RNF152-10:1 | 0.012682 | 2.833123 | lnc-KRAS-3:1 | 0.033320 | 2.120663 |
| NONHSAT055372 | 0.012769 | 2.364184 | lnc-RP11-1396O13.13.1-3:1 | 0.033426 | 3.399453 |
| lnc-PSMA8-3:1 | 0.013580 | 3.586623 | NONHSAT080449 | 0.033499 | 2.284116 |
| lnc-RNF146-3:2 | 0.013682 | 0.450543 | lnc-COR06-2:1 | 0.033600 | 2.033234 |
| ENST00000588182 | 0.013795 | 2.483066 | NR_105043 | 0.033635 | 0.497849 |
| lnc-ARL14-1:1 | 0.013947 | 2.152969 | lnc-FGF9-1:2 | 0.033740 | 2.012303 |

| | | | | | |
|---|---|---|---|---|---|
| NONHSAT082239 | 0.014164 | 2.734858 | lnc-GTF2F2-12:1 | 0.033829 | 3.110996 |
| lnc-C19orf40-2:1 | 0.014524 | 3.582016 | lnc-ZNF485-5:1 | 0.034382 | 2.888447 |
| lnc-GSG2-2:1 | 0.014790 | 2.298855 | lnc-SLC25A1-4:1 | 0.034402 | 3.591687 |
| lnc-IFNGR1-1:1 | 0.014800 | 2.017367 | NONHSAT067683 | 0.034453 | 2.106330 |
| lnc-KIAA0754-4:1 | 0.014866 | 0.303337 | lnc-TCEANC-3:1 | 0.034475 | 3.222334 |
| ENST00000580686 | 0.015090 | 2.006726 | lnc-HEATR2-2:3 | 0.034536 | 2.122075 |
| lnc-NHSL2-5:1 | 0.015458 | 5.364915 | NONHSAT069830 | 0.034658 | 2.336815 |
| lnc-CNTNAP1-2:1 | 0.015672 | 2.185384 | ENST00000623366 | 0.034730 | 2.247730 |
| NR_028484 | 0.015842 | 2.466656 | NONHSAT055039 | 0.034745 | 2.569516 |
| lnc-NIPBL-5:1 | 0.015956 | 2.068993 | lnc-XRCC6BP1-7:1 | 0.034967 | 2.403190 |
| lnc-GSTM4-3:1 | 0.016001 | 4.558921 | lnc-DLEU7-9:1 | 0.035358 | 3.739677 |
| lnc-CSPG4-4:1 | 0.016239 | 2.832767 | lnc-NXPH1-3:1 | 0.035573 | 2.622335 |
| ENST00000562878 | 0.016451 | 3.780205 | ENST00000469216 | 0.035583 | 2.991286 |
| lnc-C9orf93-4:1 | 0.016462 | 4.292720 | lnc-SAR1B-2:1 | 0.035584 | 2.945021 |
| lnc-COA5-1:2 | 0.016706 | 2.281758 | ENST00000607698 | 0.035631 | 2.236715 |
| NONHSAT037842 | 0.016826 | 2.494149 | lnc-FAM9C-7:1 | 0.035635 | 2.208227 |
| NR_003319 | 0.017015 | 2.055342 | NR_002564 | 0.035655 | 2.022936 |
| lnc-SLAIN1-6:1 | 0.017050 | 2.347503 | lnc-LPHN3-9:1 | 0.035655 | 2.887387 |
| NONHSAT014088 | 0.017060 | 3.315290 | lnc-API5-11:1 | 0.035713 | 5.360648 |
| lnc-NR2C1-2:5 | 0.017601 | 3.187805 | lnc-CNTROB-1:1 | 0.035773 | 3.034125 |
| NR_003326 | 0.017605 | 2.237539 | lnc-CREB3L4-5:1 | 0.035829 | 2.486738 |
| ENST00000618697 | 0.018278 | 2.811176 | lnc-PHYHIP-3:1 | 0.036129 | 2.411950 |
| lnc-AC011467.1-2:1 | 0.018886 | 3.873938 | lnc-CCL5-3:1 | 0.036142 | 2.169636 |
| lnc-AC024940.1-3:1 | 0.018950 | 5.721876 | lnc-PKP4-4:1 | 0.036273 | 3.574996 |
| ENST00000520185 | 0.019191 | 3.153546 | lnc-ERN1-2:1 | 0.036506 | 2.060532 |
| lnc-CAPN2-3:1 | 0.019274 | 3.059190 | NONHSAT007752 | 0.036575 | 2.068952 |
| NONHSAT023699 | 0.019354 | 3.654491 | lnc-PLEKHA5-6:1 | 0.036903 | 3.173178 |
| ENST00000457602 | 0.019451 | 2.808044 | lnc-APOD-2:1 | 0.036948 | 3.037368 |
| lnc-ATP7A-1:1 | 0.019482 | 2.117638 | ENST00000513581 | 0.037019 | 2.052258 |
| NONHSAT054838 | 0.019612 | 2.348478 | lnc-RP11-144F15.1.1-1:1 | 0.037149 | 0.416976 |
| ENST00000607849 | 0.020036 | 2.749882 | lnc-WNT7B-2:1 | 0.037222 | 2.334190 |
| lnc-RP4-811H24.6.1-3:1 | 0.020089 | 2.203762 | NONHSAT128057 | 0.037247 | 2.046945 |
| lnc-PRDM10-2:1 | 0.020139 | 6.452253 | lnc-TIPRL-1:1 | 0.037326 | 2.473408 |
| ENST00000522057 | 0.020262 | 0.447348 | lnc-TLK1-3:1 | 0.037420 | 0.405312 |
| ENST00000440714 | 0.020451 | 2.693063 | NONHSAT144261 | 0.037427 | 2.086151 |
| lnc-C8G-2:1 | 0.020470 | 2.017927 | lnc-SLC25A17-2:1 | 0.037491 | 2.112698 |
| lnc-XRCC2-5:1 | 0.020536 | 2.252912 | ENST00000516179 | 0.037776 | 3.698214 |
| lnc-C20orf196-5:1 | 0.020537 | 2.206133 | NONHSAT097497 | 0.037930 | 3.233874 |
| lnc-ERMN-2:1 | 0.020549 | 2.316518 | lnc-GCA-6:1 | 0.038066 | 0.322882 |
| lnc-MMADHC-5:1 | 0.020674 | 2.714973 | lnc-CCAR1-3:1 | 0.038094 | 2.796137 |
| ENST00000556386 | 0.020962 | 0.492902 | NONHSAT101519 | 0.038116 | 2.296229 |
| lnc-C11orf63-3:1 | 0.021055 | 5.800559 | lnc-CPB2-1:1 | 0.038135 | 2.716338 |
| lnc-GFM1-3:1 | 0.021398 | 2.138727 | lnc-ZBTB6-1:1 | 0.038167 | 2.522111 |
| NONHSAT018112 | 0.021474 | 2.380851 | lnc-CEBPZ-1:1 | 0.038312 | 2.498023 |
| ENST00000620896 | 0.021615 | 4.355321 | NONHSAT036908 | 0.038429 | 2.323269 |
| lnc-EIF2B1-5:1 | 0.021669 | 2.252508 | lnc-SCAF11-3:1 | 0.038451 | 2.155351 |
| lnc-DAOA-10:1 | 0.021737 | 2.116635 | lnc-GPR63-8:1 | 0.038508 | 2.298733 |
| lnc-CSGALNACT1-4:1 | 0.021804 | 2.754306 | lnc-A2M-2:1 | 0.038565 | 2.059797 |
| lnc-EGR1-1:1 | 0.021885 | 2.784704 | lnc-PTPRZ1-10:1 | 0.038600 | 3.074862 |

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|---|---|---|---|---|---|
| lnc-LDB1-4:1 | 0.022076 | 2.266362 | lnc-C2orf57-3:1 | 0.038703 | 3.093121 |
| lnc-RIOK2-9:1 | 0.022275 | 2.295135 | lnc-DPPA4-3:1 | 0.038898 | 2.208222 |
| ENST00000486671 | 0.022392 | 0.488640 | NONHSAT062956 | 0.038927 | 2.120931 |
| lnc-NDUFB4-3:1 | 0.022459 | 5.001966 | lnc-NPIPL2-5:1 | 0.039054 | 2.182963 |
| lnc-TNFRSF11A-1:1 | 0.022544 | 4.141308 | lnc-PRAC-1:1 | 0.039085 | 2.238885 |
| NONHSAT117148 | 0.022834 | 0.029067 | lnc-ZMYND8-6:1 | 0.039155 | 3.492289 |
| NONHSAT126218 | 0.022998 | 2.281553 | lnc-CMC1-4:1 | 0.039284 | 3.469623 |
| lnc-TMSB15A-4:1 | 0.023142 | 2.936737 | lnc-MOK-6:1 | 0.039415 | 2.039396 |
| NONHSAT127886 | 0.023160 | 4.047682 | lnc-CDH17-2:1 | 0.039494 | 2.614143 |
| lnc-ZNF366-13:1 | 0.023319 | 2.269892 | ENST00000516415 | 0.039614 | 3.495111 |
| lnc-GP5-4:1 | 0.023343 | 2.568824 | lnc-TMEM202-4:1 | 0.039682 | 2.298466 |
| lnc-AC023632.1-3:1 | 0.023438 | 5.825887 | lnc-SLC25A26-6:1 | 0.039883 | 3.238884 |
| lnc-ZNF292-1:1 | 0.023504 | 3.040714 | ENST00000619883 | 0.040129 | 2.017658 |
| lnc-RALGAPA2-7:1 | 0.023527 | 2.401887 | lnc-SNX14-5:1 | 0.040182 | 3.950922 |
| lnc-C7orf30-4:1 | 0.023586 | 3.099895 | ENST00000609669 | 0.040244 | 2.298269 |
| lnc-ADD3-5:1 | 0.023669 | 3.831370 | lnc-NXPH2-11:1 | 0.040282 | 2.443955 |
| lnc-TAS1R1-1:1 | 0.023671 | 4.650636 | lnc-PLEKHM3-2:1 | 0.040292 | 2.240296 |
| lnc-SEL1L-12:1 | 0.023680 | 4.131716 | lnc-FBXO10-1:1 | 0.040456 | 2.259429 |
| lnc-STX7-1:1 | 0.023691 | 2.371396 | lnc-NT5E-4:1 | 0.040664 | 2.560400 |
| lnc-SMC4-2:1 | 0.023745 | 2.502074 | lnc-PON3-1:1 | 0.040670 | 0.307763 |
| lnc-LPAR1-2:1 | 0.023811 | 2.397395 | lnc-ACAT1-2:1 | 0.040989 | 3.059496 |
| ENST00000432229 | 0.023891 | 4.875449 | lnc-GPR19-2:1 | 0.041076 | 2.262905 |
| lnc-CD40LG-4:1 | 0.023948 | 2.138773 | lnc-IL20RA-2:1 | 0.041154 | 3.912937 |
| lnc-FANCB-2:1 | 0.023994 | 2.493826 | ENST00000565797 | 0.041229 | 2.161403 |
| lnc-CAMP-3:1 | 0.024049 | 2.761479 | lnc-FAM71D-3:1 | 0.041316 | 2.273365 |
| lnc-VPS13C-3:1 | 0.024080 | 2.315048 | NR_046400 | 0.041377 | 3.314155 |
| lnc-DLD-2:1 | 0.024095 | 3.265361 | lnc-ETV6-5:1 | 0.041393 | 2.025817 |
| NONHSAT001395 | 0.024147 | 3.443800 | lnc-NOS2-6:1 | 0.041898 | 2.534273 |
| lnc-PSMA6-3:1 | 0.024153 | 4.842954 | lnc-SLC14A1-1:1 | 0.041905 | 2.130369 |
| lnc-CDH13-4:1 | 0.024223 | 2.417426 | NONHSAT100937 | 0.042076 | 2.366031 |
| lnc-DENND5B-2:1 | 0.024256 | 5.941084 | lnc-RPS27-2:2 | 0.042202 | 2.938509 |
| lnc-ATG14-3:1 | 0.024596 | 4.650949 | NONHSAT053484 | 0.042323 | 2.018450 |
| lnc-SFT2D2-3:1 | 0.024654 | 3.993808 | lnc-RPL7A-2:1 | 0.042364 | 2.197304 |
| NR_104160 | 0.025050 | 2.397668 | lnc-CENPJ-4:1 | 0.042422 | 3.089729 |
| lnc-TAOK3-11:1 | 0.025193 | 3.647123 | lnc-ZKSCAN2-4:1 | 0.042664 | 2.042803 |
| lnc-IFT74-6:1 | 0.025394 | 2.916980 | lnc-FAM126A-1:1 | 0.042732 | 5.815825 |
| lnc-CC2D2A-1:1 | 0.025426 | 0.234307 | lnc-TMEM183A-2:1 | 0.042736 | 2.777235 |
| lnc-VANGL1-3:1 | 0.025667 | 2.019714 | lnc-MDC1-1:1 | 0.042821 | 2.315465 |
| NONHSAT004372 | 0.025673 | 2.575596 | ENST00000515939 | 0.043099 | 2.617044 |
| lnc-RGS13-2:2 | 0.025673 | 3.580933 | lnc-RPL36A-1:1 | 0.043108 | 3.133511 |
| lnc-AC012123.1.1-4:1 | 0.025757 | 4.067355 | lnc-MBL2-9:1 | 0.043200 | 2.849667 |
| lnc-SIRT5-4:2 | 0.025865 | 2.481641 | lnc-CD82-3:1 | 0.043634 | 2.187287 |
| ENST00000563775 | 0.025868 | 0.455186 | lnc-FBXL2-2:1 | 0.043716 | 2.139475 |
| lnc-RP11-439E19.8.1-1:1 | 0.025948 | 2.443394 | lnc-PRDX6-4:1 | 0.043902 | 4.837367 |
| lnc-KATNAL2-10:1 | 0.025968 | 2.710647 | lnc-NRN1-6:2 | 0.043947 | 3.215138 |
| lnc-NPY5R-5:1 | 0.026096 | 3.325271 | NR_029663 | 0.043988 | 2.225406 |
| lnc-BORA-14:1 | 0.026121 | 3.183868 | lnc-ALS2CR8-2:1 | 0.044054 | 2.014730 |
| lnc-GALNT12-2:1 | 0.026131 | 3.003232 | ENST00000517226 | 0.044094 | 2.500426 |
| lnc-C10orf68-16:1 | 0.026166 | 3.963789 | lnc-DTHD1-16:1 | 0.044149 | 2.875734 |

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|---|---|---|---|---|---|
| NONHSAT130299 | 0.026220 | 2.243392 | lnc-WSB1-7:2 | 0.044329 | 3.056061 |
| lnc-TPRG1-1:1 | 0.026246 | 2.128522 | NR_028287 | 0.044415 | 2.220527 |
| lnc-SLC36A4-7:1 | 0.026323 | 4.331721 | lnc-RP11-32K4.2.1-3:1 | 0.044501 | 3.962538 |
| lnc-C7orf41-2:1 | 0.026356 | 3.284729 | ENST00000539313 | 0.044646 | 2.238493 |
| lnc-FAM82A1-8:1 | 0.026435 | 3.770875 | lnc-ADAMTS7-2:1 | 0.044664 | 2.180753 |
| NONHSAT127446 | 0.026492 | 3.308516 | lnc-DUSP19-3:1 | 0.044704 | 2.342081 |
| lnc-OR6J1-1:1 | 0.026586 | 4.849661 | lnc-PTPN13-1:1 | 0.044755 | 3.610328 |
| lnc-ACTL6A-1:1 | 0.026680 | 2.917185 | ENST00000608498 | 0.044916 | 0.419118 |
| NR_125398 | 0.026682 | 2.149512 | lnc-TFDP2-9:1 | 0.044919 | 3.345986 |
| NONHSAT113353 | 0.026731 | 5.714059 | lnc-LETMD1-1:1 | 0.045215 | 2.509107 |
| lnc-CNOT7-5:1 | 0.026778 | 5.887736 | lnc-C3orf65-9:1 | 0.045545 | 3.148205 |
| NONHSAT078561 | 0.026787 | 7.189788 | lnc-PLBD1-1:3 | 0.045730 | 2.433243 |
| lnc-GRIA3-2:1 | 0.026812 | 2.423567 | lnc-ARSG-2:6 | 0.045782 | 2.319127 |
| lnc-RNF222-1:1 | 0.027005 | 2.224587 | lnc-CES1-4:1 | 0.045810 | 2.797083 |
| lnc-LTA4H-2:1 | 0.027083 | 2.262939 | lnc-NR2F2-10:1 | 0.045881 | 2.529856 |
| lnc-LONP2-8:1 | 0.027114 | 2.016856 | ENST00000412944 | 0.045981 | 0.323891 |
| NR_003327 | 0.027121 | 2.951477 | lnc-C3orf72-4:2 | 0.046103 | 2.685749 |
| ENST00000517272 | 0.027323 | 3.226000 | lnc-RP11-166B2.1.1-3:1 | 0.046171 | 2.168401 |
| ENST00000603472 | 0.027359 | 3.022812 | lnc-PRRG4-4:1 | 0.046265 | 3.035505 |
| ENST00000413347 | 0.027542 | 0.211350 | lnc-RP11-24B21.1.1-2:7 | 0.046327 | 2.100781 |
| lnc-DYRK1A-1:1 | 0.027543 | 0.169983 | lnc-KBTBD13-1:1 | 0.046483 | 2.141858 |
| lnc-DTX1-2:1 | 0.027592 | 3.653670 | lnc-ARSB-1:1 | 0.046819 | 2.560501 |
| lnc-AC016586.1-1:4 | 0.027715 | 2.007466 | lnc-SUPT6H-2:7 | 0.046823 | 2.069449 |
| lnc-ACBD3-1:1 | 0.027924 | 4.281501 | lnc-C19orf12-7:1 | 0.046990 | 2.778798 |
| lnc-GTF2A1-4:1 | 0.027953 | 3.111798 | lnc-ACBD6-2:1 | 0.047054 | 2.514431 |
| ENST00000516592 | 0.027980 | 4.373258 | lnc-COMMD3-3:1 | 0.047063 | 2.503576 |
| lnc-STK35-3:1 | 0.028143 | 2.317525 | NR_002562 | 0.047112 | 2.053924 |
| lnc-RP11-849H4.2.1-2:1 | 0.028536 | 4.199084 | lnc-NDFIP2-21:1 | 0.047219 | 2.111534 |
| lnc-TUFM-4:1 | 0.028538 | 2.813072 | lnc-MUC20-7:2 | 0.047226 | 2.128360 |
| lnc-RBMY1J-7:1 | 0.028578 | 2.727599 | lnc-CXCR3-12:1 | 0.047232 | 4.464054 |
| lnc-CYP7B1-9:1 | 0.028702 | 2.930639 | lnc-CYTL1-5:2 | 0.047503 | 2.901246 |
| lnc-SMARCAD1-1:1 | 0.028779 | 3.654037 | lnc-RNF144B-5:1 | 0.047593 | 2.016126 |
| lnc-TMEM74-3:1 | 0.028832 | 2.465546 | lnc-IQCH-4:1 | 0.048068 | 2.173871 |
| NR_036695 | 0.028848 | 2.776613 | lnc-C5orf22-8:1 | 0.048284 | 3.203795 |
| NONHSAT017634 | 0.028876 | 2.028523 | lnc-CNTN4-3:1 | 0.048311 | 2.025867 |
| lnc-NAP1L3-8:1 | 0.028947 | 3.242532 | NONHSAT059117 | 0.048379 | 2.403889 |
| lnc-HPRT1-9:1 | 0.029041 | 2.730397 | lnc-LPAR4-1:1 | 0.048691 | 2.107284 |
| lnc-KCNB1-1:2 | 0.029166 | 5.540174 | lnc-JAK1-8:1 | 0.049024 | 3.100057 |
| NONHSAT137858 | 0.029188 | 2.286954 | lnc-LINC00470-3:1 | 0.049145 | 2.468314 |
| lnc-SNX10-4:1 | 0.029264 | 3.962636 | ENST00000516699 | 0.049186 | 2.252165 |
| lnc-SETD4-11:1 | 0.029358 | 5.268727 | lnc-MRP63-7:2 | 0.049218 | 2.257006 |
| lnc-BTG1-3:1 | 0.029364 | 4.188679 | lnc-C11orf82-9:1 | 0.049221 | 2.226389 |
| lnc-EBF3-11:1 | 0.029501 | 2.170030 | NR_045117 | 0.049409 | 0.459001 |
| lnc-RPS13-3:1 | 0.029547 | 5.254605 | lnc-CTNNA3-8:1 | 0.049423 | 2.616655 |
| ENST00000606596 | 0.029629 | 3.836024 | lnc-ZNF286A-11:1 | 0.049549 | 2.501332 |
| lnc-SH3RF2-4:1 | 0.029730 | 2.693729 | lnc-CAMSAP2-2:1 | 0.049577 | 3.010308 |
| lnc-DNAJC12-2:1 | 0.029822 | 3.449972 | lnc-IL6-10:1 | 0.049733 | 2.217231 |
| lnc-AVPR1A-3:1 | 0.029871 | 2.560073 | lnc-BEND6-2:1 | 0.049876 | 2.067030 |
| lnc-TNP1-7:1 | 0.029881 | 6.443609 | | | |

DE-lncRNAs, differentially expressed lncRNAs.

**Table S3-2.** All DE-mRNAs between hypertensive and normotensive groups

| DEG | *P*-value | FC | DEG | *P*-value | FC |
|---|---|---|---|---|---|
| *DMRTC2* | 0.001304 | 4.781866 | *PERP* | 0.025326 | 2.020140 |
| *ZNF347* | 0.001943 | 0.498468 | *ZNF585B* | 0.026308 | 0.488404 |
| *SFTPA2* | 0.002651 | 2.180156 | *CTAG1B* | 0.027474 | 3.382239 |
| *HIGD1C* | 0.003248 | 2.243524 | *FFAR4* | 0.027566 | 0.483000 |
| *SPRED1* | 0.003497 | 0.471448 | *KCNK7* | 0.028835 | 2.692425 |
| *CD180* | 0.003790 | 0.441027 | *CDADC1* | 0.029385 | 2.201790 |
| *ANXA8* | 0.004021 | 2.207667 | *RPL17* | 0.029567 | 2.531104 |
| *VIT* | 0.005005 | 0.407097 | *NWD1* | 0.030331 | 2.816975 |
| *RGS1* | 0.005414 | 6.486876 | *SERINC2* | 0.030338 | 2.362981 |
| *GPR20* | 0.006608 | 0.368496 | *KLHDC7A* | 0.030688 | 2.047292 |
| *ANO2* | 0.007765 | 0.461345 | *PTS* | 0.031218 | 2.250719 |
| *SLC16A14* | 0.008164 | 2.174513 | *TOB1* | 0.032654 | 2.019600 |
| *NR4A3* | 0.008749 | 6.799959 | *RSL24D1* | 0.034190 | 2.221835 |
| *ERMN* | 0.009180 | 2.044825 | *SNRPF* | 0.034645 | 2.757363 |
| *DUSP4* | 0.009823 | 2.009596 | *GPR87* | 0.037195 | 3.032198 |
| *C17orf64* | 0.012822 | 2.203667 | *CTAG2* | 0.037550 | 3.759738 |
| *PCDHGA8* | 0.012950 | 0.478581 | *EGR3* | 0.038435 | 2.320014 |
| *LACTB* | 0.013003 | 2.127301 | *SEC14L2* | 0.038820 | 2.171246 |
| *CD69* | 0.013229 | 3.024099 | *CNTN1* | 0.040303 | 0.405808 |
| *SFN* | 0.015809 | 2.376723 | *C17orf107* | 0.043330 | 2.506023 |
| *DLC1* | 0.015886 | 0.432207 | *AREG* | 0.044621 | 9.667943 |
| *TIFAB* | 0.016275 | 0.499804 | *SIGLEC14* | 0.045134 | 0.443825 |
| *C12orf79* | 0.017032 | 2.105432 | *ZNF98* | 0.045337 | 2.516863 |
| *ID1* | 0.020953 | 20.331717 | *NR4A2* | 0.045953 | 4.892434 |
| *CALN1* | 0.022189 | 2.198163 | *VWDE* | 0.047126 | 2.261225 |
| *MS4A3* | 0.022953 | 2.077624 | *GZF1* | 0.049491 | 2.059196 |

DE-mRNAs, differentially expressed mRNAs.

**Table S4-1.** Cis Targeted Genes of 387 DE-lncRNAs identified by microarray

| DE-lncRNA | Target Genes | N | DE-lncRNA | Target Genes | N |
|---|---|---|---|---|---|
| NR_029782 | *NR6A1; MIR181B-2* | 2 | lnc-SPR-3:1 | *EXOC6B* | 1 |
| lnc-EIF2AK4-6:1 | *THBS1* | 1 | lnc-CHCHD3-1:1 | *EXOC4* | 1 |
| lnc-IL2RA-4:1 | *IL2RA; Os07g0271000* | 2 | lnc-BMP2K-4:1 | *BMP2K* | 1 |
| lnc-CD52-1:1 | *AIM1L; UBXN11* | 2 | lnc-KDELR2-1:2 | *KDELR2; KDELR* | 2 |
| ENST00000614747 | *SLC18A2* | 1 | lnc-PLIN1-1:1 | *PEX11A; PLIN1* | 2 |
| ENST00000505646 | *UGT2B11; UGT1B4* | 2 | lnc-C4orf34-8:1 | *UBE2K* | 1 |
| ENST00000564481 | *AP3M2* | 1 | lnc-TRAPPC8-4:1 | *RNF125; F12L6.25* | 2 |
| lnc-LOH12CR1-6:1 | *LRP6* | 1 | lnc-TMEM185B-7:1 | *PTPN4* | 1 |
| NR_024109 | *TYW1B; SBDS-1; CTNNB1-B* | 3 | lnc-TRAF4-1:1 | *FAM222B* | 1 |
| lnc-ACTR8-2:2 | *SELK* | 1 | lnc-HSP90AA1-12:1 | *DYNC1H1* | 1 |
| lnc-GPR125-5:1 | *KCNIP4* | 1 | lnc-DPY19L4-2:1 | *ESRP1* | 1 |
| lnc-ZNF720-3:4 | *ZNF720; GM10037* | 2 | lnc-C21orf91-7:1 | *BTG3* | 1 |
| ENST00000607744 | *LRRFIP2* | 1 | lnc-HNRPDL-1:1 | *TMEM150C* | 1 |
| ENST00000604491 | *FOXP1* | 1 | lnc-AF165138.7.1-6:1 | *SAMSN1* | 1 |
| lnc-KCNB2-3:3 | *TERF1* | 1 | ENST00000418620 | *SP3* | 1 |
| lnc-ARHGEF4-1:5 | *PLEKHB2* | 1 | lnc-MKLN1-3:1 | *PODXL* | 1 |
| lnc-ITPR1-1:1 | *BHLHE40* | 1 | lnc-RRP1B-5:1 | *HSF2BP* | 1 |
| ENST00000562459 | *GPR20* | 1 | lnc-SAMHD1-2:1 | *RBL1* | 1 |

| | | | | | |
|---|---|---|---|---|---|
| lnc-PSMB4-2:1 | *POGZ* | 1 | NONHSAT035867 | *RNF212B* | 1 |
| lnc-NCDN-4:1 | *ZMYM4* | 1 | NONHSAT080449 | *CASS4* | 1 |
| lnc-FAM150A-4:1 | *ST18* | 1 | lnc-COR06-2:1 | *SSH2* | 1 |
| lnc-RNF152-10:1 | *CDH20* | 1 | lnc-GTF2F2-12:1 | *COG3* | 1 |
| NONHSAT055372 | *RGS9* | 1 | lnc-SLC25A1-4:1 | *CLTCL1; CHC* | 2 |
| lnc-PSMA8-3:1 | *SS18* | 1 | NONHSAT067683 | *ZNF813; VMN1R82* | 2 |
| lnc-RNF146-3:2 | *ECHDC1* | 1 | lnc-TCEANC-3:1 | *EGFL6* | 1 |
| lnc-C19orf40-2:1 | *CEP89; FAAP24* | 2 | lnc-HEATR2-2:3 | *PRKAR1B; KIN-2* | 2 |
| lnc-GSG2-2:1 | *GSG2* | 1 | ENST00000623366 | *HSPA4* | 1 |
| lnc-IFNGR1-1:1 | *IFNGR1* | 1 | NONHSAT055039 | *RPS6KB1* | 1 |
| lnc-KIAA0754-4:1 | *MACF1* | 1 | lnc-SAR1B-2:1 | *DDX46; CG6227* | 2 |
| lnc-CNTNAP1-2:1 | *EZH1* | 1 | ENST00000607698 | *RSRP1* | 1 |
| NR_028484 | *ADORA2A; MGC82114* | 2 | lnc-FAM9C-7:1 | *FRMPD4* | 1 |
| lnc-NIPBL-5:1 | *C5orf42; 2410089E03Rik* | 2 | NR_002564 | *SLC3A2* | 1 |
| lnc-GSTM4-3:1 | *GSTM4; RPL7A* | 2 | lnc-CNTROB-1:1 | *CNTROB* | 1 |
| lnc-CSPG4-4:1 | *NRG4* | 1 | lnc-CREB3L4-5:1 | *GATAD2B* | 1 |
| lnc-COA5-1:2 | *MGAT4A; MGATB4B* | 2 | lnc-PHYHIP-3:1 | *SLC39A14* | 1 |
| NONHSAT037842 | *NEK9* | 1 | lnc-CCL5-3:1 | *HEATR9; RPL24* | 2 |
| lnc-AC011467.1-2:1 | *LOC100193910* | 1 | ENST00000520185 | *IDO1* | 1 |
| lnc-NR2C1-2:5 | *NR2C1* | 1 | lnc-PKP4-4:1 | *CCDC148* | 1 |
| ENST00000618697 | *IGF1R* | 1 | lnc-ERN1-2:1 | *ERN1* | 1 |
| lnc-CAPN2-3:1 | *TP53BP2* | 1 | lnc-PLEKHA5-6:1 | *AEBP2* | 1 |
| ENST00000457602 | *ARHGAP25* | 1 | lnc-APOD-2:1 | *APOD* | 1 |
| lnc-ATP7A-1:1 | *PGK1; TAF9B; CG9961* | 3 | ENST00000513581 | *SEC31A; THAP9* | 2 |
| ENST00000607849 | *VGLL4* | 1 | lnc-RP11-144F15.1.1-1:1 | *POLR3B; RPLLL128* | 2 |
| lnc-RP4-811H24.6.1-3:1 | *BSDC1* | 1 | lnc-TIPRL-1:1 | *TIPRL; RPL3402* | 2 |
| lnc-PRDM10-2:1 | *APLP2* | 1 | lnc-TLK1-3:1 | *GORASP2; GRASP65* | 2 |
| ENST00000522057 | *PPP1R3B* | 1 | lnc-SLC25A17-2:1 | *MKL1; ADSL* | 2 |
| lnc-C8G-2:1 | *TRAF2; RABL6* | 2 | ENST00000516179 | *SOD2* | 1 |
| lnc-XRCC2-5:1 | *RL36A* | 1 | lnc-C11orf63-3:1 | *LOC103435013* | 1 |
| lnc-DAOA-10:1 | *RPL-35* | 1 | lnc-TNFRSF11A-1:1 | *RPL17* | 1 |
| NONHSAT117148 | *MAMU-DPA* | 1 | lnc-TMSB15A-4:1 | *GPRASP1* | 1 |
| lnc-MMADHC-5:1 | *LYPD6B* | 1 | lnc-CCAR1-3:1 | *TET1* | 1 |
| NONHSAT018112 | *FAR1* | 1 | NONHSAT101519 | *IL6ST* | 1 |
| ENST00000620896 | *SRGN* | 1 | lnc-CPB2-1:1 | *ZC3H13* | 1 |
| lnc-EIF2B1-5:1 | *ATP6V0A2* | 1 | lnc-ZBTB6-1:1 | *RC3H2* | 1 |
| lnc-CSGALNACT1-4:1 | *PSD3* | 1 | lnc-CEBPZ-1:1 | *SULT6B1* | 1 |
| lnc-EGR1-1:1 | *EGR1* | 1 | NONHSAT036908 | *GNPNAT1; MYEOV2* | 2 |
| lnc-LDB1-4:1 | *C10orf76* | 1 | lnc-A2M-2:1 | *PZP; A2M* | 2 |
| lnc-RIOK2-9:1 | *CHD1* | 1 | NONHSAT062956 | *JUND* | 1 |
| NONHSAT126218 | *SFRP1* | 1 | lnc-NPIPL2-5:1 | *GLG1* | 1 |
| NONHSAT127886 | *LAPTM4B; RPL39* | 2 | lnc-CMC1-4:1 | *ZCWPW2* | 1 |
| lnc-AC023632.1-3:1 | *LOC100306335* | 1 | ENST00000432229 | *FARP1* | 1 |
| lnc-ZNF366-13:1 | *TNPO1* | 1 | lnc-MOK-6:1 | *HSP90AA1* | 1 |
| lnc-ZNF292-1:1 | *HTR1E; RPL7L1* | 2 | ENST00000516415 | *B4GALT1* | 1 |
| lnc-RALGAPA2-7:1 | *CFAP61* | 1 | lnc-TMEM202-4:1 | *SENP8* | 1 |
| lnc-C7orf30-4:1 | *IGF2BP3* | 1 | ENST00000619883 | *RHNO1; FOXM1* | 2 |
| lnc-TAS1R1-1:1 | *NOL9* | 1 | lnc-NXPH2-11:1 | *LRP1B* | 1 |
| lnc-STX7-1:1 | *STX7* | 1 | lnc-PLEKHM3-2:1 | *PLEKHM3* | 1 |
| ENST00000609669 | *UAP1* | 1 | lnc-PON3-1:1 | *PON2* | 1 |
| lnc-NOS2-6:1 | *NOS2* | 1 | NONHSAT100937 | *RPL17* | 1 |
| lnc-CENPJ-4:1 | *OS08G0156800* | 1 | lnc-FAM126A-1:1 | *FAM126A* | 1 |
| lnc-SMC4-2:1 | *IFT80* | 1 | lnc-FBXO10-1:1 | *POLR1E* | 1 |

| | | | | | |
|---|---|---|---|---|---|
| lnc-LPAR1-2:1 | *MUSK* | 1 | lnc-ACAT1-2:1 | *CUL5* | 1 |
| lnc-CD40LG-4:1 | *ARHGEF6* | 1 | lnc-GPR19-2:1 | *CREBL2* | 1 |
| lnc-CAMP-3:1 | *MAP4; RPS27B* | 2 | ENST00000565797 | *ABHD17A; LEP* | 2 |
| lnc-DLD-2:1 | *THAP5; DNAJB9* | 2 | lnc-FAM71D-3:1 | *GPHN; GPHNA* | 2 |
| NONHSAT001395 | *EIF4G3* | 1 | NR_046400 | *DIP2A* | 1 |
| lnc-PSMA6-3:1 | *KIAA0391; AT1G33120* | 2 | lnc-RPS27-2:2 | *NUP210L; RAB13* | 2 |
| lnc-DENND5B-2:1 | *DENND5B; LOC100276690* | 2 | NONHSAT053484 | *IKZF3* | 1 |
| lnc-CC2D2A-1:1 | *C1QTNF7* | 1 | ENST00000563775 | *C25H16orf59* | 1 |
| lnc-ATG14-3:1 | *FBXO34* | 1 | lnc-RPL7A-2:1 | *SURF6; RPL21A* | 2 |
| NR_104160 | *EPC1* | 1 | lnc-TMEM183A-2:1 | *TMEM183A* | 1 |
| lnc-IFT74-6:1 | *TEK* | 1 | lnc-MDC1-1:1 | *NRM; RPL7L1* | 2 |
| NONHSAT004372 | *LRRC8C* | 1 | ENST00000515939 | *UBE2R2* | 1 |
| lnc-RGS13-2:2 | *RGS1* | 1 | lnc-RPL36A-1:1 | *TIMM8A* | 1 |
| lnc-AC012123.1.1-4:1 | *KLHL14* | 1 | lnc-FBXL2-2:1 | *CLASP2; COX6C-PS1* | 2 |
| lnc-SIRT5-4:2 | *PHACTR1* | 1 | NR_029663 | *SMC4; IFT80; MIR15B* | 3 |
| lnc-RP11-439E19.8.1-1:1 | *SCCPDH; LOC101866277* | 2 | lnc-ALS2CR8-2:1 | *CARF* | 1 |
| lnc-KATNAL2-10:1 | *ST8SIA5* | 1 | NR_028287 | *ZNF774; GRL1* | 2 |
| lnc-BORA-14:1 | *DACH1; DACHD* | 2 | ENST00000539313 | *TSG101* | 1 |
| lnc-TPRG1-1:1 | *LPP* | 1 | lnc-ADAMTS7-2:1 | *MORF4L1* | 1 |
| lnc-FAM82A1-8:1 | *RPL7* | 1 | ENST00000603472 | *SH3D19* | 1 |
| lnc-SLC36A4-7:1 | *FAT3* | 1 | lnc-DUSP19-3:1 | *DNAJC10; DUSP19* | 2 |
| ENST00000413347 | *SNAP47* | 1 | lnc-AC016586.1-1:4 | *EBI3* | 1 |
| lnc-PRDX6-4:1 | *RPL26* | 1 | lnc-RP11-32K4.2.1-3:1 | *COX6C* | 1 |
| ENST00000608498 | *RGD1306941* | 1 | lnc-NR2F2-10:1 | *GM29683* | 1 |
| lnc-TFDP2-9:1 | *TPT1* | 1 | lnc-C3orf72-4:2 | *PIK3CB* | 1 |
| lnc-SUPT6H-2:7 | *SPAG5* | 1 | lnc-ACBD6-2:1 | *QSOX1* | 1 |
| lnc-DYRK1A-1:1 | *DYRK1A* | 1 | lnc-NDUFS8-6:1 | *UNC93B1* | 1 |
| lnc-UCP3-5:1 | *CACD3* | 1 | lnc-RP11-1396O13.13.1-3:1 | *OLR1151* | 1 |
| NR_105043 | *FBXL13* | 1 | lnc-ZNF485-5:1 | *ZGC:173624* | 1 |
| lnc-GCA-6:1 | *KCNH7* | 1 | lnc-GPR63-8:1 | *T21H19.50* | 1 |
| lnc-C7orf41-2:1 | *MTURN* | 1 | lnc-PTPN13-1:1 | *C4orf36* | 1 |
| lnc-CXCR3-12:1 | *MGC152340* | 1 | NR_045117 | *WASH1* | 1 |
| lnc-CYTL1-5:2 | *CG32944* | 1 | lnc-CTNNA3-8:1 | *LOC100194643* | 1 |
| lnc-BEND6-2:1 | *DST* | 1 | lnc-NHSL2-5:1 | *MGC152340* | 1 |
| NR_125398 | *GATA2* | 1 | lnc-LETMD1-1:1 | *TFCP2; LOC101866801* | 2 |
| lnc-CNOT7-5:1 | *ZDHHC2* | 1 | lnc-C3orf65-9:1 | *SENP2* | 1 |
| lnc-RNF222-1:1 | *MYH10* | 1 | lnc-PLBD1-1:3 | *ATF7IP* | 1 |
| lnc-LONP2-8:1 | *N4BP1; LOC100160790* | 2 | lnc-ARSG-2:6 | *PRKAR1A* | 1 |
| lnc-DTX1-2:1 | *DTX1; OAS3* | 2 | lnc-RP11-166B2.1.1-3:1 | *GSPT1* | 1 |
| lnc-ACBD3-1:1 | *ACBD3* | 1 | lnc-PRRG4-4:1 | *CCDC73* | 1 |
| lnc-GTF2A1-4:1 | *STON2; LOC100284180* | 2 | lnc-KBTBD13-1:1 | *UBAP1L; RPL17* | 2 |
| lnc-RP11-849H4.2.1-2:1 | *RNF121* | 1 | lnc-C19orf12-7:1 | *URI1; LOC100162964* | 2 |
| lnc-TUFM-4:1 | *ATXN2L* | 1 | NR_002562 | *SLC3A2* | 1 |
| NR_036695 | *AGOS_ACL076W* | 1 | lnc-WDR36-1:1 | *CAMK4* | 1 |
| lnc-MEX3C-6:1 | *LOC105018348* | 1 | lnc-MBL2-9:1 | *RPL31* | 1 |
| lnc-RBMY1J-7:1 | *PRY2; RBMY* | 2 | lnc-IQCH-4:1 | *AAGAB; RPS2402* | 2 |
| NONHSAT017634 | *STIM1* | 1 | lnc-C5orf22-8:1 | *PDZD2* | 1 |
| lnc-HPRT1-9:1 | *PLAC1* | 1 | lnc-LPAR4-1:1 | *LPAR4* | 1 |
| lnc-KCNB1-1:2 | *KCNB1* | 1 | lnc-JAK1-8:1 | *DNAJC6* | 1 |
| lnc-EBF3-11:1 | *GLRX3* | 1 | ENST00000516699 | *GPC5; GPC5A* | 2 |
| lnc-RPS13-3:1 | *PIK3C2A* | 1 | lnc-MRP63-7:2 | *SAP18* | 1 |
| ENST00000606596 | *SARAF* | 1 | lnc-ZNF286A-11:1 | *CDRT4* | 1 |
| lnc-SH3RF2-4:1 | *LARS; RPL35A* | 2 | lnc-CAMSAP2-2:1 | *GPR25* | 1 |

| | | | | | |
|---|---|---|---|---|---|
| lnc-DNAJC12-2:1 | *HERC4* | 1 | lnc-TEKT3-1:1 | *PMP22* | 1 |
| lnc-TMEM14C-3:1 | *MAK* | 1 | lnc-EREG-1:1 | *AREG* | 1 |
| ENST00000588182 | *CYP4F2* | 1 | NONHSAT082239 | *BACE2* | 1 |
| lnc-NPBWR1-4:1 | *RB1CC1* | 1 | lnc-ABCC11-2:1 | *LONP2* | 1 |

DE-lncRNAs, differentially expressed lncRNAs.

**Table S4-2.** Trans Targeted Genes of 387 DE-lncRNAs identified by microarray

| DE-lncRNA | Target Genes | N |
|---|---|---|
| NR_033186 | *ADAT1; ANGEL2; ANKRD60; ARPP19; ARSB; ATP6V0A2; C4orf26; CACUL1; CHMP1B; CHP1; CLUAP1; CNNM3; CXorf56; CYP51A1; DNAL1; EIF5A2; ERCC4; FAM117B; FCAR; GPATCH2L; GPI; IKZF3; LY75; MAGEA10; MDM4; MON2; MRPL44; NICN1; NMNAT1; PDXK; PGAM5; PNMA2; POU5F1; PPM1K; RASGRP4; RBM34; RBMS2; SCAMP4; SERPINB1; SFMBT2; SIX4; SLC16A4; SPRED1; STRIP2; SV2C; TRPV1; TTC28; USP33; XPNPEP3; ZNF555; ZNF713* | 51 |
| lnc-CNOT10-2:1 | *ACPP; BAG1; BLZF1; CFLAR; CIAO1; CORO2A; CPT2; DCAF10; DTD2; EAF1; EXOG; IL4R; LPIN1; MARVELD3; MFSD11; MRPS25; NRIP2; ORAI2; PECAM1; RAD23B; SEMA5A; SLC35E1; SLC6A11; TCEANC2; TOP3A; VPS53; WDR73; ZC2HC1C; ZKSCAN1; ZNF43; ZNF841* | 31 |
| lnc-LOH12CR1-6:1 | *BRCA1; CC2D2B* | 2 |
| lnc-ARHGEF4-1:5 | *AKAP5; ATG14; C8orf44-SGK3; CCDC157; CCL5; CENPBD1; CTNS; CYB5D2; CYCS; CYP20A1; DDX51; DESI1; DPP9; GLTP; HOOK3; ITIH5; KLHL28; MAP3K9; OGFOD1; OPRK1; PAK3; PDP2; PNPT1; RAD1; RBL1; SCAF11; SGK3; SLC31A1; SLC35E3; TAF8; URB1; WDR31; XIAP; ZBTB43; ZNF260; ZNF333; ZNF426; ZNF665* | 38 |
| lnc-PSMB4-2:1 | *ADAT1; AHR; ALDH1B1; ALDH6A1; ALG1; ANKRD40; AP1S3; AP4E1; APOBEC3D; ARSA; ATP6V1A; BROX; C1orf210; CA5B; CDKAL1; CHMP1B; CLUAP1; CRISPLD2; CRX; CXorf56; CYB5R3; CYP51A1; DENND6A; DESI1; EMP2; FAM114A1; FAM117B; FAM234B; FBXW2; FOXK1; GFOD2; GGA2; GNE; GOLGA3; GPANK1; GSDMA; HOOK3; IBA57; IFNLR1; IKZF3; INMT; IRGQ; JOSD1; LAMP3; LMX1B; LY75; MAP3K13; MBOAT1; MEFV; MID1IP1; MTX3; NCOA6; NDUFV3; NF2; NLRC3; NOL9; NT5DC3; NUAK2; NXN; OLFML2A; OPRM1; OR7D2; OSBPL2; PACS2; PDDC1; PDE12; PIAS2; PIK3C2B; POU5F1; PSTPIP2; R3HDM2; RBM34; RBMS2; RIPPLY3; RNF7; SCAI; SCAMP4; SERPINB9; SHROOM1; SIRT5; SLC15A1; SLC25A15; SLC30A6; SLC35F1; SLC48A1; SMIM14; SMU1; SNX22; SPAST; SPECC1; SPRED1; SS18; STK17B; STON2; STRIP2; STYX; SYNRG; TAF8; TANGO2; TAPBP; TATDN3; TBC1D15; TLCD2; TMEM236; TMEM56; TMX4; TOR1AIP2; TRAF3IP1; TRAPPC2; TRPV1; UGGT1; WAC; WDR31; WDR55; WDR76; XIAP; ZC3H12B; ZCCHC8; ZNF250; ZNF260; ZNF426; ZNF445; ZNF451; ZNF543; ZNF550; ZNF555; ZNF699; ZNF765; ZNRF3; ZSCAN29* | 130 |
| lnc-GSG2-2:1 | *ABHD11; AFAP1L1; ALDH6A1; AP4E1; ARPP19; CCL5; CHRNB1; CLN8; CLUAP1; DENND6A; FAM117B; GCLM; GLTP; GSDMA; GSTM3; HILPDA; IKZF3; LAMP2; LRRC27; MLANA; NF2; NXPE3; OPA3; ORAI2; PER2; PNPO; RAB36; RARS2; RLIM; RNF125; SCAI; SIRT5; SMCR8; SMIM14; SPAST; STAT2; STK17B; TMEM120B; TOP3A; TRIM16; WDR55; WDR76; ZKSCAN1; ZNF490; ZNF681; ZNF765; ZSCAN29* | 47 |
| lnc-WDR60-10:1 | *BRCA1; CC2D2B* | 2 |
| lnc-SLC25A26-6:1 | *BRCA1; CC2D2B* | 2 |
| lnc-FBXO10-1:1 | *BRCA1; CC2D2B; TCF4* | 3 |
| lnc-ADAMTS7-2:1 | *BRCA1* | 1 |
| lnc-NDFIP2-21:1 | *BRCA1; CC2D2B* | 2 |
| lnc-MUC20-7:2 | *BRCA1; CC2D2B* | 2 |
| lnc-RNF144B-5:1 | *BRCA1; CC2D2B* | 2 |
| NR_028484 | *ADORA2A* | 1 |
| lnc-C8G-2:1 | *ACSL6; AKIP1; APOL1; APOL2; APPL1; C11orf58; C17orf75; C3orf70; CASP2; CASP8; CBX5; CCDC122; CDH6; CHST5; CPT1A; CRX; CXADR; CYB5R3; DSC3; DTD2; DTX3L; ERO1A; FBXL18; FBXL20; FBXO44; FOXK1; FUT1; GPR83; GREB1; HOMEZ; HOOK3; HYKK; IL17RD; INMT; IRAK4; JAK3; KIAA0825; KIAA1143; KIAA1210; KIAA1456; LEPROT; LIN54; LIX1L; LLGL1; LPP; LRRC28; LYZ; MALL; MAPK1IP1L; MAVS; MBOAT1; MPI; MPRIP; MTFMT; NANOG; NEK2; NR6A1; NRIP3; NRXN3; OPRM1; PAPOLA; PCDHA9; PDE7A; PEX13; PHKG2; PIGR; PLEKHG2; POLA2; PPIL6; PSPH; PTCHD4; PXMP4; RAB21; RBMS2; RRP15; SCARF1; SCNM1; SDE2; SERINC3; SERPINB9; SHROOM1; SIX4; SKA1; SKP2; SLC35F1; SLU7; SMAD2; SPATA5; SSR3; ST8SIA4; STEAP2; TADA3; TAPBP; TBC1D24; TBCCD1; TERF2; TMEM41B; TNFSF15; TOX4; TRAF3IP2; TRIM59; TTC39C; TVP23C; ULBP3; ULK2; UTP11; VHL; VIPR2; XPNPEP3; YES1; ZNF114; ZNF124; ZNF2; ZNF286A; ZNF286B; ZNF426; ZNF454; ZNF461; ZNF490; ZNF543; ZNF548; ZNF557; ZNF714; ZNF718; ZNF780B; ZNF793; ZNF805; ZSCAN22; ZSWIM1* | 129 |
| ENST00000620896 | *AAK1; ADARB2; ANGPT4; ANKS4B; AP4S1; ATAD3C; ATP6V1C1; C14orf178; C15orf52; CCL28; CDCP1; CELF3; CLCC1; CLDN11; CLEC19A; CYP20A1; DERL2; DNAL1; DTD2; DTX3L; EEF2K; EIF2AK2; FAM156A; FAM227A; GBP6; GSDMA; H6PD; HUNK; HUS1; HYKK; IKZF3; IL17RA; ITPRIPL2; KCNE4; KIAA1324; LITAF; LRPAP1; LRRC10; LY75; MDM4; ME2; MPP7; MRPL30; MYL10; NOS3; NSL1; NXPE3; OGFRL1; OLFML1; P2RY2; PDE6A; PER2; PHACTR4; PLEKHH2; PM20D2; PRRG4; RBBP4; RBMS2; RNF135; S1PR2; SCAI; SHCBP1; SIRT3; SKA1; SLC24A2; SLC26A2; SLC35F6; SLC6A11; SMU1; SNX27; SPN; STAP2; STYX; TINAGL1; TLCD2; TMEM241; TMTC1; TOR1AIP2; TRIP11; TRMT2B; TTC22; UVSSA; ZADH2; ZBTB40; ZC3HAV1; ZFP14; ZNF234; ZNF544* | 88 |

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|---|---|---|
| lnc-TUFM-4:1 | *ADAMTSL2; ALDH6A1; APOL1; ARPP19; ATL3; BNIPL; CEBPZOS; CHMP1B; CHP1; COX15; COX6B2; CXADR; CYP20A1; CYP4V2; EIF5A2; EXPH5; FAM114A1; FBXO45; FOXK1; GREB1; GTF2E1; HECA; KBTBD12; KIN; KLHL30; MBOAT1; ME2; MPZL3; MS4A10; MYLK3; NOL9; NR6A1; PIK3C2B; PLEKHA5; PNPO; PPM1K; RAB22A; RAB33B; RDH10; REEP3; RLIM; SCARF1; SCNM1; SCUBE3; SGTB; SIX4; SKP2; SLC16A4; SPAST; TANGO2; TERF2; TGFBRAP1; TOR1AIP2; TOX4; TRAPPC2; ZNF426* | 56 |
| lnc-BTG1-3:1 | *H6PD; ICMT; MTX3; RBMS2; REL; SLFN13* | 6 |
| lnc-NR4A2-8:1 | *ALDH6A1; ATP6V1A; ATXN3; CEP104; CLUAP1; CXorf56; DSC3; ERCC4; FOXK1; GNG4; HAVCR2; HSD17B13; IFNLR1; MANSC1; MED18; MTFMT; MYEF2; NOL9; OGFRL1; ORAI2; OSBPL2; PDE12; PSTPIP2; RAB22A; RASGRP4; RBM34; SALL4; SAR1B; SGTB; SIRT5; SLC16A4; SLC25A32; SPAST; SPRED3; SS18; TANGO2; TIMM10B; TOP3A; VENTX; VPS33A; ZNF264; ZNF426; ZNF713* | 43 |
| lnc-GPR19-2:1 | *BRCA1; CC2D2B* | 2 |
| lnc-RPL7A-2:1 | *BRCA1; CC2D2B* | 2 |
| lnc-RPL36A-1:1 | *BRCA1* | 1 |
| lnc-ADD3-5:1 | *BRCA1; CC2D2B* | 2 |
| lnc-STX7-1:1 | *BRCA1; CC2D2B* | 2 |
| lnc-CDH13-4:1 | *BRCA1; CC2D2B* | 2 |
| lnc-ZNF485-5:1 | *BRCA1* | 1 |
| lnc-XRCC6BP1-7:1 | *CC2D2B* | 1 |
| lnc-CNTROB-1:1 | *BRCA1* | 1 |
| lnc-HNRPDL-1:1 | *ACSL6; ALDH5A1; ARIH2OS; ATAD3C; ATF6; BCDIN3D; BRIP1; C17orf75; CAMK1D; CCL5; CD82; CD99; COA7; CPT1A; DENND2A; DIS3L; DNAJC21; ENTPD4; F2R; FAHD1; FBXL18; GBP4; GGPS1; GNE; GSTM3; ICA1L; IDO1; IDS; IRF1; KCNA7; KIAA1324; KREMEN1; LILRB3; LRRC27; LRRC58; MANEAL; MEAF6; MGAT4A; MRPS10; PCDH11Y; PDE6A; PIGX; PLEKHB2; PPP1R12B; RAB3B; RNF14; RNF41; RUNDC1; SHROOM1; SHROOM4; SLC26A2; SLC43A2; SPATA5; SVOP; SYNPO2L; TADA2B; TBC1D15; TNFAIP8L1; TONSL; TPM3; UBN2; UGGT1; WDR45; XIAP; XPNPEP3; ZBTB24; ZC3H12D; ZFP82; ZMAT3; ZNF114; ZNF124; ZNF669* | 72 |
| lnc-CORO6-2:1 | *BRCA1; CC2D2B; TCF4* | 3 |
| lnc-RP11-144F15.1.1-1:1 | *ADAT1; ALDH6A1; ATG14; BROX; BVES; C17orf75; CA5B; CD99; CYP20A1; CYP4V2; CYP51A1; DNAL1; EMP2; FAM118A; FOXK1; GFPT1; GNG4; GREB1; HAVCR2; HDAC2; HOMEZ; HYKK; ICE2; JAKMIP2; LPP; MED18; MTFMT; MYLK3; NMT2; NOL9; NT5DC3; NUDT19; ORAI2; PAFAH1B2; PDDC1; PHC3; PIK3C2B; PTGIS; RAB21; RBMS2; RHD; RHOF; SAR1B; SCIMP; SH3BP2; SLC16A4; SLC1A2; SLC4A8; SLC9A7; SNTB2; SSR1; TAF8; TOR4A; TOX4; TRAF3IP2; TRIM16; VENTX; XPNPEP3; YES1; ZC3HAV1; ZNF426; ZNF43; ZNF445* | 63 |
| lnc-WNT7B-2:1 | *ACER3; ADAT1; AFMID; AP3S2; AP4S1; ARCN1; ARGFX; ARSB; AS3MT; ASB6; ATL3; ATP1B4; ATP6V0A2; BLOC1S2; C15orf38-AP3S2; C19orf12; C9orf3; CA5B; CCDC141; CCNDBP1; CD99; CDCP1; CEP41; CHMP1B; CHP1; CLCC1; CRX; DESI1; DISC1; EEF2K; EIF5A2; EVI5; FAAP20; FAM114A1; FBXL18; FLCN; FXN; GNE; GPI; GSDMA; GTPBP3; H6PD; IFNLR1; IKZF3; IL11; IL17RD; JAKMIP2; KCNJ11; KIF18B; KIF1B; LRRN4CL; MAP7D3; MAVS; MCTS1; MDM4; METTL8; MRO; NATD1; NDUFV3; NMNAT1; NMUR1; NQO1; OLFML2A; OPA3; P2RY2; PDDC1; PGPEP1; PHACTR4; PHC3; PIK3CD; POU5F1; PRRG4; RASGRP4; RBMS2; RHD; RPL15; S1PR2; SCAI; SEPN1; SFMBT2; SFXN2; SHISA9; SKP2; SLC14A2; SLC4A8; SLC5A5; SPAG9; SPATA5; SVOP; TFDP2; TGFBRAP1; TIMM50; TOX4; TRAF3IP2; TTC28; USP33; USP9X; XPNPEP3; ZBTB8A; ZNF280C; ZNF426; ZNF621; ZNF677; ZNF713; ZNF829* | 105 |
| lnc-TLK1-3:1 | *GORASP2* | 1 |
| lnc-C2orf57-3:1 | *BRCA1; CC2D2B* | 2 |
| lnc-TMEM202-4:1 | *ABHD11; ADAT1; AP1S3; AP3M1; ARHGEF39; ATCAY; BCDIN3D; BHMT2; BORCS7; C11orf63; C6orf89; CARF; CCDC142; CCL5; CCR6; CD99; CEP19; COX18; CPM; CRX; CWC25; CXorf38; DBT; DCAF10; DMC1; DNAJC21; DNAL1; DNPEP; DPP9; DSG2; DSTYK; ECE1; EEF2K; ELMOD1; FBXL18; FKBP14; GLTP; GNE; GPR155; GPR82; GRM6; GSTM3; HCAR1; ICA1L; IDS; IKZF3; IL13RA1; IL17RD; IRF1; ITPRIPL2; KCNJ3; KDELC2; KIAA0355; KREMEN1; LAIR1; LAMP2; LRRC58; LRRN4CL; MANEAL; MAPK13; MARVELD3; MBOAT2; METTL21A; METTL2A; METTL2B; MREG; NMT2; NUBPL; ORAI2; PARK2; PDDC1; PDE4C; PDE6A; PDE7A; PGPEP1; PHACTR4; RBBP5; RHBDL2; RPL7L1; RRP7A; SCAF11; SEC14L4; SGSM1; SHPK; SHROOM1; SLC25A15; SLC44A4; SLC6A4; SMIM14; SNIP1; SPATS2; SRSF10; SYNPO2L; TIMM50; TLR7; TMEM168; TMEM236; TMEM56; TNFSF15; TONSL; TPM3; TRAF3IP2; TRIM65; TRIM66; TSNAX; TTPAL; TUBGCP4; UGGT1; UPK1B; VHL; XIAP; ZBTB43; ZBTB8A; ZHX3; ZKSCAN1; ZMAT3; ZNF106; ZNF34; ZNF655; ZNF749; ZNFX1* | 121 |
| lnc-CNTN4-3:1 | *BRCA1; CC2D2B* | 2 |
| lnc-TRAPPC8-4:1 | *HK1* | 1 |
| lnc-GJA1-5:1 | *HK1* | 1 |

DE-lncRNAs, differentially expressed lncRNAs.

**Table S5.** lncRNA-mRNA co-expression pairs

| lncRNA | mRNA | PCC | lncRNA | mRNA | PCC |
|---|---|---|---|---|---|
| NR_104160 | *ID1* | 0.951 | lnc-CNKSR3-2:1 | *RSL24D1* | 0.975 |
| ENST00000565797 | *CD69* | 0.951 | NONHSAT062956 | *RPL17* | 0.975 |
| lnc-LDB1-4:1 | *SNRPF* | 0.951 | lnc-HPRT1-9:1 | *RPL17* | 0.975 |
| ENST00000565797 | *GZF1* | 0.952 | NONHSAT053484 | *RSL24D1* | 0.976 |

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|---|---|---|---|---|---|
| lnc-UCP3-5:1 | *EGR3* | 0.952 | lnc-IQCH-4:1 | *RSL24D1* | 0.976 |
| lnc-ZBTB6-1:1 | *SNRPF* | 0.952 | lnc-FAM71D-3:1 | *RSL24D1* | 0.976 |
| lnc-LONP2-8:1 | *PTS* | 0.952 | NONHSAT035867 | *RPL17* | 0.976 |
| lnc-AVPR1A-3:1 | *PTS* | 0.952 | lnc-DUSP19-3:1 | *RPL17* | 0.976 |
| NONHSAT018112 | *RSL24D1* | 0.952 | lnc-NR2F2-10:1 | *RPL17* | 0.976 |
| lnc-GTF2F2-12:1 | *SNRPF* | 0.953 | lnc-RIOK2-9:1 | *CDADC1* | 0.977 |
| lnc-SAMHD1-2:1 | *RSL24D1* | 0.953 | lnc-LPAR4-1:1 | *RSL24D1* | 0.977 |
| lnc-C7orf30-4:1 | *RSL24D1* | 0.953 | lnc-CCAR1-3:1 | *RSL24D1* | 0.977 |
| lnc-DAOA-10:1 | *RPL17* | 0.953 | lnc-SAR1B-2:1 | *RSL24D1* | 0.977 |
| lnc-DNAJC12-2:1 | *RPL17* | 0.953 | lnc-SLC14A1-1:1 | *RPL17* | 0.977 |
| lnc-SPR-3:1 | *RSL24D1* | 0.954 | lnc-KBTBD13-1:1 | *RPL17* | 0.977 |
| lnc-CDH17-2:1 | *RSL24D1* | 0.954 | NR_104160 | *PTS* | 0.978 |
| lnc-HPRT1-9:1 | *RSL24D1* | 0.954 | NONHSAT144261 | *RSL24D1* | 0.978 |
| lnc-SETD4-11:1 | *RPL17* | 0.954 | lnc-CMC1-4:1 | *RSL24D1* | 0.978 |
| lnc-ERMN-2:1 | *PTS* | 0.955 | lnc-IQCH-4:1 | *RPL17* | 0.978 |
| lnc-CAPN2-3:1 | *PTS* | 0.955 | lnc-STK35-3:1 | *RPL17* | 0.978 |
| lnc-TIPRL-1:1 | *RSL24D1* | 0.955 | lnc-COMMD3-3:1 | *RPL17* | 0.978 |
| ENST00000565797 | *ERMN* | 0.956 | lnc-DUSP19-3:1 | *RSL24D1* | 0.979 |
| lnc-RIOK2-9:1 | *GZF1* | 0.956 | lnc-APOD-2:1 | *RSL24D1* | 0.979 |
| lnc-GTF2F2-12:1 | *GZF1* | 0.956 | NONHSAT067683 | *RPL17* | 0.979 |
| lnc-KDELR2-1:2 | *CDADC1* | 0.956 | lnc-PLEKHM3-2:1 | *RPL17* | 0.979 |
| lnc-GTF2F2-12:1 | *CDADC1* | 0.956 | lnc-CHCHD3-1:1 | *RPL17* | 0.979 |
| NONHSAT054838 | *RPL17* | 0.956 | lnc-CCL5-3:1 | *RSL24D1* | 0.98 |
| lnc-C4orf34-8:1 | *RPL17* | 0.956 | lnc-CEBPZ-1:1 | *RSL24D1* | 0.98 |
| lnc-CAPN2-3:1 | *ID1* | 0.957 | lnc-AVPR1A-3:1 | *RSL24D1* | 0.981 |
| ENST00000565797 | *SNRPF* | 0.957 | lnc-TRAF4-1:1 | *RSL24D1* | 0.981 |
| NR_024109 | *PTS* | 0.957 | lnc-CAMSAP2-2:1 | *RSL24D1* | 0.981 |
| lnc-AC011467.1-2:1 | *RSL24D1* | 0.957 | lnc-ZNF286A-11:1 | *RPL17* | 0.981 |
| NONHSAT130299 | *RPL17* | 0.957 | lnc-C7orf30-4:1 | *RPL17* | 0.981 |
| lnc-RPS13-3:1 | *RPL17* | 0.957 | NONHSAT100937 | *RSL24D1* | 0.982 |
| lnc-KCNB2-3:3 | *SFN* | 0.958 | lnc-CENPJ-4:1 | *RSL24D1* | 0.982 |
| lnc-ZNF286A-11:1 | *RSL24D1* | 0.958 | lnc-C3orf65-9:1 | *RSL24D1* | 0.982 |
| NR_002562 | *RPL17* | 0.958 | lnc-MEX3C-6:1 | *RPL17* | 0.982 |
| lnc-TIPRL-1:1 | *RPL17* | 0.958 | NONHSAT018112 | *RPL17* | 0.982 |
| lnc-NAP1L3-8:1 | *RPL17* | 0.958 | lnc-SAMHD1-2:1 | *RPL17* | 0.982 |
| NONHSAT127446 | *RPL17* | 0.958 | lnc-ERMN-2:1 | *CDADC1* | 0.983 |
| lnc-LDB1-4:1 | *CDADC1* | 0.959 | lnc-PRRG4-4:1 | *RSL24D1* | 0.983 |
| lnc-FAM71D-3:1 | *CD69* | 0.959 | lnc-WSB1-7:2 | *RSL24D1* | 0.983 |
| lnc-ARSG-2:6 | *PTS* | 0.959 | lnc-PTPRZ1-10:1 | *RSL24D1* | 0.983 |
| lnc-RP11-166B2.1.1-3:1 | *RPL17* | 0.959 | NONHSAT128057 | *RPL17* | 0.983 |
| NONHSAT126218 | *RPL17* | 0.959 | lnc-CCL5-3:1 | *RPL17* | 0.983 |
| lnc-TMEM74-3:1 | *RPL17* | 0.959 | lnc-MEX3C-6:1 | *RSL24D1* | 0.984 |
| ENST00000607698 | *PTS* | 0.961 | lnc-COMMD3-3:1 | *RSL24D1* | 0.984 |
| lnc-FAM71D-3:1 | *PTS* | 0.961 | lnc-NT5E-4:1 | *RSL24D1* | 0.984 |
| NONHSAT035867 | *RSL24D1* | 0.961 | lnc-CES1-4:1 | *RSL24D1* | 0.984 |
| lnc-A2M-2:1 | *RPL17* | 0.961 | lnc-C8G-2:1 | *RPL17* | 0.984 |
| lnc-FAM71D-3:1 | *RPL17* | 0.961 | NONHSAT059117 | *RPL17* | 0.984 |
| lnc-C19orf12-7:1 | *RPL17* | 0.961 | lnc-ARSB-1:1 | *RPL17* | 0.984 |
| lnc-ZBTB6-1:1 | *CDADC1* | 0.963 | lnc-AC011467.1-2:1 | *RPL17* | 0.984 |
| lnc-BEND6-2:1 | *RPL17* | 0.963 | lnc-PLEKHM3-2:1 | *RSL24D1* | 0.985 |

| | | | | | |
|---|---|---|---|---|---|
| lnc-SPR-3:1 | *RPL17* | 0.963 | lnc-MBL2-9:1 | *RSL24D1* | 0.985 |
| lnc-ARHGEF4-1:5 | *SFN* | 0.964 | lnc-NT5E-4:1 | *RPL17* | 0.985 |
| lnc-KDELR2-1:2 | *PTS* | 0.964 | lnc-CES1-4:1 | *RPL17* | 0.985 |
| NR_024109 | *CDADC1* | 0.965 | lnc-CAMSAP2-2:1 | *RPL17* | 0.985 |
| NONHSAT001395 | *RSL24D1* | 0.965 | lnc-NR2F2-10:1 | *RSL24D1* | 0.986 |
| lnc-KDELR2-1:2 | *SNRPF* | 0.966 | lnc-ARSB-1:1 | *RSL24D1* | 0.986 |
| lnc-RIOK2-9:1 | *PTS* | 0.966 | lnc-NRN1-6:2 | *RSL24D1* | 0.986 |
| lnc-PLEKHA5-6:1 | *RSL24D1* | 0.966 | lnc-GPR63-8:1 | *RPL17* | 0.986 |
| lnc-DLEU7-9:1 | *RSL24D1* | 0.966 | lnc-CEBPZ-1:1 | *RPL17* | 0.986 |
| NR_104160 | *SNRPF* | 0.967 | lnc-CCAR1-3:1 | *RPL17* | 0.986 |
| ENST00000565797 | *PTS* | 0.967 | lnc-WSB1-7:2 | *RPL17* | 0.986 |
| lnc-LONP2-8:1 | *RSL24D1* | 0.967 | lnc-C3orf65-9:1 | *RPL17* | 0.986 |
| lnc-CHCHD3-1:1 | *RSL24D1* | 0.967 | lnc-KBTBD13-1:1 | *RSL24D1* | 0.987 |
| NONHSAT080449 | *RSL24D1* | 0.967 | lnc-DTHD1-16:1 | *RSL24D1* | 0.987 |
| NONHSAT067683 | *RSL24D1* | 0.968 | NONHSAT144261 | *RPL17* | 0.987 |
| NR_104160 | *GZF1* | 0.969 | NONHSAT100937 | *RPL17* | 0.987 |
| ENST00000606596 | *C12orf79* | 0.969 | lnc-PRRG4-4:1 | *RPL17* | 0.987 |
| lnc-ARSG-2:6 | *CDADC1* | 0.969 | lnc-CENPJ-4:1 | *RPL17* | 0.987 |
| lnc-MKLN1-3:1 | *RSL24D1* | 0.969 | lnc-MBL2-9:1 | *RPL17* | 0.988 |
| lnc-CDH17-2:1 | *RPL17* | 0.969 | lnc-FAM9C-7:1 | *RSL24D1* | 0.989 |
| NR_036695 | *RPL17* | 0.969 | lnc-LPAR4-1:1 | *RPL17* | 0.989 |
| lnc-ATG14-3:1 | *RPL17* | 0.969 | lnc-RALGAPA2-7:1 | *RPL17* | 0.989 |
| lnc-ZBTB6-1:1 | *PTS* | 0.97 | lnc-DTHD1-16:1 | *RPL17* | 0.989 |
| lnc-MDC1-1:1 | *RSL24D1* | 0.97 | lnc-TRAF4-1:1 | *RPL17* | 0.989 |
| lnc-SLC25A1-4:1 | *RSL24D1* | 0.97 | lnc-SAR1B-2:1 | *RPL17* | 0.989 |
| lnc-FBXL2-2:1 | *RPL17* | 0.97 | lnc-RRP1B-5:1 | *RPL17* | 0.989 |
| lnc-ERMN-2:1 | *ERMN* | 0.971 | lnc-C8G-2:1 | *RSL24D1* | 0.994 |
| ENST00000565797 | *CDADC1* | 0.971 | lnc-FAM9C-7:1 | *RPL17* | 0.994 |
| lnc-GTF2F2-12:1 | *PTS* | 0.971 | lnc-PTPRZ1-10:1 | *RPL17* | 0.994 |
| NONHSAT128057 | *RSL24D1* | 0.971 | NONHSAT053484 | *RPL17* | 0.993 |
| lnc-UBE2NL-2:1 | *RPL17* | 0.971 | lnc-MDC1-1:1 | *RPL17* | 0.993 |
| lnc-LDB1-4:1 | *PTS* | 0.972 | NONHSAT001395 | *RPL17* | 0.993 |
| lnc-LONP2-8:1 | *RPL17* | 0.972 | lnc-CMC1-4:1 | *RPL17* | 0.993 |
| lnc-PRAC-1:1 | *RPL17* | 0.972 | lnc-MKLN1-3:1 | *RPL17* | 0.992 |
| lnc-ACBD3-1:1 | *RPL17* | 0.972 | lnc-CNKSR3-2:1 | *RPL17* | 0.992 |
| lnc-SLC14A1-1:1 | *RSL24D1* | 0.973 | lnc-GPR63-8:1 | *RSL24D1* | 0.991 |
| lnc-PRAC-1:1 | *RSL24D1* | 0.973 | lnc-DLEU7-9:1 | *RPL17* | 0.991 |
| lnc-RALGAPA2-7:1 | *RSL24D1* | 0.973 | NONHSAT080449 | *RPL17* | 0.99 |
| NONHSAT017634 | *RPL17* | 0.973 | lnc-AVPR1A-3:1 | *RPL17* | 0.99 |
| NR_104160 | *CDADC1* | 0.974 | lnc-APOD-2:1 | *RPL17* | 0.99 |
| NONHSAT059117 | *RSL24D1* | 0.974 | lnc-PLEKHA5-6:1 | *RPL17* | 0.99 |
| lnc-RRP1B-5:1 | *RSL24D1* | 0.974 | lnc-NRN1-6:2 | *RPL17* | 0.99 |
| lnc-BEND6-2:1 | *RSL24D1* | 0.975 | lnc-SLC25A1-4:1 | *RPL17* | 0.99 |
| NONHSAT062956 | *RSL24D1* | 0.975 | | | |

PCC, Pearson's correlation coefficient.

**Table S6.** lncRNA-targeted miRNAs predicted by miRDB

| lncRNA | Targeted miRNAs | Pairs |
|---|---|---|
| NR_104160 | hsa-miR-101-3p; hsa-miR-3692-3p; hsa-miR-6515-3p; hsa-miR-186-3p; hsa-miR-196a-5p; hsa-miR-600 | 6 |
| lnc-DAOA-10:1 | hsa-miR-4443; hsa-miR-4291; hsa-miR-3166 | 3 |
| lnc-DNAJC12-2:1 | hsa-miR-7106-3p; hsa-miR-4529-5p; hsa-miR-5581-3p; hsa-miR-4724-5p; hsa-miR-6854-3p; hsa-miR-5196-3p; hsa-miR-3182; hsa-miR-3679-5p; hsa-miR-1185-5p; hsa-miR-3158-5p; hsa-miR-1255b-2-3p; hsa-miR-4730 | 12 |
| lnc-SETD4-11:1 | hsa-miR-4268; hsa-miR-548ba; hsa-miR-3173-5p | 3 |
| lnc-RPS13-3:1 | hsa-miR-150-3p; hsa-miR-3173-5p; hsa-miR-362-3p; hsa-miR-329-3p; hsa-miR-6828-3p | 5 |
| lnc-TIPRL-1:1 | hsa-miR-585-5p; hsa-miR-3170; hsa-miR-7850-5p; hsa-miR-4520-2-3p; hsa-miR-939-3p; hsa-miR-6866-5p | 6 |
| lnc-NAP1L3-8:1 | hsa-miR-3622b-3p; hsa-miR-3622a-3p; hsa-miR-1299; hsa-miR-4303; hsa-miR-4279; hsa-miR-3925-3p; hsa-miR-4661-5p; hsa-miR-103a-2-5p; hsa-miR-3119 | 9 |
| lnc-TMEM74-3:1 | hsa-miR-6836-5p; hsa-miR-6132; hsa-miR-4283; hsa-miR-4317; hsa-miR-5002-3p; hsa-miR-24-3p; hsa-miR-873-5p; hsa-miR-138-1-3p; hsa-miR-627-3p | 9 |
| lnc-A2M-2:1 | hsa-miR-5096; hsa-miR-582-3p; hsa-miR-4276; hsa-miR-636; hsa-miR-329-5p; hsa-miR-1206; hsa-miR-3910; hsa-miR-3074-5p; hsa-miR-4660; hsa-miR-7153-3p; hsa-miR-4530; hsa-miR-26b-3p | 12 |
| lnc-C19orf12-7:1 | hsa-miR-1275; hsa-miR-93-3p; hsa-miR-4294; hsa-miR-3168; hsa-miR-6723-5p; hsa-miR-5706; hsa-miR-4782-5p; hsa-miR-671-5p; hsa-miR-4709-5p; hsa-miR-1227-5p; hsa-miR-4682 | 11 |
| lnc-BEND6-2:1 | hsa-miR-330-5p; hsa-miR-548ah-5p; hsa-miR-326; hsa-miR-3609; hsa-miR-939-3p; hsa-miR-3944-5p; hsa-miR-6797-3p; hsa-miR-6076; hsa-miR-766-3p; hsa-miR-4677-5p; hsa-miR-30e-3p; hsa-miR-30d-3p; hsa-miR-2116-5p; hsa-miR-3686; hsa-miR-3201 | 15 |
| lnc-SPR-3:1 | hsa-miR-6738-3p; hsa-miR-6887-3p; hsa-miR-6826-3p; hsa-miR-4267; hsa-miR-7977 | 5 |
| lnc-CDH17-2:1 | hsa-miR-3173-5p; hsa-miR-4511; hsa-miR-362-3p; hsa-miR-329-3p; hsa-miR-6828-3p; hsa-miR-504-5p; hsa-miR-4725-5p | 7 |
| lnc-ATG14-3:1 | hsa-miR-8075; hsa-miR-4310; hsa-miR-3173-5p; hsa-miR-7157-5p; hsa-miR-6126; hsa-miR-1267 | 6 |
| lnc-ACBD3-1:1 | hsa-miR-1238-3p; hsa-miR-362-3p; hsa-miR-329-3p; hsa-miR-651-3p; hsa-miR-4639-3p | 5 |
| lnc-HPRT1-9:1 | hsa-miR-873-5p; hsa-miR-4314; hsa-miR-3614-5p; hsa-miR-1227-3p; hsa-miR-4319; hsa-miR-103a-2-5p; hsa-miR-6885-3p; hsa-miR-4279; hsa-miR-661; hsa-miR-6736-3p; hsa-miR-4646-5p; hsa-miR-204-3p | 12 |
| lnc-DUSP19-3:1 | hsa-miR-544a; hsa-miR-501-5p; hsa-miR-422a; hsa-miR-378i; hsa-miR-378h; hsa-miR-378f; hsa-miR-378e; hsa-miR-378d; hsa-miR-378c; hsa-miR-378b; hsa-miR-378a-3p | 11 |
| lnc-NR2F2-10:1 | hsa-miR-520f-3p; hsa-miR-943; hsa-miR-4717-3p; hsa-miR-4534 | 4 |
| lnc-SLC14A1-1:1 | hsa-miR-431-5p; hsa-miR-6819-5p; hsa-miR-6812-5p; hsa-miR-6737-5p; hsa-miR-4441; hsa-miR-7108-3p; hsa-miR-1200; hsa-miR-1290; hsa-miR-4324; hsa-miR-504-3p | 10 |
| lnc-KBTBD13-1:1 | hsa-miR-548ah-5p; hsa-miR-3609; hsa-miR-4677-5p; hsa-miR-4286; hsa-miR-2116-5p; hsa-miR-3686; hsa-miR-3942-3p | 7 |
| lnc-IQCH-4:1 | hsa-miR-4420; hsa-miR-181b-3p; hsa-miR-181b-2-3p; hsa-miR-4532; hsa-miR-4297; hsa-miR-6873-3p; hsa-miR-6833-3p; hsa-miR-4768-5p; hsa-miR-4715-3p | 9 |
| lnc-STK35-3:1 | hsa-miR-4306; hsa-miR-4644; hsa-miR-185-5p; hsa-miR-103a-2-5p | 4 |
| lnc-COMMD3-3:1 | hsa-miR-764; hsa-miR-6766-5p; hsa-miR-6756-5p; hsa-miR-552-3p; hsa-miR-6891-3p; hsa-miR-6072 | 6 |
| lnc-PLEKHM3-2:1 | hsa-miR-4709-5p; hsa-miR-6867-5p; hsa-miR-505-3p; hsa-miR-1227-5p; hsa-miR-378g; hsa-miR-513b-3p; hsa-miR-3168 | 7 |
| lnc-CHCHD3-1:1 | hsa-miR-548b-3p; hsa-miR-4456; hsa-miR-6081; hsa-miR-4641; hsa-miR-4267; hsa-miR-571; hsa-miR-4777-5p; hsa-miR-6845-3p | 8 |
| lnc-ZNF286A-11:1 | hsa-miR-1227-5p; hsa-miR-409-3p; hsa-miR-671-5p; hsa-miR-7107-5p; hsa-miR-1234-3p | 5 |
| lnc-SAMHD1-2:1 | hsa-miR-578; hsa-miR-544a; hsa-miR-4423-5p; hsa-miR-744-3p; hsa-miR-7106-3p; hsa-miR-127-5p | 6 |
| lnc-C8G-2:1 | hsa-miR-6830-5p; hsa-miR-3674; hsa-miR-4328; hsa-miR-5095; hsa-miR-6511a-5p; hsa-miR-1910-3p; hsa-miR-5003-5p; hsa-miR-874-5p; hsa-miR-4763-5p; hsa-miR-515-5p; hsa-miR-645; hsa-miR-208b-5p; hsa-miR-208a-5p; hsa-miR-125b-2-3p; hsa-miR-7160-5p; hsa-miR-4306 | 16 |
| lnc-ARSB-1:1 | hsa-miR-4529-5p; hsa-miR-3622b-5p; hsa-miR-4310; hsa-miR-4288; hsa-miR-346; hsa-miR-6740-3p; hsa-miR-3679-5p; hsa-miR-1185-5p; hsa-miR-659-3p; hsa-miR-6806-3p; hsa-miR-3928-5p | 11 |
| lnc-NT5E-4:1 | hsa-miR-616-3p; hsa-miR-504-3p; hsa-miR-1279; hsa-miR-597-3p; hsa-miR-376a-2-5p | 5 |
| lnc-CES1-4:1 | hsa-miR-4778-3p; hsa-miR-4717-3p; hsa-miR-4323; hsa-miR-4764-5p; hsa-miR-5196-3p; hsa-miR-152-3p; hsa-miR-148b-3p; hsa-miR-148a-3p | 8 |
| lnc-CAMSAP2-2:1 | hsa-miR-3173-5p; hsa-miR-6753-5p; hsa-miR-939-3p; hsa-miR-4511; hsa-miR-6828-3p | 5 |
| lnc-GPR63-8:1 | hsa-miR-4319; hsa-miR-298; hsa-miR-103a-2-5p; hsa-miR-1299; hsa-miR-4765; hsa-miR-4279; hsa-miR-647 | 7 |
| lnc-CEBPZ-1:1 | hsa-miR-3186-3p; hsa-miR-4520-3p; hsa-miR-549a | 3 |
| lnc-CCAR1-3:1 | hsa-miR-4288; hsa-miR-1297; hsa-miR-346; hsa-miR-10b-3p; hsa-miR-591; hsa-miR-4465; hsa-miR-26b-5p; hsa-miR-26a-5p; hsa-miR-31-5p; hsa-miR-4529-5p; hsa-miR-544a; hsa-miR-632; hsa-miR-942-3p; hsa-miR-4299; hsa-miR-494-3p | 15 |
| lnc-WSB1-7:2 | hsa-miR-4268; hsa-miR-6753-5p; hsa-miR-939-3p; hsa-miR-4511 | 4 |
| lnc-PRRG4-4:1 | hsa-miR-4443; hsa-miR-6753-5p; hsa-miR-4641 | 3 |
| lnc-CENPJ-4:1 | hsa-miR-3173-5p; hsa-miR-939-3p | 2 |

| | | |
|---|---|---|
| lnc-MBL2-9:1 | hsa-miR-140-5p | 1 |
| lnc-LPAR4-1:1 | hsa-miR-1283; hsa-miR-4709-5p; hsa-miR-3679-5p; hsa-miR-1185-5p; hsa-miR-1305; hsa-miR-4717-5p; hsa-miR-6768-3p; hsa-miR-330-3p; hsa-miR-4776-3p; hsa-miR-6878-3p; hsa-miR-1297; hsa-miR-3193 | 12 |
| lnc-DTHD1-16:1 | hsa-miR-4691-3p; hsa-miR-4520-3p; hsa-miR-892a | 3 |
| lnc-TRAF4-1:1 | hsa-miR-630; hsa-miR-216a-5p; hsa-miR-4469 | 3 |
| lnc-SAR1B-2:1 | hsa-miR-6753-5p; hsa-miR-7850-5p | 2 |
| lnc-FAM9C-7:1 | hsa-miR-7114-5p; hsa-miR-3944-5p; hsa-miR-452-3p; hsa-miR-4659b-3p; hsa-miR-4659a-3p; hsa-miR-3177-3p; hsa-miR-1537-5p; hsa-miR-4677-5p; hsa-miR-8066; hsa-miR-324-5p; hsa-miR-5704; hsa-miR-2116-5p | 12 |
| lnc-MDC1-1:1 | hsa-miR-103a-2-5p; hsa-miR-326; hsa-miR-1283; hsa-miR-181a-2-3p; hsa-miR-6509-3p; hsa-miR-5590-5p; hsa-miR-3679-5p; hsa-miR-1185-5p; hsa-miR-3665; hsa-miR-335-3p; hsa-miR-5588-5p; hsa-miR-5001-3p; hsa-miR-4799-3p; hsa-miR-4720-5p; hsa-miR-4695-3p | 15 |
| lnc-CMC1-4:1 | hsa-miR-4448; hsa-miR-6844; hsa-miR-5006-5p; hsa-miR-4261; hsa-miR-345-5p; hsa-miR-652-5p; hsa-miR-6828-3p; hsa-miR-6893-3p; hsa-miR-370-3p; hsa-miR-5003-5p; hsa-miR-140-5p | 11 |
| lnc-CNKSR3-2:1 | hsa-miR-5000-3p; hsa-miR-764; hsa-miR-4663; hsa-miR-4745-3p; hsa-miR-1538; hsa-miR-943; hsa-miR-4436a; hsa-miR-1226-5p | 8 |
| lnc-DLEU7-9:1 | hsa-miR-548m; hsa-miR-23b-5p; hsa-miR-23a-5p; hsa-miR-939-3p; hsa-miR-6809-3p | 5 |
| lnc-APOD-2:1 | hsa-miR-500b-3p; hsa-miR-6718-5p; hsa-miR-203b-5p; hsa-miR-6865-3p; hsa-miR-1909-5p; hsa-miR-550a-5p; hsa-miR-1271-3p; hsa-miR-5587-5p | 8 |
| lnc-NRN1-6:2 | hsa-miR-3173-5p; hsa-miR-939-3p; hsa-miR-6753-5p; hsa-miR-4750-3p; hsa-miR-4256; hsa-miR-4511 | 6 |
| lnc-SLC25A1-4:1 | hsa-miR-4268; hsa-miR-657 | 2 |
| lnc-ARHGEF4-1:5 | hsa-miR-22-5p; hsa-miR-616-5p; hsa-miR-373-5p; hsa-miR-371b-5p; hsa-miR-6827-3p; hsa-miR-340-3p; hsa-miR-3613-3p; hsa-miR-5192; hsa-miR-6780a-5p; hsa-miR-6779-5p; hsa-miR-3689c; hsa-miR-3689b-3p; hsa-miR-3689a-3p; hsa-miR-30b-3p; hsa-miR-1273h-5p | 15 |
| lnc-ERMN-2:1 | hsa-miR-568; hsa-miR-3065-5p; hsa-miR-7159-5p; hsa-miR-7152-5p; hsa-miR-6728-3p; hsa-miR-8069; hsa-miR-6822-3p; hsa-miR-511-3p; hsa-miR-760; hsa-miR-7844-5p; hsa-miR-6760-5p; hsa-miR-708-3p; hsa-miR-6817-3P; hsa-miR-587; hsa-miR-149-5p; hsa-let-7g-3p; hsa-let-7a-2-3p; hsa-miR-1972; hsa-miR-4735-5p | 19 |
| ENST00000606596 | hsa-miR-1908-5p; hsa-miR-1225-3p; hsa-miR-369-3p; hsa-miR-4492 | 4 |
| ENST00000607698 | hsa-miR-324-5p; hsa-miR-2355-5p; hsa-miR-6077; hsa-miR-548ax; hsa-miR-548ao-5p | 5 |
| ENST00000565797 | hsa-miR-3119; hsa-miR-6774-5p; hsa-miR-635; hsa-miR-3130-3p; hsa-miR-1225-3p; hsa-miR-650; hsa-miR-3612; hsa-miR-6883-5p; hsa-miR-1251-3p | 9 |
| lnc-CAPN2-3:1 | hsa-miR-4643; hsa-miR-4308; hsa-miR-518c-5p; hsa-miR-4254; hsa-miR-548al; hsa-miR-4445-3p; hsa-miR-4297; hsa-miR-1193; hsa-miR-4293; hsa-miR-1281 | 10 |
| lnc-LONP2-8:1 | hsa-miR-4426; hsa-miR-6894-3p; hsa-miR-6773-5p; hsa-miR-6724-5p; hsa-miR-6853-3p; hsa-miR-4662b; hsa-miR-4647; hsa-miR-561-3p; hsa-miR-3977; hsa-miR-4528; hsa-miR-7155-3p; hsa-miR-3136-3p; hsa-miR-4330 | 13 |
| lnc-AVPR1A-3:1 | hsa-miR-296-5p; hsa-miR-4426; hsa-miR-4763-5p; hsa-miR-335-3p; hsa-miR-561-3p; hsa-miR-4774-5p; hsa-miR-4662b; hsa-miR-4647 | 8 |
| lnc-MEX3C-6:1 | hsa-miR-4283; hsa-miR-1204; hsa-miR-1273h-3p; hsa-miR-6894-3p; hsa-miR-4774-5p; hsa-miR-6853-3p; hsa-miR-561-3p; hsa-miR-24-3p; hsa-miR-3166; hsa-miR-296-5p; hsa-miR-1304-3p; hsa-miR-4440; hsa-miR-6515-3p | 13 |
| lnc-CCL5-3:1 | hsa-miR-4426; hsa-miR-449c-3p; hsa-miR-7155-5p; hsa-miR-4754; hsa-miR-6894-3p; hsa-miR-7159-3p; hsa-miR-6515-3p; hsa-miR-4283; hsa-miR-5787; hsa-miR-4505; hsa-miR-4662b; hsa-miR-4647; hsa-miR-3200-3p | 13 |
| lnc-FBXL2-2:1 | hsa-miR-4279; hsa-miR-3120-3p; hsa-miR-3614-5p; hsa-miR-4435; hsa-miR-6772-3p; hsa-miR-1273h-3p | 6 |

**Table S7-1.** lncRNA-miRNA-mRNA ceRNA pathways in the lncRNA-miRNA-mRNA network

| N | lncRNA | miRNA | mRNA | N | lncRNA | miRNA | mRNA |
|---|---|---|---|---|---|---|---|
| 1 | ENST00000565797 | hsa-miR-3119 | *SNRPF* | 37 | lnc-FAM9C-7:1 | hsa-miR-4659a-3p | *RSL24D1* |
| 2 | ENST00000565797 | hsa-miR-1251-3p | *SNRPF* | 38 | lnc-GPR63-8:1 | hsa-miR-103a-2-5p | *RSL24D1* |
| 3 | ENST00000565797 | hsa-miR-1251-3p | *CD69* | 39 | lnc-HPRT1-9:1 | hsa-miR-3614-5p | *RSL24D1* |
| 4 | ENST00000565797 | hsa-miR-6774-5p | *CD69* | 40 | lnc-HPRT1-9:1 | hsa-miR-103a-2-5p | *RSL24D1* |
| 5 | ENST00000565797 | hsa-miR-635 | *CD69* | 41 | lnc-IQCH-4:1 | hsa-miR-6833-3p | *RSL24D1* |
| 6 | ENST00000606596 | hsa-miR-1225-3p | *C12orf79* | 42 | lnc-IQCH-4:1 | hsa-miR-4768-5p | *RSL24D1* |
| 7 | lnc-ARSB-1:1 | hsa-miR-4310 | *RSL24D1* | 43 | lnc-LONP2-8:1 | hsa-miR-4426 | *RSL24D1* |
| 8 | lnc-AVPR1A-3:1 | hsa-miR-4426 | *RSL24D1* | 44 | lnc-LONP2-8:1 | hsa-miR-4662b | *RSL24D1* |
| 9 | lnc-AVPR1A-3:1 | hsa-miR-335-3p | *RSL24D1* | 45 | lnc-LONP2-8:1 | hsa-miR-4647 | *RSL24D1* |
| 10 | lnc-AVPR1A-3:1 | hsa-miR-335-3p | *PTS* | 46 | lnc-LONP2-8:1 | hsa-miR-4528 | *RSL24D1* |
| 11 | lnc-AVPR1A-3:1 | hsa-miR-4774-5p | *RSL24D1* | 47 | lnc-LPAR4-1:1 | hsa-miR-1305 | *RSL24D1* |
| 12 | lnc-AVPR1A-3:1 | hsa-miR-4662b | *RSL24D1* | 48 | lnc-LPAR4-1:1 | hsa-miR-4776-3p | *RSL24D1* |
| 13 | lnc-AVPR1A-3:1 | hsa-miR-4647 | *RSL24D1* | 49 | lnc-MDC1-1:1 | hsa-miR-103a-2-5p | *RSL24D1* |
| 14 | lnc-C19orf12-7:1 | hsa-miR-3168 | *RPL17* | 50 | lnc-MDC1-1:1 | hsa-miR-5590-5p | *RSL24D1* |
| 15 | lnc-C8G-2:1 | hsa-miR-515-5p | *RSL24D1* | 51 | lnc-MDC1-1:1 | hsa-miR-335-3p | *RSL24D1* |
| 16 | lnc-C8G-2:1 | hsa-miR-208b-5p | *RSL24D1* | 52 | lnc-MEX3C-6:1 | hsa-miR-4774-5p | *RSL24D1* |
| 17 | lnc-C8G-2:1 | hsa-miR-208a-5p | *RSL24D1* | 53 | lnc-NR2F2-10:1 | hsa-miR-4717-3p | *RSL24D1* |
| 18 | lnc-C8G-2:1 | hsa-miR-125b-2-3p | *RSL24D1* | 54 | lnc-NT5E-4:1 | hsa-miR-616-3p | *RSL24D1* |
| 19 | lnc-CAPN2-3:1 | hsa-miR-4297 | *PTS* | 55 | lnc-NT5E-4:1 | hsa-miR-376a-2-5p | *RSL24D1* |
| 20 | lnc-CCAR1-3:1 | hsa-miR-494-3p | *RSL24D1* | 56 | lnc-PLEKHM3-2:1 | hsa-miR-3168 | *RPL17* |
| 21 | lnc-CCL5-3:1 | hsa-miR-4426 | *RSL24D1* | 57 | lnc-PLEKHM3-2:1 | hsa-miR-378g | *RSL24D1* |
| 22 | lnc-CCL5-3:1 | hsa-miR-4662b | *RSL24D1* | 58 | lnc-PLEKHM3-2:1 | hsa-miR-513b-3p | *RSL24D1* |
| 23 | lnc-CCL5-3:1 | hsa-miR-4647 | *RSL24D1* | 59 | lnc-SPR-3:1 | hsa-miR-6826-3p | *RSL24D1* |
| 24 | lnc-CES1-4:1 | hsa-miR-4778-3p | *RSL24D1* | 60 | lnc-TIPRL-1:1 | hsa-miR-585-5p | *RSL24D1* |
| 25 | lnc-CES1-4:1 | hsa-miR-4717-3p | *RSL24D1* | 61 | lnc-TMEM74-3:1 | hsa-miR-6836-5p | *RPL17* |
| 26 | lnc-CES1-4:1 | hsa-miR-4764-5p | *RSL24D1* | 62 | lnc-TMEM74-3:1 | hsa-miR-6132 | *RPL17* |
| 27 | lnc-CHCHD3-1:1 | hsa-miR-4777-5p | *RSL24D1* | 63 | lnc-TMEM74-3:1 | hsa-miR-627-3p | *RPL17* |
| 28 | lnc-COMMD3-3:1 | hsa-miR-6891-3p | *RPL17* | 64 | lnc-TRAF4-1:1 | hsa-miR-630 | *RSL24D1* |
| 29 | lnc-COMMD3-3:1 | hsa-miR-6072 | *RPL17* | 65 | NR_104160 | hsa-miR-6515-3p | *CDADC1* |
| 30 | lnc-DLEU7-9:1 | hsa-miR-6809-3p | *RSL24D1* | 66 | NR_104160 | hsa-miR-6515-3p | *SNRPF* |
| 31 | lnc-ERMN-2:1 | hsa-miR-7152-5p | *ERMN* | 67 | NR_104160 | hsa-miR-186-3p | *GZF1* |
| 31 | lnc-ERMN-2:1 | hsa-miR-511-3p | *PTS* | 68 | NR_104160 | hsa-miR-186-3p | *CDADC1* |
| 33 | lnc-ERMN-2:1 | hsa-miR-587 | *PTS* | 69 | NR_104160 | hsa-miR-600 | *SNRPF* |
| 34 | lnc-ERMN-2:1 | hsa-miR-4735-5p | *PTS* | 70 | NR_104160 | hsa-miR-600 | *CDADC1* |
| 35 | lnc-ERMN-2:1 | hsa-let-7g-3p | *CDADC1* | 71 | NR_104160 | hsa-miR-101-3p | *ID1* |
| 36 | lnc-FAM9C-7:1 | hsa-miR-4659b-3p | *RSL24D1* | | | | |

**Table S7-2.** RNAs and the number of their associated ceRNA pathways

| lncRNA | Pathways | miRNA | Pathways | mRNA | Pathways |
|---|---|---|---|---|---|
| NR_104160 | 7 | hsa-miR-4426 | 3 | *RSL24D1* | 44 |
| lnc-AVPR1A-3:1 | 6 | hsa-miR-335-3p | 3 | *RPL17* | 7 |
| ENST00000565797 | 5 | hsa-miR-4662b | 3 | *PTS* | 5 |
| lnc-ERMN-2:1 | 5 | hsa-miR-4647 | 3 | *CDADC1* | 4 |
| lnc-LONP2-8:1 | 4 | hsa-miR-103a-2-5p | 3 | *SNRPF* | 4 |
| lnc-C8G-2:1 | 4 | hsa-miR-1251-3p | 2 | *CD69* | 3 |
| lnc-CCL5-3:1 | 3 | hsa-miR-4774-5p | 2 | *C12orf79* | 1 |
| lnc-CES1-4:1 | 3 | hsa-miR-3168 | 2 | *ID1* | 1 |

| | | | | | |
|---|---|---|---|---|---|
| lnc-MDC1-1:1 | 3 | hsa-miR-4717-3p | 2 | *ERMN* | 1 |
| lnc-PLEKHM3-2:1 | 3 | hsa-miR-6515-3p | 2 | *GZF1* | 1 |
| lnc-TMEM74-3:1 | 3 | hsa-miR-186-3p | 2 | | |
| lnc-COMMD3-3:1 | 2 | hsa-miR-600 | 2 | | |
| lnc-FAM9C-7:1 | 2 | hsa-miR-6774-5p | 1 | | |
| lnc-HPRT1-9:1 | 2 | hsa-miR-635 | 1 | | |
| lnc-IQCH-4:1 | 2 | hsa-miR-1225-3p | 1 | | |
| lnc-LPAR4-1:1 | 2 | hsa-miR-4310 | 1 | | |
| lnc-NT5E-4:1 | 2 | hsa-miR-3119 | 1 | | |
| ENST00000606596 | 1 | hsa-miR-515-5p | 1 | | |
| lnc-ARSB-1:1 | 1 | hsa-miR-208b-5p | 1 | | |
| lnc-C19orf12-7:1 | 1 | hsa-miR-208a-5p | 1 | | |
| lnc-CAPN2-3:1 | 1 | hsa-miR-125b-2-3p | 1 | | |
| lnc-CCAR1-3:1 | 1 | hsa-miR-4297 | 1 | | |
| lnc-CHCHD3-1:1 | 1 | hsa-miR-494-3p | 1 | | |
| lnc-DLEU7-9:1 | 1 | hsa-miR-4778-3p | 1 | | |
| lnc-GPR63-8:1 | 1 | hsa-miR-4764-5p | 1 | | |
| lnc-MEX3C-6:1 | 1 | hsa-miR-4777-5p | 1 | | |
| lnc-NR2F2-10:1 | 1 | hsa-miR-6891-3p | 1 | | |
| lnc-SPR-3:1 | 1 | hsa-miR-6072 | 1 | | |
| lnc-TIPRL-1:1 | 1 | hsa-miR-6809-3p | 1 | | |
| lnc-TRAF4-1:1 | 1 | hsa-miR-7152-5p | 1 | | |
| | | hsa-miR-511-3p | 1 | | |
| | | hsa-miR-587 | 1 | | |
| | | hsa-miR-4735-5p | 1 | | |
| | | hsa-let-7g-3p | 1 | | |
| | | hsa-miR-4659b-3p | 1 | | |
| | | hsa-miR-4659a-3p | 1 | | |
| | | hsa-miR-3614-5p | 1 | | |
| | | hsa-miR-6833-3p | 1 | | |
| | | hsa-miR-4768-5p | 1 | | |
| | | hsa-miR-4528 | 1 | | |
| | | hsa-miR-1305 | 1 | | |
| | | hsa-miR-4776-3p | 1 | | |
| | | hsa-miR-5590-5p | 1 | | |
| | | hsa-miR-616-3p | 1 | | |
| | | hsa-miR-376a-2-5p | 1 | | |
| | | hsa-miR-378g | 1 | | |
| | | hsa-miR-513b-3p | 1 | | |
| | | hsa-miR-6826-3p | 1 | | |
| | | hsa-miR-585-5p | 1 | | |
| | | hsa-miR-6836-5p | 1 | | |
| | | hsa-miR-6132 | 1 | | |
| | | hsa-miR-627-3p | 1 | | |
| | | hsa-miR-630 | 1 | | |
| | | hsa-miR-101-3p | 1 | | |